Trials@uspto.gov
Tel: 571-272-7822

Paper 18
Entered: May 29, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

2WIRE, INC.,
Petitioner,

v.

TQ DELTA, LLC,
Patent Owner.

Case IPR2015-00241
Patent 8,073,041 B1

Before KALYAN K. DESHPANDE, JUSTIN T. ARBES, and TREVOR M. JEFFERSON, *Administrative Patent Judges*.

JEFFERSON, *Administrative Patent Judge*.

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

Petitioner 2Wire, Inc., Inc. filed a Petition (Paper 2, "Pet.") requesting an *inter partes* review of claims 1 and 14 of U.S. Patent No. 8,073,041 B1 (Ex. 1001, "the '041 patent") pursuant to 35 U.S.C. §§ 311–319. Patent Owner TQ Delta, LLC filed a Preliminary Response (Paper 11, "Prelim. Resp."). We have jurisdiction under 35 U.S.C. § 314(a), which provides that an inter partes review may not be instituted "unless . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." After considering the Petition, and associated evidence, we conclude that Petitioner has not demonstrated a reasonable likelihood that it would prevail in showing unpatentability of all the challenged claims. For the reasons that follow, we deny institution of an *inter partes* review of claims 1 and 14 of the '041 patent.

II. BACKGROUND

A. *Related Proceedings*

The parties state that the '041 patent has been asserted in *TQ Delta LLC v. 2Wire Inc.*, Case No. 1:13-cv-01835-RGA (D. Del.); *TQ Delta LLC v. Zhone Technologies, Inc.*, Case No. 1:13-cv-01836-RGA (D. Del.); *TQ Delta LLC v. ZyXEL Communications Inc. et al.*, Case No. 1:13-cv-02013-RGA (D. Del.); *TQ Delta, LLC v. ADTRAN*, Inc., Case No. 1:14-cv-00954-RGA (D. Del.); and *ADTRAN, Inc. v. TQ Delta LLC*, Case No. 5:14-cv-01381 (N.D. Ala.). Pet. 1; Paper 13, 2.

B. *The '041 Patent*

The '041 patent pertains to communications systems using multicarrier modulation, such as digital subscriber line (DSL) systems using discrete multitone modulation (DMT), where a transmitter communicates over a communication channel by modulating "[c]arrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel." Ex. 1001, col. 1, ll. 29–34. In such a system, the phase and amplitude of the modulated carrier signals typically "can be considered random" because they "result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information." *Id.* at col. 1, ll. 44–48. In some situations, however, the phases of the modulated carriers may combine to produce a spike in the transmitted signal, which increases the peak-to-average power ratio (PAR) of the signal, i.e., the "ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter." *Id.* at col. 1, l. 55–col. 2, l. 22. According to the '041 patent, PAR is an important consideration in designing a DMT communication system because an increased PAR can result in high power consumption or clipping of the transmission signal. *Id.* at col. 2, ll. 8–27. Therefore, there was a need in the art for a system that can "effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal." *Id.* at col. 2, ll. 28–30.

Figure 1 of the '041 patent is reproduced below.

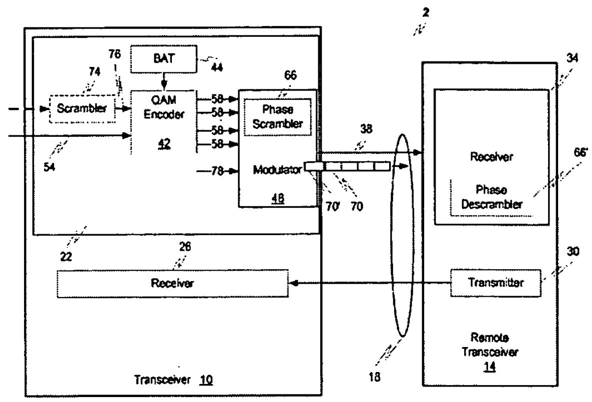


FIG. 1

Figure 1 above depicts transceiver 10 communicating transmission signals 38 over communication channel 18 (e.g., a pair of twisted wires of a telephone line) to remote transceiver 14. *Id.* at col. 3, ll. 25–50. Quadrature amplitude modulation (QAM) encoder 42 maps input serial data bit stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. *Id.* at col. 3, ll. 62–67. Modulator 46 modulates each carrier signal with a different QAM symbol 58 so that the signals have the phase and amplitude associated with the respective QAM symbol 58 (and input serial bit stream 54). *Id.* at col. 4, ll. 9–21. Phase scrambler 66 in modulator 46 calculates a phase shift for each carrier signal and combines the calculated phase shift with the phase characteristic of the respective carrier signal. *Id.* at col. 4, l. 47–col. 5, l. 3, col. 6, ll. 40–52. Phase scrambler 66 calculates the phase shift for a carrier signal by (1) determining one or more values "independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal," and (2) solving a "predetermined equation" using the value associated with the carrier signal. *Id.* at col. 4, ll. 47–52, 63–66. For example, the value for a carrier signal may be "derived from one or more predefined parameters, such as a pseudo random number generator." *Id.* at col. 4, ll. 53–55. According to the '041 patent, the use of a value determined independently of the input bit values results in a lower PAR for the transmission signal. *Id.* at col. 2, l. 31–col. 3, l. 2, col. 6, ll. 46–53. Transceiver 10 combines all of the carrier signals to form the transmission signal that is sent to remote transceiver 14. *Id.* at col. 8, ll. 16–22.

C. *Challenged Claims of the '041 Patent*

Independent claims 1 and 14 of the '041 patent recite:

> 1. A method, in a first multicarrier transceiver that uses a plurality of carrier signals for receiving a bit stream, wherein each carrier signal has a phase characteristic associated with the bit stream, the method comprising:
>
> receiving the bit stream, wherein:
>
> each carrier signal is associated with a value determined independently of any bit value of the bit stream carried by that respective carrier signal, the value associated with each carrier signal determined by a pseudo-random number generator,
>
> a phase shift for each carrier signal is based on:
>
> the value associated with that carrier signal, and

the combining of a phase for each carrier signal with the phase characteristic of that respective carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals, and

multiple carrier signals corresponding to the plurality of phase shifted and scrambled carrier signals are used by the first multicarrier transceiver to demodulate a same bit value of the received bit stream.

14. A multicarrier system including a first transceiver that uses a plurality of carrier signals for receiving a bit stream, wherein each carrier signal has a phase characteristic associated with the bit stream, the transceiver capable of receiving the bit stream, wherein:

each carrier signal is associated with a value determined independently of any bit value of the bit stream carried by that respective carrier signal, the value associated with each carrier signal determined by a pseudo-random number generator,

a phase shift for each carrier signal is based on:

the value associated with that respective carrier signal, and

the combining of a phase shift for each carrier signal with the phase characteristic of that respective carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals corresponding to the plurality of phase shifted and scrambled carrier signals are used by the first multicarrier transceiver to demodulate a same input bit value of the received bit stream.

Ex. 1001, col. 10, l. 58–col. 11, l. 11; col. 11, l. 42–col. 12, l. 16.

D. *The Asserted Grounds*

Petitioner asserts that the challenged claims of the '041 patent are unpatentable for the following specific grounds (Pet. 14–15):

Reference	Basis	Claims Challenged
Suzuki '614,[1] Suzuki '415,[2] and Admitted Prior Art[3]	35 U.S.C. § 103(a)	1 and 14
Laroia,[4] Suzuki '415, and T1.413[5]	35 U.S.C. § 103(a)	1 and 14
Fifield,[6] Suzuki '415, and Admitted Prior Art	35 U.S.C. § 103(a)	1 and 14

---

[1] U.S. Patent No. 5,903,614, issued May 11, 1999 (Ex. 1003, "Suzuki '614").
[2] U.S. Patent No. 5,694,415, issued Dec. 2, 1997 (Ex. 1009, "Suzuki '415").
[3] Alleged admitted prior art in the Specification of the '041 patent at col. 1, ll. 29–43, 49–54, 57–64, col. 3, ll. 24–36, and Fig. 1 (Ex. 1001, "Admitted Prior Art").
[4] U.S. Patent No. 6,301,268 B1, filed Mar. 10, 1998, issued Oct. 9, 2001 (Ex. 1004, "Laroia").
[5] U.S. Patent No. 6,781,951 B1, filed Oct. 22, 1999, issued Aug. 24, 2004 (Ex. 1008, "Fifield").
[6] ANSI T1.413-1998, DRAFT AMERICAN NATIONAL STANDARD FOR TELECOMMUNICATIONS, NETWORK AND CUSTOMER INSTALLATION INTERFACES—ASYMMETRIC DIGITAL SUBSCRIBER LINE (ADSL) METALLIC INTERFACE (John Bingham & Frank Van der Putten, eds., 1998) (Ex. 1006, "T1.413").

III. ANALYSIS

A. *Claim Interpretation*

We determine the meaning of the claims as the first step of our analysis. In an *inter partes* review, we interpret claims of an unexpired patent using the broadest reasonable construction. 37 C.F.R. § 42.100(b); *see* Office Patent Trial Practice Guide, 77 Fed. Reg. 48,756, 48,766 (Aug. 14, 2012); *In re Cuozzo Speed Techs., LLC*, 778 F.3d 1271, 1278–82 (Fed. Cir. 2015). If an inventor acts as his or her own lexicographer, the definition must be set forth in the specification with reasonable clarity, deliberateness, and precision. *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1249 (Fed. Cir. 1998). Claim terms generally are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Petitioner argues that the terms in claims 1 and 14 do not require interpretation. Pet. 15–16. Patent Owner proposes interpretations for two limitations: "a value determined independently of any bit value" and "multiple carrier signals corresponding to the plurality of phase shifted and scrambled carrier signals are used by the first multicarrier transceiver to demodulate a same bit value of the received bit stream." Prelim. Resp. 9–16. After reviewing the parties' papers, we find that no express claim constructions are required for purposes of this Decision.

B. *Obviousness based on Suzuki '614, Suzuki '415, and Admitted Prior Art*

Petitioner contends that claims 1 and 14 are unpatentable over Suzuki '614, Suzuki '415, and Admitted Prior Art under 35 U.S.C. § 103(a). Pet. 27–38. Petitioner relies on Suzuki '614 and Suzuki '415 for the limitations recited in claims 1 and 14. *Id.* at 33–38. Petitioner provides a claim chart citing various portions of Suzuki '614 and Suzuki '415, and states that the claim chart is supported by the Declaration of Krista S. Jacobsen, Ph.D. *Id.* at 27, 31–35 (citing Ex. 1002 ¶¶ 158–220, App. A1).

We are not persuaded that Petitioner has established a reasonable likelihood of prevailing on its asserted ground based on Suzuki '614, Suzuki '415, and Admitted Prior Art. "Section 103(a) forbids issuance of a patent when 'the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.'" *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 405 (2007). A patent claim, however, "is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art." *Id.* at 401. "Rather, obviousness requires the additional showing that a person of ordinary skill at the time of the invention would have selected and combined those prior art elements in the normal course of research and development to yield the claimed invention." *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). For an obviousness analysis, "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does." *KSR*, 550 U.S. at 418. Further, an assertion of obviousness "'cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.'" *Id.* (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

Petitioner argues that the Suzuki '614 with Suzuki '415 references teach various aspects of the challenged claims. Pet. 27–31. For example, with respect to the limitation of "each carrier signal . . . associated with a value determined independently of any bit value of the bit stream carried by that respective carrier signal" in claim 1, Petitioner acknowledges that Suzuki '614 does not "describe the details" of how the reference generates random phase shift data for each subcarrier, arguing that Suzuki '415 teaches the generation of M-bit random numbers, which are "determined independently of any bit value" according to Petitioner because they are random. *Id.* at 29–30 (citing Ex. 1009, col. 1, ll. 52–55, col. 3, ll. 25–30, col. 4, ll. 22–34).

With respect to combining these references, Petitioner argues as follows:

> It would have been obvious to combine Suzuki '614 with Suzuki '415 in order to produce the subject matter of Claim 1. For example, it would have been obvious to compute the random phases disclosed in Suzuki '614 in the manner

> disclosed in Suzuki '415 in order to produce the random phase shifts used in Suzuki '614.

Id. at 31 (citations omitted).

Petitioner's first statement that it "would have been obvious" to combine Suzuki '614 with Suzuki '415 is conclusory and does not demonstrate a reason to combine. *See KSR*, 550 U.S. at 417–18; *Unigene*, 655 F.3d at 1360; *In re Chaganti*, 554 F. App'x 917, 922 (Fed. Cir. 2014) (stating that "[i]t is not enough to say that there would have been a reason to combine two references because to do so would 'have been obvious to one of ordinary skill.' Such circular reasoning is not sufficient—more is needed to sustain an obviousness rejection.") (citation omitted). Petitioner's second statement also is insufficient, as it merely states the *result* of the asserted combination, i.e., the basic components of Suzuki '614 performing the random number calculations described in Suzuki '415.

Petitioner has not provided articulated reasoning with some rational underpinning to support its contentions that a person of ordinary skill in the art would have had reason to combine the teachings of Suzuki '614, Suzuki '415, and Admitted Prior Art to achieve the method of claim 1 or system of claim 14. Petitioner does not offer any rationale to combine the basic components of Suzuki '614 to perform the calculations of Suzuki '415. Furthermore, Petitioner does not explain why an ordinarily skilled artisan would have incorporated the phase shift calculations of Suzuki '415 into the system of Suzuki '614. The mere fact that Suzuki '614 does not describe the "details" of its random phase shift data does not mean that a person of ordinary skill in the art would have looked to the particular calculations of Suzuki '415. *See* Pet. 28–29. Indeed, as Patent Owner correctly points out, Suzuki '614 only discloses the end result of phase shifts, without any detail as to how the phase shifts are calculated. *See* Prelim. Resp. 19–20; Ex. 1003, col. 6, l. 36–col. 7, l. 18, Fig. 6. Accordingly, we find that Petitioner has not set forth an articulated rationale for combining the calculations of Suzuki '415 with Suzuki '614 in reaching a conclusion of obviousness.

Petitioner also fails to set forth an articulated rationale for combining the Admitted Prior Art with the teachings of Suzuki '614 and Suzuki '415. *See* Pet. 27. Petitioner's asserted ground is based on the combination of Suzuki '614, Suzuki '415, and Admitted Prior Art, but Petitioner's claim charts and analysis does not specifically cite the Admitted Prior Art in its analysis, or identify any rationale to combine any Admitted Prior Art teachings with those of the other cited references. *See id.* at 27–38. Petitioner merely offers conclusory statements on combining the prior art references, stating that: "[t]o the extent that some claimed aspect of the transceiver or multicarrier modulation is considered missing in Suzuki '614 and Suzuki '415, it would have been obvious from the Admitted Prior Art in order to implement the multicarrier modulation and transmission disclosed in Suzuki '614." Pet. 31–32 (citations omitted). Accordingly, Petitioner has not provided, in the Petition, sufficient explanation of an articulated reason to combine the various teachings of the prior art. *See* 37 C.F.R. § 2.104(b)(4)–(5); *see* Prelim. Resp. 23–25.

We recognize that the Declaration of Dr. Jacobsen (Ex. 1002) includes additional discussion regarding the combination of Suzuki '614, Suzuki '415, and Admitted Prior Art. *See, e.g.*, Ex. 1002 ¶¶ 199–203. That analysis, however, is not discussed adequately in the Petition itself, as Petitioner relies on blanket citations to 62 paragraphs and a 27-page appendix of the Declaration. *See* Pet. 27–30 (citing Ex. 1002 ¶¶ 158–220, Appendix A1). A petition seeking *inter partes* review must identify "[h]ow the construed claim is unpatentable under the statutory grounds identified" and "where each element of the claim is found in the prior art," and must explain the "relevance of the evidence to the challenge raised," because the Board may "give no weight to the evidence where a party has failed to state its relevance or to identify specific portions of the evidence that support the challenge." 37 C.F.R. § 42.104(b)(4)–(5); *see also* 37 C.F.R. § 42.22(a)(2) (a petition must include a "full statement of the reasons for the relief requested, including a detailed explanation of the significance of the evidence"). Dr. Jacobsen's analysis of the combination of prior art is not reflected in the Petition itself, and cannot be incorporated in the Petition by reference. *See* 37 C.F.R. § 42.6(a)(3) ("Arguments must not be incorporated by reference from one document into another document."); *Cisco Sys., Inc. v. C-Cation Techs., LLC*, Case IPR2014-00454, slip op. at 7–10 (PTAB Aug. 29, 2014) (Paper 12) (informative) (noting that "[o]ne purpose of the prohibition against incorporation by reference is to eliminate abuses" of the page limits established for the parties' substantive papers, and that citing "large portions of another document, without sufficient explanation of those portions, amounts to incorporation by reference"). Consequently, we do not consider information presented in the Declaration but not discussed sufficiently in the Petition.

Petitioner has not demonstrated a reasonable likelihood of prevailing on its assertion that claims 1 and 14 are unpatentable over Suzuki '614, Suzuki '415, and Admitted Prior Art.

C. *Obviousness Based on Laroia, Suzuki '415, and T1.413*

Petitioner's asserted ground of unpatentability based on Laroia, Suzuki '415, and T1.413 under 35 U.S.C. § 103(a) suffers from the same deficiency as its ground based on Suzuki '614, Suzuki '415, and Admitted Prior Art. *See supra* Section II.A; Prelim. Resp. 31–32. Petitioner relies on Laroia, Suzuki '415, and T1.413 for the limitations recited in claims 1 and 14, specifically relying on Laroia for the multicarrier transceiver as well as the "value associated with [a] carrier signal" and "combining" steps of each claim. Pet. 39–47. Petitioner relies on Laroia in combination with Suzuki '415 for the remaining steps recited in each claim, citing 57 paragraphs and a 19-page appendix of Dr. Jacobsen's Declaration. Pet. 39–47 (citing Ex. 1002 ¶¶ 221–278, App. B1). Again, Petitioner argues that the claims would have been "obvious" in view of the three prior art references, but does not identify in the Petition any reason why an ordinarily skilled artisan would have combined the teachings of Laroia and Suzuki '415. *See id.* at 36–39.

With respect to T1.413, Petitioner argues that "it would have been obvious to combine the network structures disclosed in T1.413 to implement them with the multicarrier modulation and transmission systems disclosed in Laroia. [Ex. 1002] Jacobsen Decl., ¶¶ 254-257." Pet. 41. As Patent Owner notes, Petitioner fails to offer any rationale for the combination of Suzuki '415 with Laroia and T1.413. Prelim. Resp. 31; Pet. 41. In addition, Petitioner's conclusory statements cannot rely on the more detailed analysis of Dr. Jacobsen, as that analysis is not discussed or reflected in the arguments made in the Petition itself. *See* Pet. 39–47; *KSR*, 550 U.S. at 417–18; *Unigene*, 655 F.3d at 1360; *Chaganti*, 554 F. App'x at 922. Further, it is unclear what "network structures" in T1.413 Petitioner is relying on for the asserted combination, as Petitioner cites four figures and four pages of the lengthy standard document without pointing out any specific features. *See* Pet. 42, 44 (citing Ex. 1006, 10–13, Figs. 2–5). Petitioner has not shown sufficiently an articulated reason with rational underpinnings to support combining the teachings of T1.413 with those of Laroia and Suzuki '415 or explained sufficiently what aspects of the references would be combined.

Accordingly, Petitioner has not demonstrated a reasonable likelihood of prevailing on its assertion that claims 1 and 14 are unpatentable over Laroia, Suzuki '415, and T1.413.

D. *Obviousness Based on Fifield, Suzuki '415, and Admitted Prior Art*

Petitioner's asserted ground of unpatentability based on Fifield, Suzuki '415, and Admitted Prior Art under 35 U.S.C. § 103(a) suffers from the same deficiencies discussed above. *See* Prelim. Resp. 34–36. Similar to the ground based on Suzuki '614, Suzuki '415, and Admitted Prior Art, Petitioner relies on Fifield for the limitations recited in the preambles of claims 1 and 14 (e.g., transceiver, carrier signals), relies on "Fifield, combined with Suzuki '415," for the remaining limitations recited in the claims, relies on "Fifield alone or in combination with Suzuki '415, T1.413[7] or the Admitted Prior Art," for the limitation of "multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to demodulate a same bit value" and cites 52 paragraphs and a 26-page appendix of Dr. Jacobsen's Declaration. Pet. 48–56 (citing Ex. 1002 ¶¶ 279–331, App. C1).

---

[7] Petitioner also argues that "it would have been obvious for multiple carriers to be used by the DMT transceiver of Fifield combined with Suzuki '415 to demodulate a same bit value of a received bit stream, as T1.413 teaches that such multiple carriers may be used for backup transmissions of a same bitstream," and that claim 14 would have been obvious in view of "Fifield, in combination with Suzuki '415 and the Admitted Prior Art or T1.413." Pet. 48–50. We presume that the citations to T1.413 were typographical errors, as the asserted ground is based only on Fifield, Suzuki '415, and Admitted Prior Art. *See id.* at 15, 48.

Petitioner fails to demonstrate a rationale to combine Fifield, Suzuki '415, and Admitted Prior Art. Pet. 48–56; Prelim. Resp. 34. Indeed, the word "obvious" is used only in conclusory statements that the claims are "rendered obvious" with citation to the Jacobsen Declaration. Pet. 48, 50. Petitioner cannot rely on the more detailed analysis of Dr. Jacobsen, which is not discussed sufficiently in the Petition. Accordingly, Petitioner has not demonstrated a reasonable likelihood of prevailing on its assertion that claims 1 and 14 are unpatentable over Fifield, Suzuki '415, and Admitted Prior Art.

IV. CONCLUSION

For the foregoing reasons, we conclude that Petitioner has not demonstrated a reasonable likelihood that at least one of the challenged claims of the '041 patent is unpatentable based on the asserted grounds. Therefore, we do not institute an *inter partes* review on any of the asserted grounds as to any of the challenged claims.

V. ORDER

Accordingly, it is

ORDERED that the Petition is denied as to all challenged claims of the '041 patent.

PETITIONER:

Jennifer A. Albert
Eleanor M. Yost
GOODWIN PROCTER LLP
jalbert@goodwinprocter.com
eyost@goodwinprocter.com

PATENT OWNER:

Peter J. McAndrews
Thomas J. Wimbiscus
Christopher M. Scharff
McANDREWS HELD & MALLOY, LTD.
pmcandrews@mcandrews-ip.com
wimbiscus@mcandrews-ip.com
cscharff@mcandrews-ip.com

AO 120 (Rev. 08/10)

TO: **Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Transferred to Delaware from Alabama on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
15-cv-121-RGA	7/17/2014	Transferred to Delaware from Alabama

PLAINTIFF	DEFENDANT
ADTRAN, Inc.	TQ Delta, LLC

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attachment #1		
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY	
3/13/2015	☐ Amendment ☑ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attachment #2		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Attachment #1

Patent or Trademark No.	Date of Patent or Trademark	Holder of Patent or Trademark
1. U.S. 7,453,881 B2	11/18/2008	TQ Delta, LLC
2. U.S. 7,809,028 B2	10/05/2010	TQ Delta, LLC
3. U.S. 7,978,706 B2	7/12/2011	TQ Delta, LLC
4. U.S. 8,422,511 B2	4/16/2013	TQ Delta, LLC
5. U.S. 6,445,730 B1	9/03/2002	TQ Delta, LLC
6. U.S. 7,292,627 B2	11/6/2007	TQ Delta, LLC
7. U.S. 7,451,379 B2	11/11/2008	TQ Delta, LLC
8. U.S. 7,471,721 B2	12/30/2008	TQ Delta, LLC
9. U.S. 7,570,686 B2	8/4/2009	TQ Delta, LLC
10. U.S. 7,831,890 B2	11/09/2010	TQ Delta, LLC
11. U.S. 7,835,430 B2	11/16/2010	TQ Delta, LLC
12. U.S. 7,836,381 B1	11/16/2010	TQ Delta, LLC
13. U.S. 7,844,882 B2	11/30/2010	TQ Delta, LLC
14. U.S. 7,889,784 B2	2/15/2011	TQ Delta, LLC
15. U.S. 7,925,958 B2	04/12/2011	TQ Delta, LLC
16. U.S. 7,978,753 B2	07/12/2011	TQ Delta, LLC
17. U.S. 7,979,778 B2	07/12/2011	TQ Delta, LLC
18. U.S. 8,073,041 B1	12/6/2011	TQ Delta, LLC
19. U.S. 8,090,008 B2	1/3/2012	TQ Delta, LLC
20. U.S. 8,218,610 B2	7/10/2012	TQ Delta, LLC
21. U.S. 8,238,412 B2	08/07/2012	TQ Delta, LLC
22. U.S. 8,276,048 B2	09/25/2012	TQ Delta, LLC
23. U.S. 8,355,427 B2	1/15/2013	TQ Delta, LLC

24. U.S. 8,432,956 B2	4/30/2013	TQ Delta, LLC
25. U.S. 8,437,382 B2	5/7/2013	TQ Delta, LLC
26. U.S. 8,462,835 B2	6/11/2013	TQ Delta, LLC
27. U.S. 8,495,473 B2	7/23/2013	TQ Delta, LLC
28. U.S. 8,516,337 B2	08/20/2013	TQ Delta, LLC

Attachment #2

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 7,796,705 B2	9/14/2010	TQ Delta, LLC
2	US 8,335,956 B2	12/18/2012	TQ Delta, LLC
3	US 8,407,546 B2	3/26/2013	TQ Delta, LLC
4	US 8,468,411 B2	6/18/2013	TQ Delta, LLC
5	US 8,645,784 B2	2/4/2014	TQ Delta, LLC
6	US 8,595,577 B2	11/26/2013	TQ Delta, LLC

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED 7/18/2014	U.S. DISTRICT COURT District of Delaware
PLAINTIFF TQ Delta, LLC		DEFENDANT ADTRAN, Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attached		
2 32 Pats		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 8,090,008 B2	1/3/2012	TQ Delta, LLC
2	US 8,073,041 B1	12/6/2011	TQ Delta, LLC
3	US 7,292,627 B2	11/6/2007	TQ Delta, LLC
4	US 7,471,721 B2	12/30/2008	TQ Delta, LLC
5	US 8,218,610 B2	7/10/2012	TQ Delta, LLC
6	US 8,355,427 B2	1/15/2013	TQ Delta, LLC
7	US 7,453,881 B2	11/18/2008	TQ Delta, LLC
8	US 7,809,028 B2	10/5/2010	TQ Delta, LLC
9	US 7,978,706 B2	7/12/2011	TQ Delta, LLC
10	US 8,422,511 B2	4/16/2013	TQ Delta, LLC
11	US 7,889,784 B2	2/15/2011	TQ Delta, LLC
12	US 7,835,430 B2	11/16/2010	TQ Delta, LLC
13	US 7,570,686 B2	8/4/2009	TQ Delta, LLC
14	US 8,238,412 B2	8/7/2012	TQ Delta, LLC
15	US 8,432,956 B2	4/30/2013	TQ Delta, LLC
16	US 7,451,379 B2	11/11/2008	TQ Delta, LLC
17	US 8,516,337 B2	8/20/2013	TQ Delta, LLC
18	US 7,979,778 B2	7/12/2011	TQ Delta, LLC
19	US 7,925,958 B2	4/12/2011	TQ Delta, LLC
20	US 8,462,835 B2	6/11/2013	TQ Delta, LLC
21	US 8,594,162 B2	11/26/2013	TQ Delta, LLC
22	US 7,978,753 B2	7/12/2011	TQ Delta, LLC
23	US 6,445,730 B1	9/3/2002	TQ Delta, LLC
24	US 8,611,404 B2	12/17/2013	TQ Delta, LLC
25	US 8,437,382 B2	5/7/2013	TQ Delta, LLC
26	US 7,836,381 B1	11/16/2010	TQ Delta, LLC
27	US 7,844,882 B2	11/30/2010	TQ Delta, LLC
28	US 8,276,048 B2	9/25/2012	TQ Delta, LLC
29	US 8,495,473 B2	7/23/2013	TQ Delta, LLC
30	US 8,607,126 B1	12/10/2013	TQ Delta, LLC
31	US 7,831,890 B2	11/9/2010	TQ Delta, LLC
32	US 8,625,660 B2	1/7/2014	TQ Delta, LLC

Birch, Melvin (Akima)

From: ded_nefreply@ded.uscourts.gov
Sent: Wednesday, November 20, 2013 4:56 PM
To: ded_ecf@ded.uscourts.gov
Subject: Activity in Case 1:13-cv-01835-RGA TQ Delta LLC v. Pace Americas Inc. Patent/Trademark Report to Commissioner

This is an automatic e-mail message generated by the CM/ECF system. Please DO NOT RESPOND to this e-mail because the mail box is unattended.
*****NOTE TO PUBLIC ACCESS USERS*** Judicial Conference of the United States policy permits attorneys of record and parties in a case (including pro se litigants) to receive one free electronic copy of all documents filed electronically, if receipt is required by law or directed by the filer. PACER access fees apply to all other users. To avoid later charges, download a copy of each document during this first viewing. However, if the referenced document is a transcript, the free copy and 30 page limit do not apply.**

U.S. District Court

District of Delaware

Notice of Electronic Filing

The following transaction was entered by Farnan, Brian on 11/20/2013 at 4:56 PM EST and filed on 11/20/2013
Case Name: TQ Delta LLC v. Pace Americas Inc.
Case Number: 1:13-cv-01835-RGA
Filer:
Document Number: 7

Docket Text:
Report to the Commissioner of Patents and Trademarks for Patent/Trademark Number(s) US 8,090,008 B2; US 8,073,041 B1; US 7,292,627 B2; US 7,471,721 B2; US 8,218,610 B2; US 8,355,427 B2; US 7,453,881 B2; US 7,978,706 B2; US 8,422,511 B2; US 7,889,784 B2; US 7,835,430 B2; US 7,570,686 B2; US 8,238,412 B2; US 8,432,956 B2; US 7,451,379 B2; US 8,516,337 B2; US 7,979,778 B2; US 7,925,958 B2; US 8,462,835 B2; US 7,836,381 B1; US 7,844,882 B2; US 8,276,048 B2; US 8,495,473 B2; US 7,831,890 B2; . (Farnan, Brian)

1:13-cv-01835-RGA Notice has been electronically mailed to:

Brian E. Farnan bfarnan@farnanlaw.com, tfarnan@farnanlaw.com

Michael J. Farnan mfarnan@farnanlaw.com, tfarnan@farnanlaw.com

1:13-cv-01835-RGA Filer will deliver document by other means to:

The following document(s) are associated with this transaction:

From: ded_nefreply@ded.uscourts.gov
Sent: Wednesday, November 20, 2013 5:07 PM
To: ded_ecf@ded.uscourts.gov
Subject: Activity in Case 1:13-cv-01836-RGA TQ Delta LLC v. Zhone Technologies Inc. Patent/Trademark Report to Commissioner

This is an automatic e-mail message generated by the CM/ECF system. Please DO NOT RESPOND to this e-mail because the mail box is unattended.
*****NOTE TO PUBLIC ACCESS USERS*** Judicial Conference of the United States policy permits attorneys of record and parties in a case (including pro se litigants) to receive one free electronic copy of all documents filed electronically, if receipt is required by law or directed by the filer. PACER access fees apply to all other users. To avoid later charges, download a copy of each document during this first viewing. However, if the referenced document is a transcript, the free copy and 30 page limit do not apply.**

U.S. District Court

District of Delaware

Notice of Electronic Filing

The following transaction was entered by Farnan, Brian on 11/20/2013 at 5:07 PM EST and filed on 11/20/2013
Case Name: TQ Delta LLC v. Zhone Technologies Inc.
Case Number: 1:13-cv-01836-RGA
Filer:
Document Number: 7

Docket Text:
Report to the Commissioner of Patents and Trademarks for Patent/Trademark Number(s) US 8,090,008 B2; US 8,073,041 B1; US 7,292,627 B2; US 7,471,721 B2; US 8,218,610 B2; US 8,355,427 B2; US 7,453,881 B2; US 7,809,028 B2; US 7,978,706 B2; US 8,422,511 B2; US 7,796,705 B2; US 7,889,784 B2; US 7,835,430 B2; US 7,570,686 B2; US 8,238,412 B2; US 8,432,956 B2; US 7,451,379 B2; US 8,516,337 B2; US 7,979,778 B2; US 7,925,958 B2; US 8,462,835 B2; US 7,978,753 B2; US 6,445,730 B1; US 8,437,382 B2; US 7,836,381 B1; US 7,844,882 B2; US 8,276,048 B2; US 8,495,473 B2; US 7,831,890 B2; US 8,335,956 B2; US 8,468,411 B2; US 8,407,546 B2 . (Farnan, Brian)

1:13-cv-01836-RGA Notice has been electronically mailed to:

Brian E. Farnan bfarnan@farnanlaw.com, tfarnan@farnanlaw.com

Michael J. Farnan mfarnan@farnanlaw.com, tfarnan@farnanlaw.com

1:13-cv-01836-RGA Filer will deliver document by other means to:

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED 12/9/2013	U.S. DISTRICT COURT District of Delaware
PLAINTIFF TQ Delta, LLC		DEFENDANT ZyXEL Communications Corporation and ZyXEL Communications, Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attached		
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 8,090,008 B2	1/3/2012	TQ Delta, LLC
2	US 8,073,041 B1	12/6/2011	TQ Delta, LLC
3	US 7,292,627 B2	11/6/2007	TQ Delta, LLC
4	US 7,471,721 B2	12/30/2008	TQ Delta, LLC
5	US 8,218,610 B2	7/10/2012	TQ Delta, LLC
6.	US 8,355,427 B2	1/15/2013	TQ Delta, LLC
7	US 7,453,881 B2	11/18/2008	TQ Delta, LLC
8	US 7,809,028 B2	10/5/2010	TQ Delta, LLC
9	US 7,978,706 B2	7/12/2011	TQ Delta, LLC
10	US 8,422,511 B2	4/16/2013	TQ Delta, LLC
11	US 7,796,705 B2	9/14/2010	TQ Delta, LLC
12	US 7,889,784 B2	2/15/2011	TQ Delta, LLC
13	US 7,835,430 B2	11/16/2010	TQ Delta, LLC
14	US 7,570,686 B2	8/4/2009	TQ Delta, LLC
15	US 8,238,412 B2	8/7/2012	TQ Delta, LLC
16	US 8,432,956 B2	4/30/2013	TQ Delta, LLC
17	US 7,451,379 B2	11/11/2008	TQ Delta, LLC
18	US 8,516,337 B2	8/20/2013	TQ Delta, LLC
19	US 7,979,778 B2	7/12/2011	TQ Delta, LLC
20	US 7,925,958 B2	4/12/2011	TQ Delta, LLC
21	US 8,462,835 B2	6/11/2013	TQ Delta, LLC
22	US 7,978,753 B2	7/12/2011	TQ Delta, LLC
23	US 6,445,730 B1	9/3/2002	TQ Delta, LLC
24	US 8,437,382 B2	5/7/2013	TQ Delta, LLC
25	US 7,836,381 B1	11/16/2010	TQ Delta, LLC
26	US 7,844,882 B2	11/30/2010	TQ Delta, LLC
27	US 8,276,048 B2	9/25/2012	TQ Delta, LLC
28	US 8,495,473 B2	7/23/2013	TQ Delta, LLC
29	US 7,831,890 B2	11/9/2010	TQ Delta, LLC
30	US 8,335,956 B2	12/18/2012	TQ Delta, LLC
31	US 8,468,411 B2	6/18/2013	TQ Delta, LLC
32	US 8,407,546 B2	3/26/2013	TQ Delta, LLC

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of Texas, Dallas Division on the following

☑ Trademarks or ☐ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 3:12-cv-1462-L	DATE FILED 5/10/2012	U.S. DISTRICT COURT Northern District of Texas, Dallas Division
PLAINTIFF Boulle Ltd		DEFENDANT De Boulle Diamond & Jewelry Inc

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 4,086,050	1/17/2012	Boulle Ltd
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED 12/9/2013	INCLUDED BY ☑ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 3,078,625	4/11/2006	De Boulle Diamond & Jewelry Inc
2 3,078,627	4/11/2006	De Boulle Diamond & Jewelry Inc
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
Karen Mitchell	s/A. Lowe-Monserrate	12/10/2013

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED 11/4/2013	U.S. DISTRICT COURT District of Delaware
PLAINTIFF TQ Delta, LLC		DEFENDANT Pace Americas, Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attached		
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 US 8,090,008 B2	1/3/2012	TQ Delta, LLC
2 US 8,073,041 B1	12/6/2011	TQ Delta, LLC
3 US 7,292,627 B2	11/6/2007	TQ Delta, LLC
4 US 7,471,721 B2	12/30/2008	TQ Delta, LLC
5 US 8,218,610 B2	7/10/2012	TQ Delta, LLC
6. US 8,355,427 B2	1/15/2013	TQ Delta, LLC
7 US 7,453,881 B2	11/18/2008	TQ Delta, LLC
8 US 7,978,706 B2	7/12/2011	TQ Delta, LLC
9 US 8,422,511 B2	4/16/2013	TQ Delta, LLC
10 US 7,889,784 B2	2/15/2011	TQ Delta, LLC
11 US 7,835,430 B2	11/16/2010	TQ Delta, LLC
12 US 7,570,686 B2	8/4/2009	TQ Delta, LLC
13 US 8,238,412 B2	8/7/2012	TQ Delta, LLC
14 US 8,432,956 B2	4/30/2013	TQ Delta, LLC
15 US 7,451,379 B2	11/11/2008	TQ Delta, LLC
16 US 8,516,337 B2	8/20/2013	TQ Delta, LLC
17 US 7,979,778 B2	7/12/2011	TQ Delta, LLC
18 US 7,925,958 B2	4/12/2011	TQ Delta, LLC
19 US 8,462,835 B2	6/11/2013	TQ Delta, LLC

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED 11/4/2013	U.S. DISTRICT COURT District of Delaware
PLAINTIFF TQ Delta, LLC		DEFENDANT Zhone Technologies, Inc.
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 See Attached		
2		
3		
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 US 8,090,008 B2	1/3/2012	TQ Delta, LLC
2 US 8,073,041 B1	12/6/2011	TQ Delta, LLC
3 US 7,292,627 B2	11/6/2007	TQ Delta, LLC
4 US 7,471,721 B2	12/30/2008	TQ Delta, LLC
5 US 8,218,610 B2	7/10/2012	TQ Delta, LLC
6. US 8,355,427 B2	1/15/2013	TQ Delta, LLC
7 US 7,453,881 B2	11/18/2008	TQ Delta, LLC
8 US 7,809,028 B2	10/5/2010	TQ Delta, LLC
9 US 7,978,706 B2	7/12/2011	TQ Delta, LLC
10 US 8,422,511 B2	4/16/2013	TQ Delta, LLC
11 US 7,796,705 B2	9/14/2010	TQ Delta, LLC
12 US 7,889,784 B2	2/15/2011	TQ Delta, LLC
13 US 7,835,430 B2	11/16/2010	TQ Delta, LLC
14 US 7,570,686 B2	8/4/2009	TQ Delta, LLC
15 US 8,238,412 B2	8/7/2012	TQ Delta, LLC
16 US 8,432,956 B2	4/30/2013	TQ Delta, LLC
17 US 7,451,379 B2	11/11/2008	TQ Delta, LLC
18 US 8,516,337 B2	8/20/2013	TQ Delta, LLC
19 US 7,979,778 B2	7/12/2011	TQ Delta, LLC
20 US 7,925,958 B2	4/12/2011	TQ Delta, LLC
21 US 8,462,835 B2	6/11/2013	TQ Delta, LLC
22 US 7,978,753 B2	7/12/2011	TQ Delta, LLC
23 US 6,445,730 B1	9/3/2002	TQ Delta, LLC
24 US 8,437,382 B2	5/7/2013	TQ Delta, LLC

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 62574

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 62574

OR

☐ Firm or Individual Name				
Address				
City		State		Zip
Country				
Telephone		Email		

Assignee Name and Address: TQ DELTA, LLC
805 Las Cimas Parkway, Suite 240
Austin, Texas 78746

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	Mark K Roche	Date	10/4/12
Name	Mark K. Roche	Telephone	512-609-1810
Title	Managing Director		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	14170591
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	6936-47-CON-DIV
Receipt Date:	07-NOV-2012
Filing Date:	24-SEP-2007
Time Stamp:	14:26:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		EntityStatus_373c_w_POA.pdf	419012 64f1b890451f4ec2682e26a525b8d1c525991d75	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Miscellaneous Incoming Letter	1	1
	Assignee showing of ownership per 37 CFR 3.73.	2	3
	Power of Attorney	4	4

Warnings:	
Information:	
Total Files Size (in bytes):	419012

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Patent No.: 8,073,041
Application No.: 11/860,080	) Issued: December 6, 2011
Filed: September 24, 2007	) Examiner: WILLIAMS, Lawrence
Atty. File No.: 6936-47-CON-DIV	) Confirmation No.: 5967

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

ASSERTION OF ENTITLEMENT TO SMALL ENTITY STATUS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

In accordance with MPEP §§ 509.02 and 509.03 and 37 CFR 1.27, this document is being filed to inform the U.S. Patent Office of the change of status for the above-identified patent from large entity status to small entity status. All fees paid to date have been paid as large entity status. No fees have yet been paid as small entity status. Due to the sale of the referenced patent, the Applicant is now entitled to small entity status.

We respectfully request that small entity status be granted for the above-referenced patent.

Please contact the undersigned if there are any questions regarding this notification.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: 7 Mar '12

By: ______________________

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: TQ DELTA, LLC

Application No./Patent No.: 8,073,041 Filed/Issue Date: December 6, 2011

Titled: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

TQ DELTA, LLC, a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is ____________%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel ____________, Frame ____________, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Marcos C. Tzannes To: AWARE, INC.

The document was recorded in the United States Patent and Trademark Office at Reel 010877, Frame 0307, or for which a copy thereof is attached.

2. From: AWARE, INC. To: TQ DELTA, LLC

The document was recorded in the United States Patent and Trademark Office at Reel 029154, Frame 0937, or for which a copy thereof is attached.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

4. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

5. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

6. From: ______________________ To: ______________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature	7 Nov '12 Date
Jason H. Vick Printed or Typed Name	45,285 Title or Registration Number

[Page 2 of 2]

DEPARTMENT OF DEFENSE
ACCESS ACKNOWLEDGEMENT / SECRECY ORDER RECOMMENDATION
FOR PATENT APPLICATION

Application Serial No: DP11860080 Date Referred: 10/09/2007

I hereby acknowledge that the Department of Defense reviewers have inspected this application in administration of 35 USC 181 on behalf of the Agencies/Commands specified below. DoD reviewers will not divulge any information from this application for any purpose other than administration of 35 USC 181.

Defense Agency	Recommendation	Reviewer Name	Date Reviewed
Army	Forwarded	Alan Klein	14 Feb 2008
CERDEC	Secrecy Not Recommended	Jeremy Aller	04 Apr 2012

Defense Agency	Reviewer Name	Date Viewed PDF
Army	Angela Brassell	03 May 2010 12:33
ARL (Army)	Antoinnette Morris	12 Sep 2011 12:46

Instructions to Reviewers:

1. All DoD personnel reviewing this application will be listed on this form regardless of whether they are making a secrecy order recommendation.
2. This form will be forwarded to USPTO once all assigned DoD entities have provided their secrecy order recommendation.

DoD Completion of Review: Final
Forwarded to USPTO: 04/05/2012

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	12/06/2011	8073041	5550-47-CON-DIV	5967

62574 7590 11/16/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 1091 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Marcos C. Tzannes, Orinda, CA;

IR103 (Rev. 10/09)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

Bib Data Sheet

CONFIRMATION NO. 5967

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/860,080	09/24/2007 RULE	375	2611	5550-47-CON-DIV

APPLICANTS

Marcos C. Tzannes, Orinda, CA;

** **CONTINUING DATA** *************************

This application is a DIV of 11/211,535 08/26/2005 PAT 7,292,627
which is a CON of 09/710,310 11/09/2000 PAT 6,961,369
which claims benefit of 60/164,134 11/09/1999

** **FOREIGN APPLICATIONS** ********************

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ yes ☐ no 35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance Verified and Acknowledged _____ Examiner's Signature _____ Initials	CA	2	1	1

ADDRESS

62574

TITLE

SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

FILING FEE RECEIVED 1612	FEES: Authority has been given in Paper No. ________ to charge/credit DEPOSIT ACCOUNT No. ________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________ ☐ Credit

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

Bib Data Sheet

CONFIRMATION NO. 5967

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/860,080	09/24/2007 **RULE**	375	2611	5550-47-CON-DIV

APPLICANTS

Marcos C. Tzannes, Orinda, CA;

** **CONTINUING DATA** *************************

This application is a DIV of 11/211,535 08/26/2005 PAT 7,292,627
which is a CON of 09/710,310 11/09/2000 PAT 6,961,369
which claims benefit of 60/164,134 11/09/1999

** **FOREIGN APPLICATIONS** ********************

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ yes ☐ no 35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance Verified and Acknowledged ______ Examiner's Signature Initials	CA	2	1	1

ADDRESS

62574

TITLE

SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

FILING FEE RECEIVED 1612	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

62574 7590 11/03/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

EXAMINER	
WILLIAMS, LAWRENCE B	
ART UNIT	**PAPER NUMBER**
2611	

NOTIFICATION DATE	DELIVERY MODE
11/03/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jvick@sheridanross.com

PTOL-90A (Rev. 04/07)

Response to Rule 312 Communication	Application No. 11/860,080	Applicant(s) TZANNES, MARCOS C.
	Examiner LAWRENCE WILLIAMS	Art Unit 2611

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

1. ☒ The amendment filed on *19 October 2011* under 37 CFR 1.312 has been considered, and has been:
   - a) ☒ entered.
   - b) ☐ entered as directed to matters of form not affecting the scope of the invention.
   - c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
     Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.
   - d) ☐ disapproved. See explanation below.
   - e) ☐ entered in part. See explanation below.

/Tesfaldet Bocure/
Primary Examiner, Art Unit 2611

OK TO ENTER: /L.W./

10/28/2011

AMENDMENTS TO THE SPECIFICATION

In the Title:

Please change the title to read as follows:

SYSTEM AND METHOD FOR DESCRAMBLING~~SCRAMBLING~~ THE PHASE OF ~~THE~~ CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62574 7590 10/17/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

TITLE OF INVENTION: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	01/17/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
WILLIAMS, LAWRENCE B	2611	375-260000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

   1 Jason H. Vick
   2 Sheridan Ross P.C.
   3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: AWARE, INC.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Bedford, MA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☑ Issue Fee
- ☑ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 19-1970 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____ Date 19 Oct '11

Typed or printed name Jason H. Vick Registration No. 45,285

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

Sir:

Applicant submits this Comments on Statement of Reasons for Allowance to address further the Notice of Allowability ("Notice") having a mailing date of October 17, 2011.

In the Notice, the Examiner's stated reasons for allowance were that:

> The following is a statement of reasons for the indication of allowable subject matter:
>
> The instant application discloses a method and system for demodulating a bit stream. A search of prior art records has filed to teach or suggest, alone or in combination:
>
> In a first multicarrier transceiver, having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, a method comprising:
>
> demodulating the bit stream, wherein:
>
> "each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal,
>
> a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and a value associated with the carrier signal was determined using a pseudo-random number generator" (Fig(s). 1,2; pg. 7, line 11- pg. 8, line 10) as disclosed in claim 47.

A multicarrier system including a first transceiver having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, the transceiver capable of demodulating the bit stream, wherein:

"each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal,

a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and a value associated with the carrier signal was determined using a pseudo-random number generator" (Fig(s). 1,2; pg. 7, line 11- pg. 8, line 10) as disclosed in claim 60.

Based on the Notice, the patentability of all other independent and dependent claims is assumed to be based upon the elements as set forth in such claims and that such claims meet all criteria for patentability under §101, §102, §103 and §112.

As is clear from MPEP 1302.14,

"The statement [of reasons for allowance] is not intended to necessarily state all the reasons for allowance or all the details why claims are allowed and should not be written to specifically or impliedly state that all the reasons for allowance are set forth."

While the stated Reasons for Allowance may be a stated reason for allowing some independent claims, Applicant submits that some independent claims have a different reason for allowance and that some independent claims have other reasons for allowance.

Specifically, the prior art fails to teach the specific combination of features as recited in the independent claims 47 and 60.

Although the Applicant believes that no fees are due for filing this Comments on Statement of Reasons for Allowance, please charge any fees deemed necessary to Deposit Account No. 19-1970.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: 11 Oct '14

By: ____________________

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM (as amended)

AMENDMENT AFTER ALLOWANCE UNDER 37 C.F.R. 1.312

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants submit this Amendment After Allowance pursuant to 37 C.F.R. 1.312 in response to the Notice of Allowance having a mailing date of October 17, 2011. While Applicants believe that no fees are due with the filing of this response, the undersigned hereby authorizes the charge of any fees deemed necessary to Deposit Account No. 19-1970.

An amendment may be entered after the mailing of a Notice of Allowance but prior to payment of the issue fee upon recommendation of the primary Examiner. Therefore, it is respectfully requested that the above-referenced application be amended as follows:

Amendments to the Specification begin on page 2 of this paper.

Remarks begin on page 3 of this paper.

AMENDMENTS TO THE SPECIFICATION

In the Title:

Please change the title to read as follows:

SYSTEM AND METHOD FOR DESCRAMBLING~~SCRAMBLING~~ THE PHASE OF ~~THE~~ CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

REMARKS

The amendment to the specification displayed herein amends the title of the application. No new matter is believed to be introduced by this amendment.

The Commissioner is hereby authorized to charge to deposit account number 19-1970 any fees under 37 CFR § 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: 19 05 '11

By: ______________________

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

RESPONSE TO INTERVIEW SUMMARY

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant would like to thank Examiner Williams for the courtesies extended to Applicant's undersigned representative during the September 22, 2011 interview. During the interview claims 47 and 60 were discussed. The undersigned also agreed to a minor change to the abstract to reflect the amended claims and drawings. The changes are accurately reflected in the Examiner's Amendment of 9/22/11.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: 19 Oct '11

By:

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700

Electronic Patent Application Fee Transmittal

Application Number:	11860080
Filing Date:	24-Sep-2007
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Filer:	Jason Vick/Joanne Vos
Attorney Docket Number:	5550-47-CON-DIV

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1740	1740
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2040**

Electronic Acknowledgement Receipt

EFS ID:	11222024
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	19-OCT-2011
Filing Date:	24-SEP-2007
Time Stamp:	16:46:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$2040
RAM confirmation Number	3320
Deposit Account	191970
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	Issue_fee_Transmittal.pdf	110851 fd78f3349458342953fe65e51e12a319bda775e6	no	1
Warnings:					
Information:					
2	Post Allowance Communication - Incoming	Comments_on_Reason_for_Allowance.pdf	114720 6ad8fa681f297b7908578de619407db5827888fd	no	3
Warnings:					
Information:					
3		Amendment_312.pdf	68537 881e45a3ef2a74d605ea91f67110d22cea6a4b03	yes	3

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment after Notice of Allowance (Rule 312)	1	1
Specification	2	2
Applicant Arguments/Remarks Made in an Amendment	3	3

Warnings:					
Information:					
4	Applicant summary of interview with examiner	Response_to_Interview_Summary.pdf	36981 a03e6591f75d1bf7dc6c9203d8e44bd5475b1903	no	1
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	32159 a2026b909a0956b3ad42e307a8c3657ebb3aa601	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	363248	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

62574 7590 10/17/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

EXAMINER	
WILLIAMS, LAWRENCE B	
ART UNIT	PAPER NUMBER
2611	

DATE MAILED: 10/17/2011

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

TITLE OF INVENTION: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	01/17/2012

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62574 7590 10/17/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

TITLE OF INVENTION: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	01/17/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
WILLIAMS, LAWRENCE B	2611	375-260000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ______________________
   2 ______________________
   3 ______________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ______________________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________________ Date ______________________________

Typed or printed name ______________________________ Registration No. ______________________________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

62574 7590 10/17/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

EXAMINER	
WILLIAMS, LAWRENCE B	
ART UNIT	**PAPER NUMBER**
2611	

DATE MAILED: 10/17/2011

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 1057 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 1057 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Examiner-Initiated Interview Summary	Application No. 11/860,080	Applicant(s) TZANNES, MARCOS C.	
	Examiner LAWRENCE WILLIAMS	Art Unit 2611	

All participants (applicant, applicant's representative, PTO personnel):

(1) *LAWRENCE WILLIAMS*. (3)_____.

(2) *JASON VICK*. (4)_____.

Date of Interview: *22 September 2011*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☐ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☒112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *47,60* .

Identification of prior art discussed: _____.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Agreed upon changes to independent claims 47 and 60 to overcome possible 112 rejections. Changes as agreed upon are reflected in allowed independent claims 47 and 60. Agreed upon minor changes to abstract to reflect invention as disclosed by amended claims and minor changes to drawings, all of which are reflected in corrections/examiner's amendment of 9/22/2011.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Lawrence B Williams/
Examiner, Art Unit 2611

Notice of Allowability	Application No. 11/860,080	Applicant(s) TZANNES, MARCOS C.	
	Examiner LAWRENCE WILLIAMS	**Art Unit** 2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☐ This communication is responsive to *amendments filed on 9/22/2011*.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are *47-72, renumbered as 1-26, respectively*.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 12/6/07, 4/30/08, 10/17/08, 11/25/08, 01//18/10, 6/21/10, 5/31/11
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date *9/22/2011* .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *OA. Appendix*.

/Tesfaldet Bocure/
Primary Examiner, Art Unit 2611

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Jason Vick on 22 September 2011.

The application has been amended as follows:

<u>In the abstract:</u>

a.) In line 1 of the abstract, replace the word "scrambles" with "demodulates".

REMARKS

2. The drawings were received on 22 September 2011. These drawings are accepted by the examiner. The drawing objections are withdrawn.

3. The examiner thanks the applicant for the amendment to the specification. The specification objections are withdrawn.

REASONS FOR ALLOWANCE

1. The following is a statement of reasons for the indication of allowable subject matter: The instant application discloses a method and system for demodulating a bit stream. A search of prior art records has filed to teach or suggest, alone or in combination:

In a first multicarrier transceiver, having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, a method comprising:

demodulating the bit stream, wherein:

"each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal,

a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and a value associated with the carrier signal was determined using a pseudo-random number generator" (Fig(s). 1, 2; pg. 7, line 11- pg. 8, line 10) as disclosed in claim 47.

A multicarrier system including a first transceiver having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, the transceiver capable of demodulating the bit stream, wherein:

"each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal,

a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and

a value associated with the carrier signal was determined using a pseudo-random number generator" (Fig(s). 1, 2; pg. 7, line 11- pg. 8, line 10) as disclosed in claim 60.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

CONCLUSION

2. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

a.) Tzannes discloses System And Method For Scrambling The Phase Of The Carriers In A Multicarrier Communications System in US Patent 6,961,369 B1.

b.) Sakoda et al. discloses Receiving Device And Signal Receiving Method in US Patent 6,590,860 B1.

c.) Goldenberg et al. discloses Dual Speed Full Duplex Data Transmission in US Patent 4,069,392.

d.) Switzer et al. discloses Method And Apparatus For Reducing Distortion In Multicarrier Communication Systems in US Patent 3,898,566.

e.) Tzannes discloses System And Method For Scrambling The Phase of The Carriers In A Multicarrier Communications System in US 2010/0290507 A1.

f.) Tzannes discloses System And Method For Scrambling The Phase Of The Carriers In A Multicarrier Communications System in US Patent 7,471,721 B2.

g.) Tzannes discloses System And Method For Scrambling The Phase Of The Carriers In A Multicarrier Communications System in US Patent 7,292,627 B2.

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lawrence B Williams whose telephone number is 571-272-3037. The examiner can normally be reached on Monday-Friday (8:00-6:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Khanh Tran can be reached on 571-272-3007. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

lbw
October 12, 2011

Notice of References Cited	Application/Control No. 11/860,080	Applicant(s)/Patent Under Reexamination TZANNES, MARCOS C.	
	Examiner LAWRENCE WILLIAMS	Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,961,369	11-2005	Tzannes, Marcos C.	375/220
*	B	US-6,590,860	07-2003	Sakoda et al.	370/203
*	C	US-4,069,392	01-1978	Goldenberg et al.	370/295
*	D	US-3,898,566	08-1975	Switzer et al.	455/3.03
*	E	US-2010/0190507	07-2010	Karabinis et al.	455/452.1
*	F	US-7,471,721	12-2008	Tzannes, Marcos C.	375/222
*	G	US-7,292,627	11-2007	Tzannes, Marcos C.	375/222
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

IEEE Xplore®
DIGITAL LIBRARY

IEEE

SEARCH RESULTS

You searched for: multicarrier AND "phase shift" AND scrambling , "phase characteristics" &
You refined by:
Publication Year: 1938 - 2000

Results per Page 25

Showing 1 - 3 of 3 results

Unapproved Draft Cable-TV access method and physical layer specification (PAR Withdrawn)

IEEE Std P802.14/D3, R2
Publication Year: 1998
IEEE STANDARDS

Reduced complexity peak-to-average power ratio reduction for OFDM by selective time domain filtering

Zheng Du; Beaulieu, N.C.; Jinkang Zhu;
Global Telecommunications Conference, 2005. GLOBECOM '05. IEEE
Volume: 5
Digital Object Identifier: 10.1109/GLOCOM.2005.1578270
Publication Year: 2005 , Page(s): 5 pp. - 2806
IEEE CONFERENCES

Voice-band data communication modems-a historical review: 1919-1988

Pahlavan, K.; Holsinger, J.L.
Communications Magazine, IEEE
Volume: 26 , Issue: 1
Digital Object Identifier: 10.1109/35.418
Publication Year: 1988 , Page(s): 16 - 27
Cited by: 2
IEEE JOURNALS

IET Inspec

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 5967

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/860,080	09/24/2007 RULE	375	2611	5550-47-CON-DIV

APPLICANTS
Marcos C. Tzannes, Orinda, CA;

** CONTINUING DATA *************************
This application is a DIV of 11/211,535 08/26/2005 PAT 7,292,627
which is a CON of 09/710,310 11/09/2000 PAT 6,961,369
which claims benefit of 60/164,134 11/09/1999

** FOREIGN APPLICATIONS **************************

** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **

Foreign Priority claimed ☐ Yes ☑ No; 35 USC 119(a-d) conditions met ☐ Yes ☑ No; Verified and Acknowledged /LAWRENCE B WILLIAMS/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	2	26 LBW	2 LBW

ADDRESS
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202
UNITED STATES

TITLE
SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
1312	No.______ to charge/credit DEPOSIT ACCOUNT No.______ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ______ ☐ Credit

BIB (Rev. 05/07).

OK TO ENTER: /L.W./

09/22/2011

REPLACEMENT SHEET

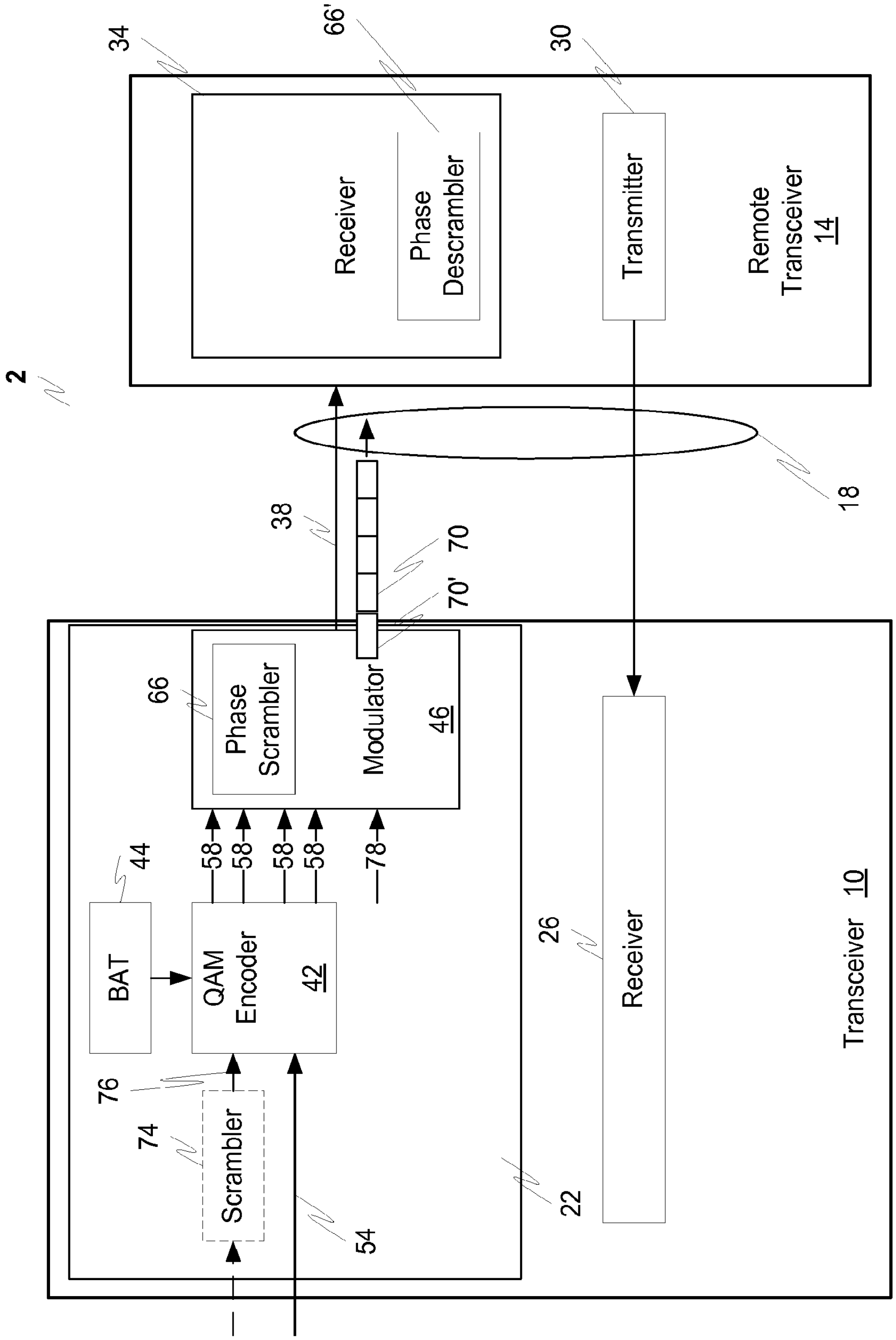


FIG. 1

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	11/860,080
	Filing Date	September 24, 2007
	First Named Inventor	Marcos C. Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
Sheet 1 of 1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/L.W./	1	4069392	01/17/78	Goldenberg et al.	
/L.W./	2	6967997	11/22/05	Humphrey	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
/L.W./	3	Official Action for U.S. Patent Application No. 12/255,713, mailed October 15, 2009 (Attorney's File No. 5550-47-CON-3)

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	11/860,080
	Filing Date	09-24-2007
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
Sheet 1 of 1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/L.W./	1	5,682,376	10/28/97	Hayashino et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/L.W./	2	JP H10(1998)-084329	03/31/98	NIPPON HOSO KYOKAI		(Translated Abstract and partial translation)
/L.W./	3	JP H08(1996)-321820	12/03/96	MATSUSHITA ELECTRIC IND CO LTD		(Translated Abstract)

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
/L.W./	4	Notification of Reasons for Refusal (including translation) for Japanese Patent Application No. 2001-537217, date of dispatch, March 3, 2008 (Attorney's Ref. No. 5550-47-PJP)
/L.W./	5	Official Action for U.S. Patent Application No. 11/863,581, mailed February 6, 2008 (Attorney's File No. 5550-47-CON-2)

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	September 24, 2007
				First Named Inventor	Marcos C. Tzannes
				Art Unit	2611
				Examiner Name	Not Yet Assigned
Sheet	1	of	2	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/L.W./	1	5381449	01/10/95	Jasper et al.	
/L.W./	2	5694395	12/02/97	Myer et al.	
/L.W./	3	5870016	02/09/99	Shrestha	
/L.W./	4	5991262	11/23/99	Laird et al.	
/L.W./	5	6128350	10/03/00	Shastri et al.	
/L.W./	6	6366555	04/02/02	Gatherer et al.	
/L.W./	7	6757299	06/29/04	Verma	
/L.W./	8	7610028	10/27/09	Cimini, Jr. et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
/L.W./	9	HENKEL, "Analog Codes for Peak-to-Average Ratio Reduction," in Proceedings 3rd ITG Conf. Source and Channel Coding, Munich, Germany, Jan. 2000, 5 pages
/L.W./	10	NARAHASHI et al., "New phasing scheme of N multiple carriers for reducing peak-to-average power ratio," Electronics Letters, Aug. 1994, Vol. 30(17), pp. 1382-83
/L.W./	11	TELLADO et al., "Revisiting DMT's Peak-to-Average Ratio," Antwerp, Apr. 20-24, 1998, pp. 1-14
/L.W./	12	TELLAMBURA, "A coding technique for reducing peak-to-average power ratio in OFDM," In the Proceedings of Global Telecommunications Conference, IEEE, Nov. 1998, pp. 2783-2787
/L.W./	13	TELLAMBURA, "Phase optimisation criterion for reducing peak-to-average power ratio in OFDM," Electronics Letters, Jan. 1998, Vol. 34(2), pp. 169-170

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	September 24, 2007
				First Named Inventor	Marcos C. Tzannes
				Art Unit	2611
				Examiner Name	Not Yet Assigned
Sheet	2	of	2	Attorney Docket Number	5550-47-CON-DIV

/L.W./	14	VAN EETVELT et al., "Peak to average power reduction for OFDM schemes by selective scrambling," Electronics Letters, Oct. 1996, Vol. 32(21), pp. 1963-64
/L.W./	15	Written Opinion for International (PCT) Patent Application No. PCT/US00/30958, mailed Dec. 18, 2001 (Attorney Ref. No. 5550-47-PCT)
/L.W./	16	Official Action for U.S. Patent Application No. 09/710,310, mailed May 4, 2004 (Attorney Ref. No. 5550-47)
/L.W./	17	Notice of Allowance for U.S. Patent Application No. 09/710,310, mailed Jul 5, 2005 (Attorney Ref. No. 5550-47)
/L.W/	18	Notice of Allowance for U.S. Patent Application No. 11/211,535, mailed Sep. 6, 2007 (Attorney Ref. No. 5550-47-CON)

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	11/860,080
	Filing Date	September 24, 2007
	First Named Inventor	Marcos C. Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
Sheet 1 of 1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/L.W./	1	6519292	02/11/03	Sakoda et al.	
/L.W./	2	6519929	02/18/03	Ahrendt	
/L.W./	3	12/783725		Tzannes (05-20-2010)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
/L.W./	4	Notice of Allowance for U.S. Patent Application No. 12/255,713, mailed May 18, 2010 (Attorney's File No. 5550-47-CON-3)

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11860080
	Filing Date	2007-09-24
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
	Attorney Docket Number	5550-47-CON-DIV

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11860080
	Filing Date	2007-09-24
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
	Attorney Docket Number	5550-47-CON-DIV

/L.W./	1	Notice of Allowance for U.S. Patent Application No. 11/863,581, mailed October 8, 2008 (Attorney's File No. 5550-47-CON-2)	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	1	of	1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
~~/L.W./~~	~~1~~	~~12/253713~~		~~Tzannes (10-22-2008)~~	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
/L.W./	2	Decision of Refusal (including translation) for Japanese Patent Application No. 2001-537217, date of dispatch, November 4, 2008 (Attorney's Ref. No. 5550-47-PJP) page(s) 1-6

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.W./

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	1	of	2	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/L.W./	1	3,955,141	05/01/76	Lyon et al.	
/L.W./	2	4,985,900	01/01/91	Rhind et al.	
/L.W./	3	5,748,677	05/01/98	Kumar	
/L.W./	4	6,256,355	07/03/01	Sakoda et al.	
/L.W./	5	6,507,585	01/01/03	Dobson	
/L.W./	6	6,590,860	07/08/03	Sakoda et al.	
/L.W./	7	6,704,317	03/01/04	Dobson	
/L.W./	8	6,961,369	11/01/05	Tzannes	
/L.W./	9	2005/0141410	06/30/05	Zhang et al.	
/L.W./	10	2006/0002454	01/05/06	Tzannes	
/L.W./	11	2006/0092902	05/04/06	Schmidt	
/L.W./	12	2006/0140288	06/29/06	Holden	
/L.W./	13	11/863581		Tzannes (09-28-2007)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/L.W./	14	EP 0584534	03/02/94	ALCATEL ITALIA		
/L.W./	15	EP 0719004	06/26/96	MATSUSHITA ELECTRIC IND CO LTD		
/L.W./	16	GB 2330491	04/21/99	BRITISH BROADCASTING CORP		
/L.W./	17	WO 98/32065	07/23/98	FORTRESS TECHNOLOGIES INC		
/L.W./	18	WO 99/22463	05/06/99	MOTOROLA INC		

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	2	of	2	Attorney Docket Number	5550-47-CON-DIV

/L.W./	19	WO 99/29078	06/10/99	TELIA AB		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
/L.W./	20	Bauml R. W. et al.: "Reducing The Peak-To-Average Power Ratio Of Multicarrier Modulation By Selected Mapping" Electronics Letters, GB, IEE Stevenage, vol. 32, No. 22, Oct. 24, 1996, pp. 2056-2057, XP000643915 ISSN: 0013-5194
/L.W./	21	Copy of Annex to Form PCT/ISA/206 for PCT/US00/30958, Mar. 23, 2001 (5550-47-PCT)
/L.W./	22	International Search Report for International (PCT) Patent Application No. PCT/US00/30958, completed June 12, 2001 (5550-47-PCT)
/L.W./	23	International Preliminary Examination Report for International (PCT) Patent Application No. PCT/US00/30958, completed March 4, 2002 (5550-47-PCT)
/L.W./	24	Notice of Preliminary Rejection for Korean Patent Application No. 7005830/2002 dated November 22, 2006 (Attorney's Ref. No. 5550-47-PKR)

Examiner Signature	/Lawrence Williams/	Date Considered	08/08/2011

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Search Notes	Application/Control No. 11860080	Applicant(s)/Patent Under Reexamination TZANNES, MARCOS C.
	Examiner LAWRENCE WILLIAMS	Art Unit 2611

SEARCHED

Class	Subclass	Date	Examiner
375	219, 220, 222,259-261, 267, 298, 299, 316, 320, 324, 340	9/21/2011	LW
370	281 295, 343, 480, 481		
455	73, 91, 108		

SEARCH NOTES

Search Notes	Date	Examiner
EAST, NPL, INVENTOR	9/21/2011	LW

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
375	222, 261, 298, 316	9/21/2011	LW

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11860080	TZANNES, MARCOS C.
	Examiner	Art Unit
	LAWRENCE WILLIAMS	2611

ORIGINAL

CLASS	SUBCLASS
375	222

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
375	261	298	316		

INTERNATIONAL CLASSIFICATION

CLAIMED					NON-CLAIMED
H	0	4	B	1 / 38 (2006.01.01)	
H	0	4	L	5 / 12 (2006.01.01)	
H	0	4	L	27 / 36 (2006.01.01)	
H	0	4	L	27 / 06 (2006.01.01)	

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
-	1	-	17	-	33	3	49	19	65						
-	2	-	18	-	34	4	50	20	66						
-	3	-	19	-	35	5	51	21	67						
-	4	-	20	-	36	6	52	22	68						
-	5	-	21	-	37	7	53	23	69						
-	6	-	22	-	38	8	54	24	70						
-	7	-	23	-	39	9	55	25	71						
-	8	-	24	-	40	10	56	26	72						
-	9	-	25	-	41	11	57								
-	10	-	26	-	42	12	58								
-	11	-	27	-	43	13	59								
-	12	-	28	-	44	14	60								
-	13	-	29	-	45	15	61								
-	14	-	30	-	46	16	62								
-	15	-	31	1	47	17	63								
-	16	-	32	2	48	18	64								

/LAWRENCE WILLIAMS/ Examiner.Art Unit 2611 (Assistant Examiner)	9/22/2011 (Date)	Total Claims Allowed: 26
/TESFALDET BOCURE/ Primary Examiner.Art Unit 2611 (Primary Examiner)	09/23/2011 (Date)	O.G. Print Claim(s): 47 / O.G. Print Figure: 1

Index of Claims	**Application/Control No.** 11860080	**Applicant(s)/Patent Under Reexamination** TZANNES, MARCOS C.
	Examiner LAWRENCE WILLIAMS	**Art Unit** 2611

✓	**Rejected**	-	**Cancelled**	N	**Non-Elected**	A	**Appeal**
=	**Allowed**	÷	**Restricted**	I	**Interference**	O	**Objected**

☐ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

CLAIM		DATE								
Final	Original	09/20/2011								
	1	-								
	2	-								
	3	-								
	4	-								
	5	-								
	6	-								
	7	-								
	8	-								
	9	-								
	10	-								
	11	-								
	12	-								
	13	-								
	14	-								
	15	-								
	16	-								
	17	-								
	18	-								
	19	-								
	20	-								
	21	-								
	22	-								
	23	-								
	24	-								
	25	-								
	26	-								
	27	-								
	28	-								
	29	-								
	30	-								
	31	-								
	32	-								
	33	-								
	34	-								
	35	-								
	36	-								

Index of Claims	Application/Control No. 11860080	Applicant(s)/Patent Under Reexamination TZANNES, MARCOS C.
	Examiner LAWRENCE WILLIAMS	**Art Unit** 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE							
Final	Original	09/20/2011							
	37	-							
	38	-							
	39	-							
	40	-							
	41	-							
	42	-							
	43	-							
	44	-							
	45	-							
	46	-							
1	47	=							
2	48	=							
3	49	=							
4	50	=							
5	51	=							
6	52	=							
7	53	=							
8	54	=							
9	55	=							
10	56	=							
11	57	=							
12	58	=							
13	59	=							
14	60	=							
15	61	=							
16	62	=							
17	63	=							
18	64	=							
19	65	=							
20	66	=							
21	67	=							
22	68	=							
23	69	=							
24	70	=							
25	71	=							
26	72	=							

A System and Method for Descrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed on November 9, 2000, now U.S. Patent No. 6,961,369, which claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value

for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with

the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad

cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 26 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse

discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase descrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that

effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe

count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3,}$ modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3}$ (mod 2π) = $\frac{2}{3}\pi$. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3}$(mod2π) = π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N+M)\times\frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+8)\times\frac{\pi}{4}$ (mod 2π) = $\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+9)\times\frac{\pi}{4}$(mod 2π) = $\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}, \bmod 2\pi$, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{3\pi}{2}$ (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero

volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the

subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment,

the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10-7 for the time domain transmission signal 38 can therefore operate with a 10-5 probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10-5 probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	67	(375/259 375/260 375/261 375/295 375/298 375/316 375/320 375/340).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 21:56
L2	9	1 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 21:56
L3	75	(375/259 375/260 375/261 375/295 375/298 375/316 375/320 375/340).ccls. and phase near2 scrambl$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 21:57
L4	8	3 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 21:57
L5	235	phase near2 scrambl$3 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 21:59
L6	29	5 and phase near2 scrambl$3 same (carrier$3 cahnnel$1)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/09/20 22:00
S1	16	tzannes.in. and scrambling near3 phase	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/10/02 21:12
S2	4	"60164134"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/10/02 21:16
S3	0	" a method for randomizing the phase of the carriers in a multicarrier"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/10/02 21:18
S4	0	"a method for randomizing the phase"	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2009/10/02 21:19

			JPO; DERWENT; IBM_TDB			
S5	4	"7471721".pn. "7292627".pn. "6961369".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/10/05 10:18
S6	3	"7471721".pn. "7292627".pn. "6961369".pn.	USPAT	OR	ON	2009/10/05 10:19
S7	15	"3955141".pn. "4985900".pn. "5682376".pn. "5748677".pn. "6256355".pn. "6507585".pn. "6590860".pn. "6704317".pn. "6961369".pn. "7292627".pn. "20050141410" "20060092902" "20060140288" "20080069253"	US-PGPUB; USPAT	OR	ON	2009/10/05 13:54
S8	4	S7 and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT	OR	ON	2009/10/05 13:57
S9	23	375/260.ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 13:58
S10	1	S9 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 13:58
S11	8	(375/219 375/222).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 13:59
S12	0	S11 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 14:00
S13	11	375/260.ccls. and (scrambl$3 randomiz$3) near4 phase same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 14:01
S14	1	S13 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 14:01
S15	7	(375/219 375/222).ccls. and (scrambl$3 randomiz$3) near4 phase same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 14:03
S16	1	S15 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 14:03
S17	5	(370/281 370/295 370/330 370/343 370/436 370/478 370/480 370/481 370/57 370/69.1).ccls. and (scrambl$3 randomiz$3) near4 phase same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:45

S18	1	S17 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:45
S19	10	(370/281 370/295 370/330 370/343 370/436 370/478 370/480 370/481 370/57 370/69.1).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:47
S20	4	S19 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:48
S21	13	(375/260 375/267 375/362).ccls. and (scrambl$3 randomiz$3) near4 phase same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:53
S22	2	S21 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:53
S23	31	(375/260 375/267 375/362).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:54
S24	2	S23 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:54
S25	3	(375/295).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:55
S26	0	S25 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/05 15:57
S27	2	"6,590,860" .pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/04/19 22:54
S28	6	tzannes.in. and ((randomiz$3 scrambling) near3 phase).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/04/20 08:32
S29	15	tzannes.in. and scrambling near3 phase	US-PGPUB; USPAT	OR	ON	2010/04/22 16:22
S30	5	tzannes.in. and scrambling near3 phase.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2010/04/22 16:23

			IBM_TDB			
S31	14	(375/259 375/261 375/295 375/298 375/219 375/220).ccls. and (comput$3 estimat$3 determin$3) near4 phase adj shift same (carrier$3 sub adj carrier$1 multi adj carrier)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:45
S32	2	S31 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:45
S33	43	(375/259 375/261 375/295 375/298 375/219 375/220).ccls. and (randomiz$3 scrambl$3) near3 phase	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:47
S34	12	S33 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:47
S35	17	(370/206 370/208).ccls. and (randomiz$3 scrambl$3) near3 phase	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:52
S36	6	S35 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:52
S37	2	(455/73 455/91 455/108).ccls. and (randomiz$3 scrambl$3) near3 phase	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/22 22:55
S38	8	"6519292".pn. "6256355".pn. "5742679".pn. "5682376".pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 11:38
S39	4	"6519292".pn. "6256355".pn. "5742679".pn. "5682376".pn.	USPAT	OR	ON	2010/04/26 11:38
S40	4	S38 and (randomiz$3 scrambl$3) near3 phase	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 11:39
S41	1	"12255713" and independently	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 11:41
S42	1	"6519292".pn. and randomiz$3 near2 phase$1	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 13:50
S43	1	"6519292".pn. and (predetermined adj rule initial adj phase adj value$1)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 13:51
S44	1	"6256355".pn. and (predetermined adj rule initial adj phase adj value$1)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2010/04/26 13:53
S45	4	(375/377).ccls. and (randomiz$3 scrambl$3) near3 phase	US-PGPUB; USPAT;	OR	ON	2010/04/26 16:50

			EPO; JPO; DERWENT			
S46	25	("6590860" | "6967997" | "6757299" | "7610028" | "20060002454" | "6519292" | "5991262" | "6519929" | "5694395" | "5870016" | "6366555" | "4985900" | "6507585" | "20060140288" | "3955141" | "6256355" | "6704317" | "4069392" | "5381449" | "20050141410" | "5748677" | "20060092902" | "5682376" | "6128350" | "6961369").PN.	US-PGPUB; USPAT	OR	ON	2011/08/30 23:54
S47	4	S46 and (phase near2 characteristic$1 scrambl$3 random$3 spreading) same phase near2 shift same carrier$1	US-PGPUB; USPAT	OR	ON	2011/08/30 23:56
S48	3	"12255713"	US-PGPUB; USPAT	OR	ON	2011/08/31 00:04
S49	220	(375/259 375/260 375/261 375/267 375/298 375/299 375/316 375/320 375/324 375/340).ccls. and (phase near2 characteristic$1 scrambl$3 random$3 spreading) same phase near2 shift same carrier$1	US-PGPUB; USPAT	OR	ON	2011/08/31 00:27
S50	220	(375/259 375/260 375/261 375/267 375/298 375/299 375/316 375/320 375/324 375/340).ccls. and (phase near2 characteristic$1 scrambl$3 random$3 spreading) same phase near2 shift same carrier$1	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/08/31 00:27
S51	44	S50 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/08/31 00:28
S52	41	(375/219 375/220 375/222).ccls. and (phase near2 characteristic$1 scrambl$3 random$3 spreading) same phase near2 shift same carrier$1	US-PGPUB; USPAT	OR	ON	2011/08/31 00:31
S53	23	S52 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/08/31 00:31
S54	29	(370/281 370/295 370/343 370/480 370/481).ccls. and (phase near2 characteristic$1 scrambl$3 random$3 spreading) same phase near2 shift same carrier$1	US-PGPUB; USPAT	OR	ON	2011/08/31 00:32
S55	11	S54 and @ad<="19991109"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/08/31 00:32
S56	6	tzannes.in. and scrambling near3 phase.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/08/31 00:39
S57	2	"12840024"	US-PGPUB; USPAT	OR	ON	2011/08/31 01:22

9/20/2011 10:10:12 PM
C:\Users\lwilliams5\Documents\EAST\Workspaces\11860080a.wsp

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV

CONFIRMATION NO. 5967

NEW OR REVISED PPD NOTICE

OC000000050239609

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

NOTICE OF NEW OR REVISED PROJECTED PUBLICATION DATE

The above-identified application has a new or revised projected publication date. The current projected publication date for this application is 01/12/2012. If this is a new projected publication date (there was no previous projected publication date), the application has been cleared by Licensing & Review or a secrecy order has been rescinded and the application is now in the publication queue.

If this is a revised projected publication date (one that is different from a previously communicated projected publication date), the publication date has been revised due to processing delays in the USPTO or the abandonment and subsequent revival of an application. The application is anticipated to be published on a date that is more than six weeks different from the originally-projected publication date.

More detailed publication information is available through the private side of Patent Application Information Retrieval (PAIR) System. The direct link to access PAIR is currently http://pair.uspto.gov. Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Questions relating to this Notice should be directed to the Office of Data Management, Application Assistance Unit at (571) 272-4000, or (571) 272-4200, or 1-888-786-0101.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Date:

MAILED

OCT - 5 2011

LICENSING & REVIEW

Defense Technology Security Administration
2850 Eisenhower Avenue
Alexandria, VA 22314

Attn: DTSA Patent Review

Application serial number(s) identified below was referred at least one DoD defense agency under 35 U.S.C. 181 on the noted dates which are more than the 6 months as provided for in 35 U.S.C. 184. The Patent and Trademark Office (USPTO) has not received a communication from you regarding secrecy of this application under 35 USC 181.

Examination of this application has been completed and has been found to be in condition for allowance as a U.S. Patent. Since the USPTO has no authority to withhold the issue of a patent absent a recommendation for a secrecy order under 181, this application is being prepared for issue as a U.S. patent.

Serial Number	Referral Date
11/860,080	09/27/07

You are also reminded that although these applications are being cleared by the USPTO, dated access acknowledgement forms continue to be required in these applications pursuant to 35 USC 181.

Thank you for attention to this matter.

For:
Wanda A. ~~Brown~~,
Supervisor Licensing and Review.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

62574 7590 09/27/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

EXAMINER	
WILLIAMS, LAWRENCE B	
ART UNIT	**PAPER NUMBER**
2611	

NOTIFICATION DATE	DELIVERY MODE
09/27/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jvick@sheridanross.com

PTOL-90A (Rev. 04/07)

Applicant-Initiated Interview Summary	Application No. 11/860,080	Applicant(s) TZANNES, MARCOS C.	
	Examiner TESFALDET BOCURE	Art Unit 2611	

All participants (applicant, applicant's representative, PTO personnel):

(1) TESFALDET BOCURE. (3)_____.

(2) Mr. Vick Jason (Reg. # 45,285). (4)_____.

Date of Interview: 20 September 2011.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 47 and 60.

Identification of prior art discussed: None.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

See Continuation Sheet.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Tesfaldet Bocure/
Primary Examiner, Art Unit 2611

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Applicant's representative, Mr. Vick Jason (Reg. # 45,285) discussed how to overcome possible 112 2nd paragraph with respect to the drafted claims 47 and 60. The following proposals have been suggested by the Examiner and agreed upon by Mr. Vick (see underlined limitations proposed by the Examiner):

47. (New) A method, in a first multicarrier transceiver that uses a plurality of carrier signals for receiving a bit stream, wherein each carrier signal has a phase characteristic associated with the bit stream, the method comprising:
receiving the bit stream, wherein:
each carrier signal is associated with a value determined independently of any bit value corresponding or (associated) to the received bit stream carried by that respective carrier signal, the value associated with each carrier signal determined by a pseudo-random number generator,
a phase shift for each carrier signal is based on:
the value associated with that respective carrier signal, and
the combining of the phase shift for each carrier signal with the phase characteristic of that respective carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals, and
multiple carrier signals corresponding to the phase scrambled plurality of carrier signals are used by the first multicarrier transceiver to demodulate a same input bit value corresponding or (associated) to the received bit stream.

It should be noted that the word "corresponding or associated" can be used interchangeably according to the specification whichever one is applicable. The same proposal also applies to claim 70.
In the meantime, discussed some minor issues regarding:
In the drawing element 54 has been disclosed as received by the scrambler 74 and agreed to correct; and a miss spelled word, "non-lipped" in page 2. Line 26 of the specification (see parent US patent number 7,292,627) to be amended to read as---non-clipped--.
As to the disclosed transmission signal 78, the amended drawing received on 8/30/2011 corrects the concern by the Examiner; therefore, the issue has been resolved.
In the meantime, Mr. Vick agreed to change the scrambler 66' by descrambler 66' since the receiver has been disclosed as performing inverse of that of the scrambler 66 at the transmitter and to include in his remarks that the claimed phase scrambling is performed by the transmitter to overcome drawing objection (Form Par. 6.36).

.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

SIXTH PRELIMINARY AMENDMENT

Dear Sir:

Prior to the initial review of the above-identified patent application by the Examiner, and supplemental to the September 9, 2011 Preliminary Amendment, please enter the following Preliminary Amendment. Although Applicants do not believe that any fees are due based upon the filing of this Preliminary Amendment, please charge any such fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Drawings begin on page 3 of this paper and include both an attached replacement sheet and an annotated sheet showing changes.

Amendments to the Claims are shown in the listing of claims which begin on page 4 of this paper.

Remarks begin on page 9 of this paper.

AMENDMENTS TO THE SPECIFICATION

Submitted herewith is a marked-up and clean version of a substitute specification. No new matter is believed to have been added therein.

AMENDMENTS TO THE DRAWINGS:

The attached drawing sheet(s) include(s) changes to Figure 1. This sheet, which includes Figure 1 replaces the previously submitted sheet.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-46. (Canceled)

47. (Currently Amended) A method, ~~In~~in a first multicarrier transceiver~~, having~~ that uses a plurality of carrier signals for receiving a bit stream, wherein each carrier signal ~~having~~has a phase characteristic associated with the bit stream, ~~a~~the method comprising:

~~demodulating~~receiving the bit stream, wherein:

each carrier signal ~~was~~is associated with a value determined independently of any bit value of the bit stream carried by that respective carrier signal, the value associated with each carrier signal determined by a pseudo-random number generator,

a phase shift for each carrier signal is based on:

~~was computed for each carrier signal based on~~ the value associated with that carrier signal, and

~~the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal~~ the combining of a phase for each carrier signal with the phase characteristic of that respective carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals, and

multiple carrier signals corresponding to the plurality of phase shifted and scrambled carrier signals ~~were~~are used by the first multicarrier transceiver to ~~modulate~~demodulate a same ~~input~~ bit value~~, and~~

~~a value associated with the carrier signal was determined using a pseudo-random number generator.~~ of the received bit stream.

48. (Previously Presented) The method of claim 47, wherein the first transceiver is a cable transceiver.

49. (Previously Presented) The method of claim 47, wherein the first transceiver is VDSL transceiver.

50. (Previously Presented) The method of claim 47, wherein the bit stream is used to transport video.

51. (Previously Presented) The method of claim 47, wherein the bit stream is used to transport high speed internet access.

52. (Previously Presented) The method of claim 47, further comprising, in a second transceiver in communication with the first transceiver, independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

53. (Previously Presented) The method of claim 52, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

54. (Previously Presented) The method of claim 52, wherein the first and second transceivers are wireless transceivers.

55. (Previously Presented) The method of claim 52, wherein the first and second transceivers are cable transceivers.

56. (Previously Presented) The method of claim 52, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

57. (Previously Presented) The method of claim 56, wherein the first and second transceivers are VDSL transceivers.

58. (Previously Presented) The method of claim 52, wherein the bit stream is used to transport video.

59. (Previously Presented) The method of claim 52, wherein the bit stream is used to transport high speed internet access.

60. (Currently Amended) A multicarrier system including a first transceiver ~~having a~~ that uses a plurality of carrier signals for receiving a bit stream, wherein each carrier signal ~~having~~ has a phase characteristic associated with the bit stream, the transceiver capable of ~~demodulating~~ receiving the bit stream, wherein:

each carrier signal ~~was~~is associated with a value determined independently of any bit value of the bit stream carried by that respective carrier signal, the value associated with each carrier signal determined by a pseudo-random number generator,

a phase shift for each carrier signal is based on:

~~was computed for each carrier signal based on~~ the value associated with that respective carrier signal, and

~~the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal~~ the combining of a phase shift for each carrier signal with the phase characteristic of that respective carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals corresponding to the plurality of phase shifted and scrambled carrier signals ~~were~~are used by the first multicarrier transceiver to ~~modulate~~demodulate a same ~~input~~ bit value~~, and~~

~~a value associated with the carrier signal was determined using a pseudo-random number generator~~ of the received bit stream.

61. (Previously Presented) The system of claim 60, wherein the first transceiver is a cable transceiver.

62. (Previously Presented) The system of claim 60, wherein the first transceiver is VDSL transceiver.

63. (Previously Presented) The system of claim 60, wherein the bit stream is used to transport video.

64. (Previously Presented) The system of claim 60, wherein the bit stream is used to transport high speed internet access.

65. (Previously Presented) The system of claim 60, further comprising a second transceiver in communication with the first transceiver, the second transceiver independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

66. (Previously Presented) The system of claim 65, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

67. (Previously Presented) The system of claim 65, wherein the first and second transceivers are wireless transceivers.

68. (Previously Presented) The system of claim 65, wherein the first and second transceivers are cable transceivers.

69. (Previously Presented) The system of claim 65, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

70. (Previously Presented) The system of claim 69, wherein the first and second transceivers are VDSL transceivers.

71. (Previously Presented) The system of claim 65, wherein the bit stream is used to transport video.

72. (Previously Presented) The system of claim 65, wherein the bit stream is used to transport high speed internet access.

REMARKS/ARGUMENTS

Applicant requests examination on the merits.

Applicant would like to thank Examiners Bocure and Williams for the courtesies extended during the September 20 telephone conference. During the conference, the Examiner requested the changes to the claims as shown above. The Examiner also requested element 66' be changed to "phase descrambler" since it is performing the inverse functions of phase scrambler 66.

Attached hereto are a substitute specification and replacement figure that make the changes as requested.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 22 Sept '11

A System and Method for Descrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed on November 9, 2000, now U.S. Patent No. 6,961,369, which claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value

for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with

the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad

cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 26 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse

discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase ~~scrambler~~descrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that

effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe

count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3,}$ modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3}$ (mod 2π) = $\frac{2}{3}\pi$. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3}$(mod2π) = π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N+M)\times\frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+8)\times\frac{\pi}{4}$ (mod 2π) = $\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+9)\times\frac{\pi}{4}$(mod 2π) = $\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}, \mathrm{mod}\ 2\pi$, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\mathrm{mod}\ 2\pi)=\frac{3\pi}{2}$ (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\mathrm{mod}\ 2\pi)=\frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero

volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the

subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment,

the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10-7 for the time domain transmission signal 38 can therefore operate with a 10-5 probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10-5 probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

A System and Method for Descrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed on November 9, 2000, now U.S. Patent No. 6,961,369, which claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value

for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with

the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad

cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 26 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse

discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase descrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that

effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe

count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3,}$ modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3}$ (mod 2π) = $\frac{2}{3}$π. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3}$(mod2π) = π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N+M)\times\frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+8)\times\frac{\pi}{4}$ (mod 2π) = $\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+9)\times\frac{\pi}{4}$(mod 2π) = $\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}, \bmod 2\pi$, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{3\pi}{2}$ (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero

volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the

subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment,

the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10-7 for the time domain transmission signal 38 can therefore operate with a 10-5 probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10-5 probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

ANNOTATED SHEET

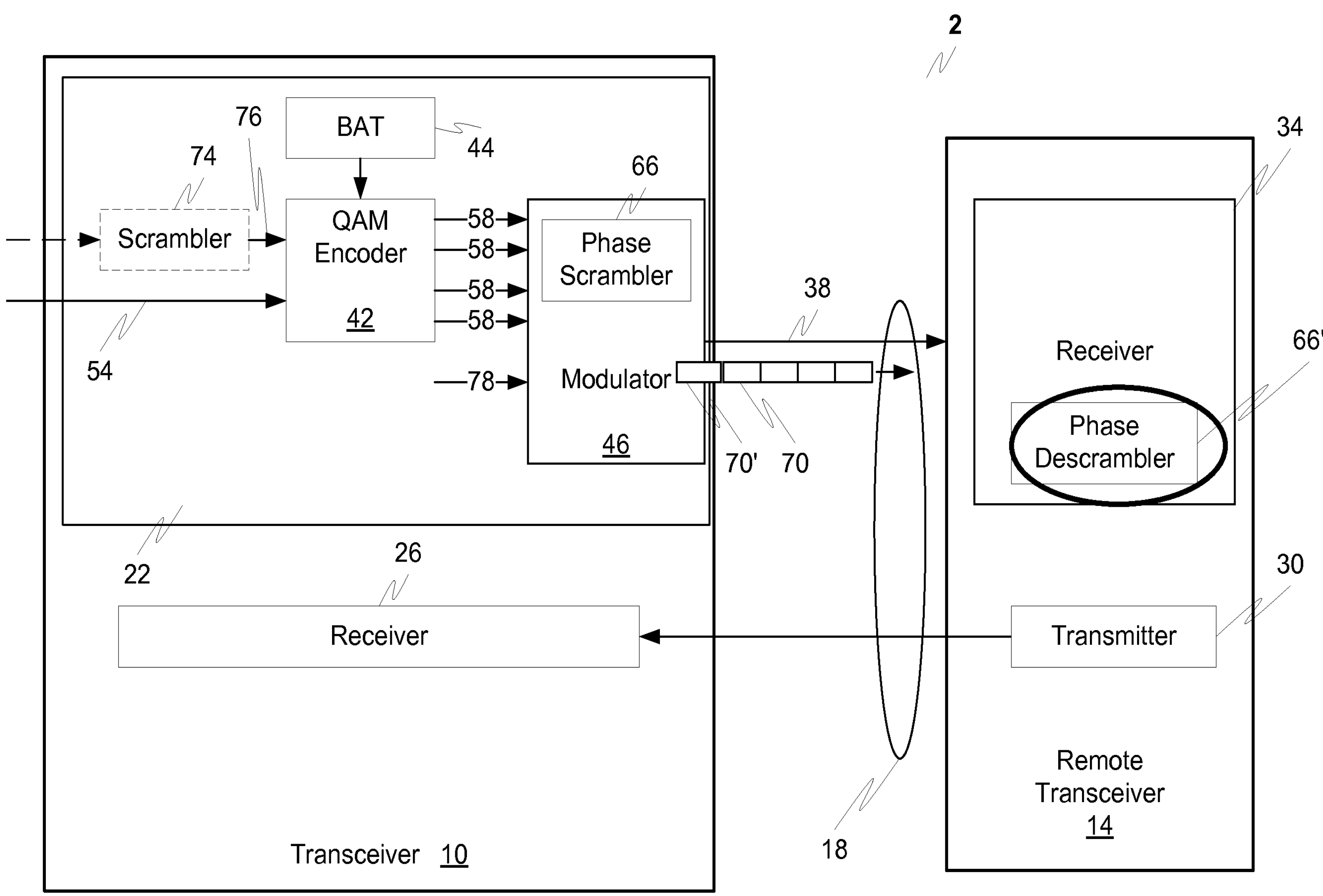


FIG. 1

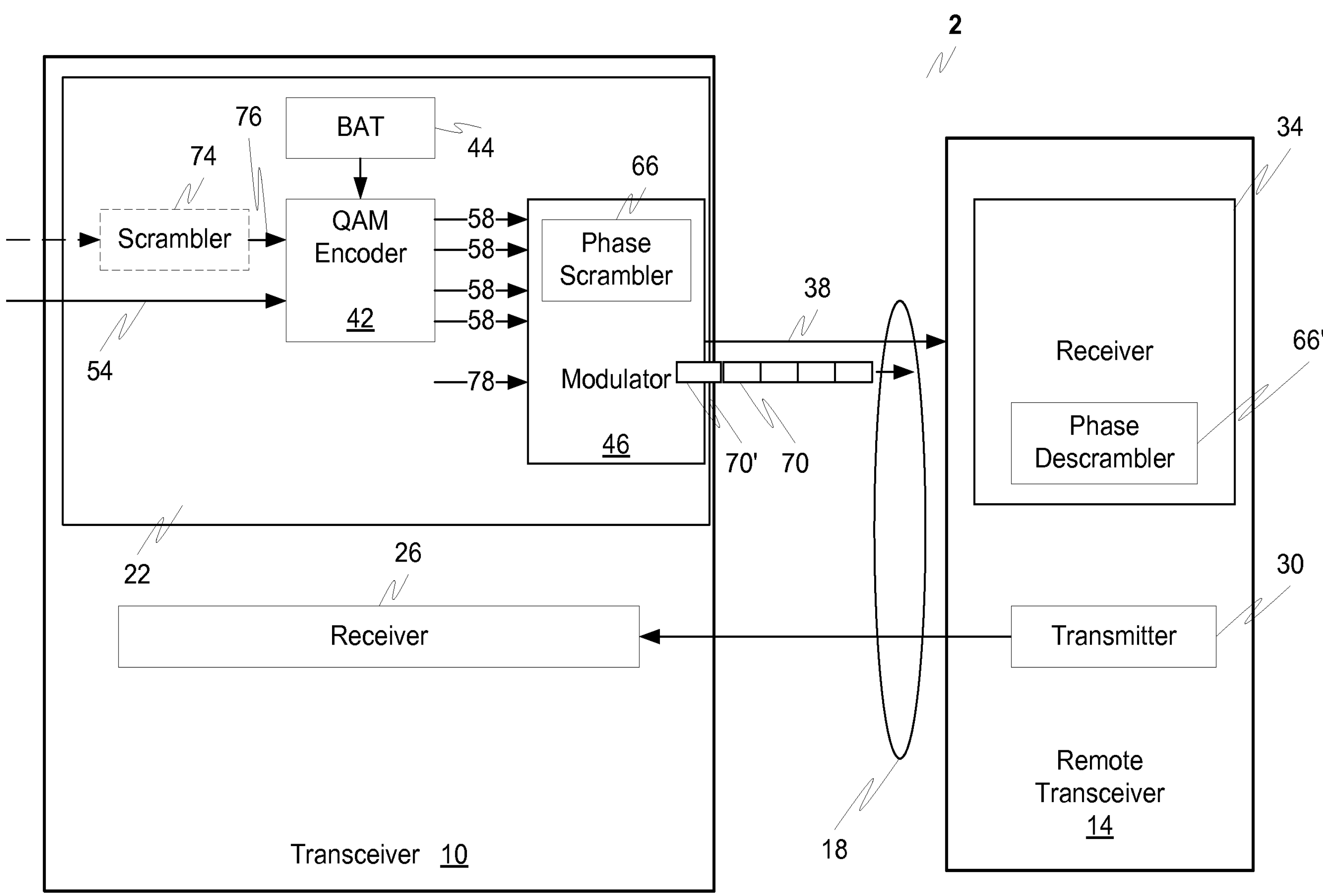

2
Scrambler
74
76
BAT
44
QAM
Encoder
42
54
58
58
58
58
78
Phase
Scrambler
66
Modulator
46
70'
70
38
22
26
Receiver
Transceiver 10
18
Receiver
Phase
Descrambler
34
66'
Transmitter
30
Remote
Transceiver
14

FIG. 1

Electronic Acknowledgement Receipt

EFS ID:	11014460
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	22-SEP-2011
Filing Date:	24-SEP-2007
Time Stamp:	14:21:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_PRELIM_06.pdf	525938 5b9f6b1922f778f6cfb07059cd83acf0b4ea252f	yes	9

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Preliminary Amendment		1	1	
	Specification		2	2	
	Drawings-only black and white line drawings		3	3	
	Claims		4	8	
	Applicant Arguments/Remarks Made in an Amendment		9	9	
Warnings:					
Information:					
2		Second_Marked_up_Copy_of_Substitute_Spec.pdf	136808 be73105b6ee07014b69936882263f8f86b9b475c	yes	15
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	14	
	Abstract		15	15	
Warnings:					
Information:					
3		Second_Clean_Copy_of_Substitute_Spec.pdf	136498 7351fcadd9ad877094287ed2a9352b3b7cae0a41	yes	15
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	14	
	Abstract		15	15	
Warnings:					
Information:					
4	Drawings-only black and white line drawings	SecondAnnotatedSheet1.pdf	52870 f66e26fa69603b6e0b6d2bdac1eeea8a9cffa6b4	no	1
Warnings:					
Information:					

5	Drawings-only black and white line drawings	SecondReplacementSheet1.pdf	52881 1019c6a68779567dbe21a9dbb9ce5e4b5586ab0c	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	904995		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/860,080	Filing Date 09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/22/2011	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 26	Minus	** 26	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/TIA BENTLEY/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

FIFTH PRELIMINARY AMENDMENT

Dear Sir:

Prior to the initial review of the above-identified patent application by the Examiner, and supplemental to the August 30, 2011 Preliminary Amendment, please enter the following Preliminary Amendment. Although Applicants do not believe that any fees are due based upon the filing of this Preliminary Amendment, please charge any such fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Remarks begin on page 3 of this paper.

<u>**AMENDMENTS TO THE SPECIFICATION**</u>

Submitted herewith is a marked-up and clean version of a substitute specification. No new matter is believed to have been added therein.

REMARKS/ARGUMENTS

Applicant requests examination on the merits.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 9 Sept '11

A System and Method for Descrambling~~Scrambling~~ the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed on November 9, 2000, now U.S. Patent No. 6,961,369, which~~This application~~ claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value

for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 26~~36~~ which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase scrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe

count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3}$, modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3}$ (mod 2π) = $\frac{2}{3}$ π. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to 51 $\times \frac{\pi}{3}$ (mod2π)=π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N + M) \times \frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50 + 8) \times \frac{\pi}{4}$ (mod 2π)= $\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50 + 9) \times \frac{\pi}{4}$ (mod 2π) = $\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N) \times \frac{\pi}{6}, \text{mod } 2\pi,$

where XN is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and XN equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\mathrm{mod}\,2\pi)=\frac{3\pi}{2}$ (Note that 9 is the 5th value in XN.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\mathrm{mod}\,2\pi)=\frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter

22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3}\times(M+N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment, the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10-7 for the time domain transmission signal 38 can therefore operate with a 10-5 probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10-5 probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols.

Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

A System and Method for Descrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed on November 9, 2000, now U.S. Patent No. 6,961,369, which claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value

for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with

the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad

cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 26 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse

discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase scrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that

effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe

count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3,}$ modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3}$ (mod 2π) = $\frac{2}{3}\pi$. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3}$(mod2π) = π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N + M) \times \frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50 + 8) \times \frac{\pi}{4}$ (mod 2π) = $\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50 + 9) \times \frac{\pi}{4}$(mod 2π) = $\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N) \times \frac{\pi}{6}, \bmod 2\pi$, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9) \times \frac{\pi}{6} (\bmod 2\pi) = \frac{3\pi}{2}$ (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5) \times \frac{\pi}{6} (\bmod 2\pi) = \frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero

volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the

subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment,

the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10-7 for the time domain transmission signal 38 can therefore operate with a 10-5 probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10-5 probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

Electronic Acknowledgement Receipt

EFS ID:	10918003
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	09-SEP-2011
Filing Date:	24-SEP-2007
Time Stamp:	17:23:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_PRELIM_05.pdf	143172 7dad4639d0ac97e1a5c5fb90aeb516d025b7833d	yes	3

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Preliminary Amendment		1	1	
	Specification		2	2	
	Applicant Arguments/Remarks Made in an Amendment		3	3	
Warnings:					
Information:					
2		Marked_Up_Substitute_Spec.pdf	137685 551dc688929a043951a42c39d87dfbb0d2455594	yes	17
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	16	
	Abstract		17	17	
Warnings:					
Information:					
3		Clean_Copy_Substitute_Spec.pdf	136450 517bf1e8fd6bcb2602b16f78b55a3bc63d9bdaa3	yes	15
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	14	
	Abstract		15	15	
Warnings:					
Information:					
		Total Files Size (in bytes):	417307		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV	5967

62574 7590 08/31/2011

Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

EXAMINER	
WILLIAMS, LAWRENCE B	

ART UNIT	PAPER NUMBER
2611	

NOTIFICATION DATE	DELIVERY MODE
08/31/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jvick@sheridanross.com

PTOL-90A (Rev. 04/07)

Interview Summary	Application No.	Applicant(s)
	11/860,080	TZANNES, MARCOS C.
	Examiner	**Art Unit**
	LAWRENCE WILLIAMS	2611

All participants (applicant, applicant's representative, PTO personnel):

(1) *LAWRENCE WILLIAMS*.	(3) *MARCOS C. TZANNES*.
(2) *JASON VICK*.	(4)_____.

Date of Interview: *15 August 2011*.

Type: a)☐ Telephonic b)☐ Video Conference
c)☒ Personal [copy given to: 1)☐ applicant 2)☐ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: *21 and 34*.

Identification of prior art discussed: _____.

Agreement with respect to the claims f)☒ was reached. g)☐ was not reached. h)☐ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *Discussed independent claims in respect to specification. Applicant will rewrite claims to be more in line with specification since specification does not use the word descrambling but does teach demdulation for the phase characteristics of the signals*.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN A NON-EXTENDABLE PERIOD OF THE LONGER OF ONE MONTH OR THIRTY DAYS FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

/Lawrence B Williams/
Examiner, Art Unit 2611

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
– Application Number (Series Code and Serial Number)
– Name of applicant
– Name of examiner
– Date of interview
– Type of interview (telephonic, video-conference, or personal)
– Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
– An indication whether or not an exhibit was shown or a demonstration conducted
– An identification of the specific prior art discussed
– An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
– The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	))	Group Art Unit: 2611
Application No.: 11/860,080	))	Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	))	Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	))	

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

FOURTH PRELIMINARY AMENDMENT

Dear Sir:

Prior to the initial review of the above-identified patent application by the Examiner, and supplemental to the August 11, 2011 Preliminary Amendment, please enter the following Preliminary Amendment. Although Applicants do not believe that any fees are due based upon the filing of this Preliminary Amendment, please charge any such fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Claims are shown in the listing of claims which begin on page 2 of this paper.

Amendments to the Drawings begin on page 6 of this paper and include both an attached replacement sheet and an annotated sheet showing changes.

Remarks begin on page 7 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-46. (Canceled)

47. (New) In a first multicarrier transceiver, having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, a method comprising:

demodulating the bit stream, wherein:

each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal,

a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and

a value associated with the carrier signal was determined using a pseudo-random number generator.

48. (New) The method of claim 47, wherein the first transceiver is a cable transceiver.

49. (New) The method of claim 47, wherein the first transceiver is VDSL transceiver.

50. (New) The method of claim 47, wherein the bit stream is used to transport video.

51. (New) The method of claim 47, wherein the bit stream is used to transport high speed internet access.

52. (New) The method of claim 47, further comprising, in a second transceiver in communication with the first transceiver, independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

53. (New) The method of claim 52, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

54. (New) The method of claim 52, wherein the first and second transceivers are wireless transceivers.

55. (New) The method of claim 52, wherein the first and second transceivers are cable transceivers.

56. (New) The method of claim 52, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

57. (New) The method of claim 56, wherein the first and second transceivers are VDSL transceivers.

58. (New) The method of claim 52, wherein the bit stream is used to transport video.

59. (New) The method of claim 52, wherein the bit stream is used to transport high speed internet access.

60. (New) A multicarrier system including a first transceiver having a plurality of carrier signals for receiving a bit stream, each carrier signal having a phase characteristic associated with the bit stream, the transceiver capable of demodulating the bit stream, wherein:

each carrier signal was associated with a value determined independently of any bit value carried by that carrier signal, a phase shift was computed for each carrier signal based on the value associated with that carrier signal,

the phase shift computed for each carrier signal was combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals,

multiple carrier signals were used to modulate a same input bit value, and

a value associated with the carrier signal was determined using a pseudo-random number generator.

61. (New) The system of claim 60, wherein the first transceiver is a cable transceiver.

62. (New) The system of claim 60, wherein the first transceiver is VDSL transceiver.

63. (New) The system of claim 60, wherein the bit stream is used to transport video.

64. (New) The system of claim 60, wherein the bit stream is used to transport high speed internet access.

65. (New) The system of claim 60, further comprising a second transceiver in communication with the first transceiver, the second transceiver independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

66. (New) The system of claim 65, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

67. (New) The system of claim 65, wherein the first and second transceivers are wireless transceivers.

68. (New) The system of claim 65, wherein the first and second transceivers are cable transceivers.

69. (New) The system of claim 65, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

70. (New) The system of claim 69, wherein the first and second transceivers are VDSL transceivers.

71. (New) The system of claim 65, wherein the bit stream is used to transport video.

72. (New) The system of claim 65, wherein the bit stream is used to transport high speed internet access.

AMENDMENTS TO THE DRAWINGS:

The attached drawing sheet(s) include(s) changes to Figure 1. This sheet, which includes Figure 1 replaces the original sheet.

REMARKS/ARGUMENTS

Applicant requests examination on the merits.

Claims 1-46 are cancelled without prejudice or disclaimer in favor of the new claims presented herein.

By this amendment, Figure 1 has been updated to include all reference numbers from the specification.

Applicant would like to thank Ex. Williams for the courtesies extended during the August 15 Personal Interview. During the Interview, the above claims were discussed and the Examiner requested the Figures be updated to include all reference numbers from the specification.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: /Jason H. Vick/

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: August 30, 2011

ANNOTATED SHEET

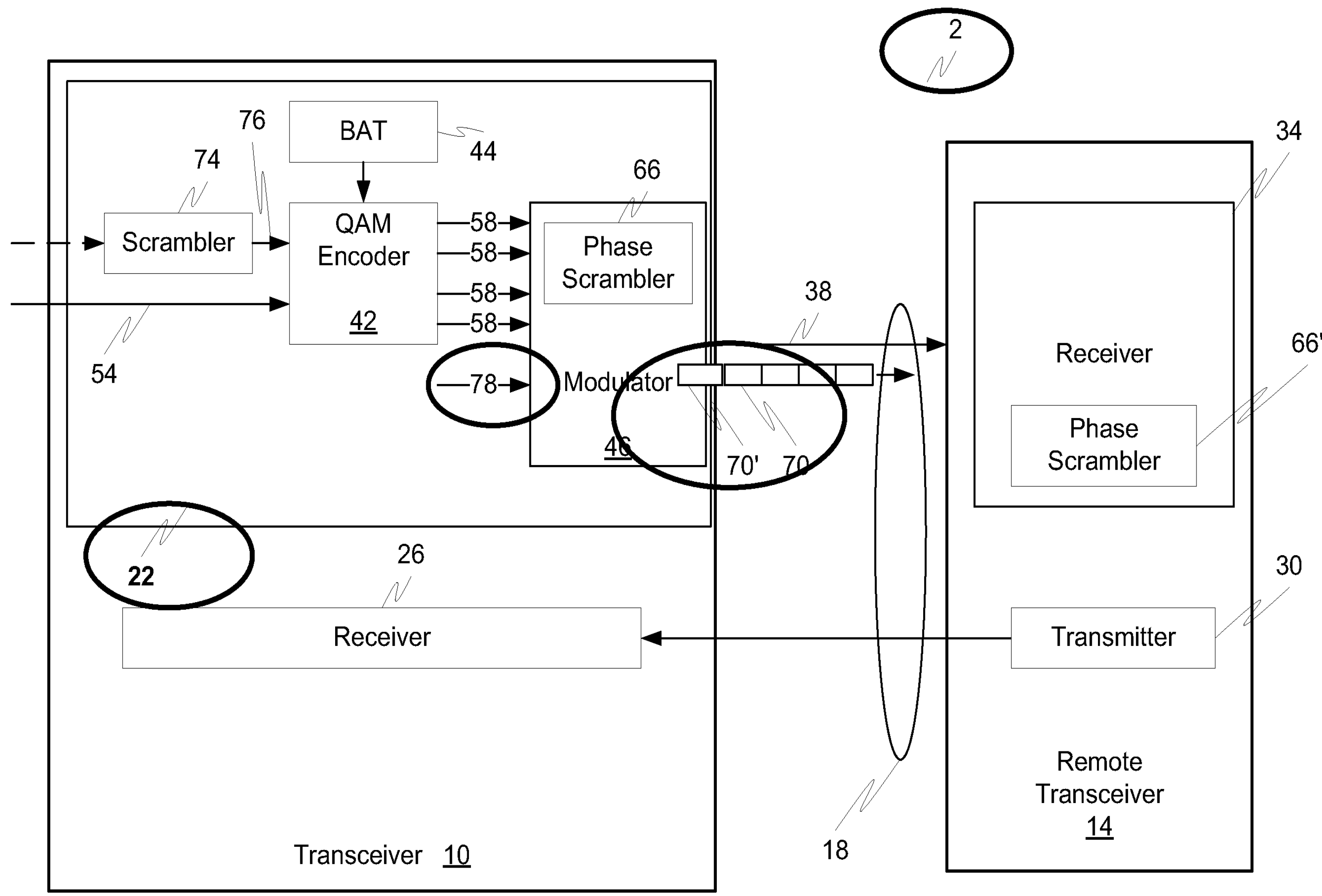


FIG. 1

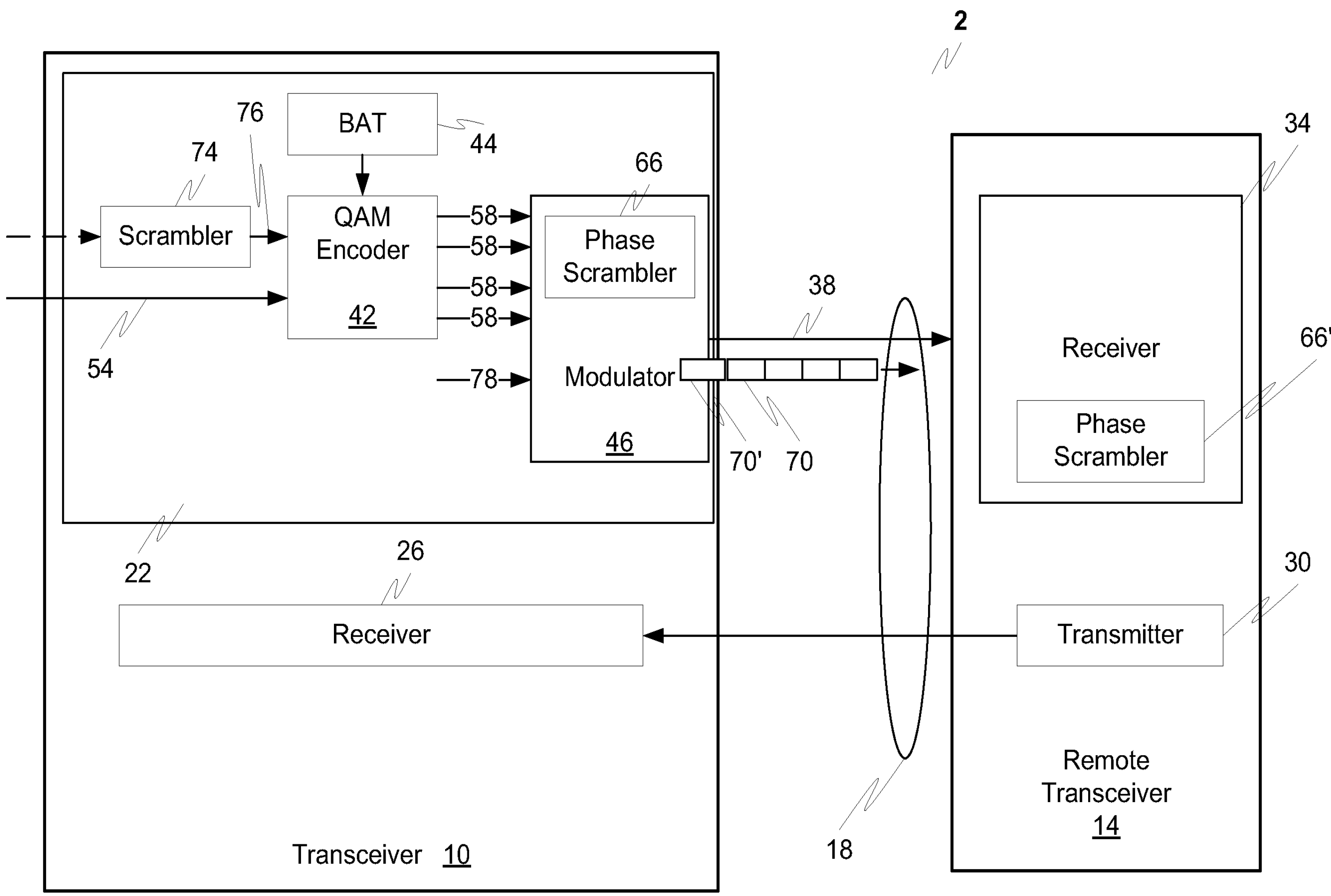

2
BAT
44
76
74
Scrambler
QAM
Encoder
42
54
58
58
58
58
78
66
Phase
Scrambler
Modulator
46
70'
70
38
22
26
Receiver
Transceiver 10
18
34
Receiver
66'
Phase
Scrambler
30
Transmitter
Remote
Transceiver
14

FIG. 1

Electronic Acknowledgement Receipt

EFS ID:	10842315
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	30-AUG-2011
Filing Date:	24-SEP-2007
Time Stamp:	13:21:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_PRELIM_04.pdf	82038 c10eed40268a9f5ce71762d8d0c6e3a02b300405	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Claims	2	5
	Drawings-only black and white line drawings	6	6
	Applicant Arguments/Remarks Made in an Amendment	7	7

Warnings:

Information:

2	Drawings-only black and white line drawings	Annotated_Fig_1.pdf	19257 35a066f307e1f8e9c7926585a554a8a3e91eeb13	no	1

Warnings:

Information:

3	Drawings-only black and white line drawings	Replacement_Fig_1.pdf	22608 e6993d3d4655a4da73c301a44b04fc5010e34a9c	no	1

Warnings:

Information:

Total Files Size (in bytes):	123903

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number	Filing Date	
11/860,080	09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT 08/30/2011	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 26	Minus	** 26	= 0	X $ =		OR	X $52=	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/LYNNELL JOHNSON/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV

CONFIRMATION NO. 5967

POA ACCEPTANCE LETTER

OC000000049344567

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Date Mailed: 08/18/2011

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/10/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/agizaw/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes	) Group Art Unit: 2611
Application No.: 11/860,080	) Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007	) Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV	)

For: SYSTEM AND METHOD FOR DESCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM (As Amended)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

THIRD PRELIMINARY AMENDMENT

Dear Sir:

Prior to the initial review of the above-identified patent application by the Examiner, and supplemental to the August 10, 2011 Preliminary Amendment, please enter the following Preliminary Amendment. Although Applicants do not believe that any fees are due based upon the filing of this Preliminary Amendment, please charge any such fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are shown in the listing of claims which begin on page 3 of this paper.

Remarks begin on page 7 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please replace the Title with:

SYSTEM AND METHOD FOR DESCRAMBLING~~SCRAMBLING~~ THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-20. (Canceled)

21. (Currently Amended) In a first multicarrier ~~modulation~~ transceiver having a plurality of carrier signals for demodulating a bit stream, each carrier signal having a phase characteristic associated with the bit stream, a method for descrambling the phase characteristics of the carrier signals comprising:

associating each carrier signal with a value determined independently of any bit value carried by that carrier signal;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

using the phase shift computed for each carrier signal to descramble the phase characteristics of the plurality of carrier signals, wherein multiple carrier signals are used to demodulate the same bit value, and the value associated with the carrier signal is determined using a pseudo-random number generator.

22. (Currently Amended) The method of claim 21, wherein the first transceiver is a cable transceiver.

23. (Currently Amended) The method of claim 21, wherein the first transceiver is VDSL transceiver.

24. (Previously Presented) The method of claim 21, wherein the bit stream is used to transport video.

25. (Previously Presented) The method of claim 21, wherein the bit stream is used to transport high speed internet access.

26. (Previously Presented) The method of claim 21, further comprising, in a second transceiver in communication with the first transceiver, independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

27. (Previously Presented) The method of claim 26, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

28. (Previously Presented) The method of claim 26, wherein the first and second transceivers are wireless transceivers.

29. (Previously Presented) The method of claim 26, wherein the first and second transceivers are cable transceivers.

30. (Previously Presented) The method of claim 26, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

31. (Previously Presented) The method of claim 30, wherein the first and second transceivers are VDSL transceivers.

32. (Previously Presented) The method of claim 26, wherein the bit stream is used to transport video.

33. (Previously Presented) The method of claim 26, wherein the bit stream is used to transport high speed internet access.

34. (Currently Amended) A multicarrier ~~modulation~~ system including a first transceiver having a plurality of carrier signals for demodulating a bit stream, each carrier signal having a phase characteristic associated with the bit stream, the transceiver capable of:

associating each carrier signal with a value determined independently of any bit value carried by that carrier signal;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

using the phase shift computed for each carrier signal to descramble the phase characteristics of the plurality of carrier signals, wherein multiple carrier signals are used to demodulate the same bit value, and the value associated with the carrier signal is determined using a pseudo-random number generator.

35. (Currently Amended) The system of claim 34, wherein the first transceiver is a cable transceiver.

36. (Currently Amended) The system of claim 34, wherein the first transceiver is VDSL transceiver.

37. (Previously Presented) The system of claim 34, wherein the bit stream is used to transport video.

38. (Previously Presented) The system of claim 34, wherein the bit stream is used to transport high speed internet access.

39. (Previously Presented) The system of claim 34, further comprising a second transceiver in communication with the first transceiver, the second transceiver independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

40. (Previously Presented) The system of claim 39, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

41. (Previously Presented) The system of claim 39, wherein the first and second transceivers are wireless transceivers.

42. (Previously Presented) The system of claim 39, wherein the first and second transceivers are cable transceivers.

43. (Previously Presented) The system of claim 39, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

44. (Previously Presented) The system of claim 43, wherein the first and second transceivers are VDSL transceivers.

45. (Previously Presented) The system of claim 39, wherein the bit stream is used to transport video.

46. (Previously Presented) The system of claim 39, wherein the bit stream is used to transport high speed internet access.

REMARKS/ARGUMENTS

Applicant requests examination on the merits.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 11 Aug '11

Electronic Acknowledgement Receipt

EFS ID:	10713879
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	11-AUG-2011
Filing Date:	24-SEP-2007
Time Stamp:	12:30:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_PRELIM_03.pdf	408764 27bd65c9f156cca5a915ad016b91f259bbe4f51a	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Specification	2	2
	Claims	3	6
	Applicant Arguments/Remarks Made in an Amendment	7	7

Warnings:	
Information:	
Total Files Size (in bytes):	408764

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number	Filing Date	
11/860,080	09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter “0” in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT	08/11/2011	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 26	Minus	** 20	= 6	X $ =		OR	X $52=	312
	Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**312**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write “0” in column 3.
** If the “Highest Number Previously Paid For” IN THIS SPACE is less than 20, enter “20”.
*** If the “Highest Number Previously Paid For” IN THIS SPACE is less than 3, enter “3”.
The “Highest Number Previously Paid For” (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/SONYA HILLIARD/

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number	Filing Date	
	11/860,080	09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	08/11/2011	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 26	Minus	** 26	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/MOLIKI MAY/

PTO/SB/80 (01-06)
Approved for use through 12/31/2008. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

☑ Practitioners associated with the Customer Number: 62574

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

☑ The address associated with Customer Number: 62574

OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address:

AWARE, INC.
40 Middlesex Turnpike
Bedford, MA 07130-1423

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	1/8/09
Name	Kevin T. Russell	Telephone	781-687-0335
Title	VP, General Counsel		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	11860080
Filing Date:	24-Sep-2007
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Filer:	Jason Vick/Joanne Vos
Attorney Docket Number:	5550-47-CON-DIV

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1202	6	52	312
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**312**

Electronic Acknowledgement Receipt

EFS ID:	10702498
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	10-AUG-2011
Filing Date:	24-SEP-2007
Time Stamp:	11:10:13
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$312
RAM confirmation Number	7424
Deposit Account	191970
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_PRELIM_02.pdf	673110 c20d82d0fe035aa8b6b02920c9208e5cbad7e213	yes	8

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Specification	2	2
Claims	3	5
Applicant Arguments/Remarks Made in an Amendment	6	6
Assignee showing of ownership per 37 CFR 3.73(b).	7	7
Power of Attorney	8	8

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Fee Worksheet (SB06)	fee-info.pdf	30382 d95bb122cf897eb8200bfd53a228599ea4bd180a	no	2

Warnings:

Information:

Total Files Size (in bytes):	703492

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Marcos C. Tzannes)	Group Art Unit: 2611
Application No.: 11/860,080)	Examiner: WILLIAMS, Lawrence B.
Filed: September 24, 2007)	Confirmation No.: 5967
Atty. File No.: 5550-47-CON-DIV)	

For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

PRELIMINARY AMENDMENT

Dear Sir:

Prior to the initial review of the above-identified patent application by the Examiner, please enter the following Preliminary Amendment. Although Applicants do not believe that any fees are due based upon the filing of this Preliminary Amendment, please charge any such fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are shown in the listing of claims which begin on page 3 of this paper.

Remarks begin on page 6 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please amend the first paragraph of the application beneath the heading "RELATED APPLICATION":

Related Application

This application is a divisional of U.S. Application No. 11/211,535, filed August 26, 2005, now U.S. Patent No. 7,292,627, which is a continuation of U.S. Application No. 09/710,310, filed November 9, 2000, now U.S. Patent No. 6,961,369, which claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," each of which are ~~the entirety of which provisional application is~~ incorporated ~~by reference~~ herein by reference in their entirety.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-20. (Canceled)

21. (New) In a multicarrier modulation transceiver having a plurality of carrier signals for demodulating a bit stream, each carrier signal having a phase characteristic associated with the bit stream, a method for descrambling the phase characteristics of the carrier signals comprising: associating each carrier signal with a value determined independently of any bit value carried by that carrier signal; computing a phase shift for each carrier signal based on the value associated with that carrier signal; and using the phase shift computed for each carrier signal to descramble the phase characteristics of the plurality of carrier signals, wherein multiple carrier signals are used to demodulate the same bit value, and the value associated with the carrier signal is determined using a pseudo-random number generator.

22. (New) The method of claim 21, wherein the transceiver is a cable transceiver.

23. (New) The method of claim 21, wherein the transceiver is VDSL transceiver.

24. (New) The method of claim 21, wherein the bit stream is used to transport video.

25. (New) The method of claim 21, wherein the bit stream is used to transport high speed internet access.

26. (New) The method of claim 21, further comprising, in a second transceiver in communication with the first transceiver, independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

27. (New) The method of claim 26, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

28. (New) The method of claim 26, wherein the first and second transceivers are wireless transceivers.

29. (New) The method of claim 26, wherein the first and second transceivers are cable transceivers.

30. (New) The method of claim 26, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

31. (New) The method of claim 30, wherein the first and second transceivers are VDSL transceivers.

32. (New) The method of claim 26, wherein the bit stream is used to transport video.

33. (New) The method of claim 26, wherein the bit stream is used to transport high speed internet access.

34. (New) A multicarrier modulation system including a transceiver having a plurality of carrier signals for demodulating a bit stream, each carrier signal having a phase characteristic associated with the bit stream, the transceiver capable of: associating each carrier signal with a value determined independently of any bit value carried by that carrier signal; computing a phase shift for each carrier signal based on the value associated with that carrier signal; and using the phase shift computed for each carrier signal to descramble the phase characteristics of the plurality of carrier signals, wherein multiple carrier signals are used to demodulate the same bit value, and the value associated with the carrier signal is determined using a pseudo-random number generator.

35. (New) The system of claim 34, wherein the transceiver is a cable transceiver.

36. (New) The system of claim 34, wherein the transceiver is VDSL transceiver.

37. (New) The system of claim 34, wherein the bit stream is used to transport video.

38. (New) The system of claim 34, wherein the bit stream is used to transport high speed internet access.

39. (New) The system of claim 34, further comprising a second transceiver in communication with the first transceiver, the second transceiver independently deriving the values associated with each carrier using a second pseudo-random number generator in the second transceiver.

40. (New) The system of claim 39, wherein the first and second transceivers use a same seed for the pseudo-random number generator.

41. (New) The system of claim 39, wherein the first and second transceivers are wireless transceivers.

42. (New) The system of claim 39, wherein the first and second transceivers are cable transceivers.

43. (New) The system of claim 39, wherein the first and second transceivers are DSL transceivers connected using a pair of twisted wires of a telephone subscriber system.

44. (New) The system of claim 43, wherein the first and second transceivers are VDSL transceivers.

45. (New) The system of claim 39, wherein the bit stream is used to transport video.

46. (New) The system of claim 39, wherein the bit stream is used to transport high speed internet access.

REMARKS/ARGUMENTS

By this amendment, claim 20 has been canceled without prejudice or disclaimer in favor of the newly presented claims.

Applicant requests examination on the merits.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ____________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 10 Aug '11

PTO/SB/96 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: AWARE, INC.

Application No./Patent No.: 11/860,080 Filed/Issue Date: September 24, 2007

Titled: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

AWARE, INC. (Name of Assignee), a Corporation (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] the assignee of the entire right, title, and interest in;

2. [ ] an assignee of less than the entire right, title, and interest in (The extent (by percentage) of its ownership interest is ________ %); or

3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. [X] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 010877, Frame 0307, or for which a copy therefore is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: ________________ To: ________________

The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

2. From: ________________ To: ________________

The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

3. From: ________________ To: ________________

The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[X] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. <u>See</u> MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature: ________________ Date: 10 Aug 11

Jason H. Vick
Printed or Typed Name

Attorney for Assignee
Title

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/860,080	Filing Date 09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 09/24/2007	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 1	Minus	** 20	= 0	X $ =		OR	X $50=	0
Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $ =		OR	X $200=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT 08/10/2011	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 26	Minus	** 20	= 6	X $ =		OR	X $52 =	312
Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0	X $ =		OR	X $220 =	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**312**

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/SONYA HILLIARD/

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Complete if Known	
Application Number	11/860,080
Filing Date	September 24, 2007
First Named Inventor	Marcos C. Tzannes
Art Unit	2611
Examiner Name	Not Yet Assigned
Attorney Docket Number	5550-47-CON-DIV

Sheet	1	of	2

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5381449	01/10/95	Jasper et al.	
	2	5694395	12/02/97	Myer et al.	
	3	5870016	02/09/99	Shrestha	
	4	5991262	11/23/99	Laird et al.	
	5	6128350	10/03/00	Shastri et al.	
	6	6366555	04/02/02	Gatherer et al.	
	7	6757299	06/29/04	Verma	
	8	7610028	10/27/09	Cimini, Jr. et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
	9	HENKEL, "Analog Codes for Peak-to-Average Ratio Reduction," in Proceedings 3rd ITG Conf. Source and Channel Coding, Munich, Germany, Jan. 2000, 5 pages
	10	NARAHASHI et al., "New phasing scheme of N multiple carriers for reducing peak-to-average power ratio," Electronics Letters, Aug. 1994, Vol. 30(17), pp. 1382-83
	11	TELLADO et al., "Revisiting DMT's Peak-to-Average Ratio," Antwerp, Apr. 20-24, 1998, pp. 1-14
	12	TELLAMBURA, "A coding technique for reducing peak-to-average power ratio in OFDM," In the Proceedings of Global Telecommunications Conference, IEEE, Nov. 1998, pp. 2783-2787
	13	TELLAMBURA, "Phase optimisation criterion for reducing peak-to-average power ratio in OFDM," Electronics Letters, Jan. 1998, Vol. 34(2), pp. 169-170

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	September 24, 2007
				First Named Inventor	Marcos C. Tzannes
				Art Unit	2611
				Examiner Name	Not Yet Assigned
Sheet	2	of	2	Attorney Docket Number	5550-47-CON-DIV

	14	VAN EETVELT et al., "Peak to average power reduction for OFDM schemes by selective scrambling," Electronics Letters, Oct. 1996, Vol. 32(21), pp. 1963-64
	15	Written Opinion for International (PCT) Patent Application No. PCT/US00/30958, mailed Dec. 18, 2001 (Attorney Ref. No. 5550-47-PCT)
	16	Official Action for U.S. Patent Application No. 09/710,310, mailed May 4, 2004 (Attorney Ref. No. 5550-47)
	17	Notice of Allowance for U.S. Patent Application No. 09/710,310, mailed Jul 5, 2005 (Attorney Ref. No. 5550-47)
	18	Notice of Allowance for U.S. Patent Application No. 11/211,535, mailed Sep. 6, 2007 (Attorney Ref. No. 5550-47-CON)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

VICK, Jason H.
Nixon Peabody LLP
8180 Greensboro Drive,Suite 800
McLean,Virginia 22102
ETATS-UNIS D'AMERIQUE

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	18.12.2001
REPLY DUE	**within 1 month(s) and 15 days** from the above date of mailing

Applicant's or agent's file reference 081513-49		
International application No. PCT/US00/30958	International filing date *(day/month/year)* 09/11/2000	Priority date *(day/month/year)* 09/11/1999
International Patent Classification (IPC) or both national classification and IPC H04L27/26		
Applicant AWARE, INC.		

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain document cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

   When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

   How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

   Also: For an additional opportunity to submit amendments, see Rule 66.4.
   For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.
   For an informal communication with the examiner, see Rule 66.6.

   If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 09/03/2002.

Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer / Examiner Pajatakis, E Formalities officer (incl. extension of time limits) Barrio Baranano, A Telephone No. +49 89 2399 8621

Form PCT/IPEA/408 (cover sheet) (January 1994)

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. According to the description (page 3, lines 10-16, page 4, lines 4-10) the phase characteristics of the modulated carrier signals are scrambled by **combining the phase shift computed for each carrier signal with the phase characteristic of that carrier signal**. As this essential feature is missing from Claims 20-36, their scope comprises embodiments in which phase scrambling is carried out without the above feature which are not supported by the description, see also Guidelines III, 4.3.

2. To meet the requirement of conciseness, Article 6, a single independent claim in each category should be filed for the first invention.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The subject-matter of Claim 1 is not new, Article 33(2)

   D1 = *BAUML R W ET AL: 'REDUCING THE PEAK-TO-AVERAGE POWER RATIO OF MULTICARRIER MODULATIONBY SELECTED MAPPING' ELECTRONICS LETTERS,GB,IEE STEVENAGE, vol. 32, no. 22, 24 October 1996 (1996-10-24), pages 2056-2057*, **XP000643915** *ISSN: 0013-5194* discloses a method for scrambling the phase characteristics of the carrier signals in a multicarrier modulation system. The method comprises associating each carrier signal **V(μ)** with a value ϕ_μ determined independently of any input bit value (page 2056, right col., last but one paragraph). A phase shift $\mathbf{e^{i\phi\mu}}$ is computed for each carrier signal and combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of the carrier signals (page 2056, right col., equation 4).

2. All features of Claim 1 are also known from **D2 = EP-A-0 719 004** (col. 14, line 39 - col. 15, fig. 9).

3. The above finding also applies to Claim 37 which corresponds to Claim 1.

4. The additional features of the dependent claims do not add anything new or inventive to the above-mentioned independent claims because these features are either known from the above prior art (reduced peak-to-average power ratio, varying value with each carrier, pseudo-random pattern) or common measures (using symbol and frame counts).

I. Basis of the opinion

1. With regard to the **elements** of the international application (Replacement *sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed")*:

   Description, pages:

   1-17 as originally filed

   Claims, No.:

   1-39 as originally filed

   Drawings, sheets:

   1/2-2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   ☐ the language of publication of the international application (under Rule 48.3(b)).
   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been and will not be examined in respect of:

   ☐ the entire international application,

   ☒ claims Nos. 20-36,

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☒ the claims, or said claims Nos. 20-36 are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A written opinion cannot be drawn due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-3,6,19,37,38
Inventive step (IS)	Claims	1-19,37,38

Industrial applicability (IA) Claims

2. Citations and explanations
   see separate sheet

Electronic Acknowledgement Receipt

EFS ID:	10200509
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Amy Duarte
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	31-MAY-2011
Filing Date:	24-SEP-2007
Time Stamp:	18:31:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_07.pdf	449175 f2b27b78a342ae19ccbf03cb31ae4e658ea42058	yes	5

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	3	
	Information Disclosure Statement (IDS) Filed (SB/08)		4	5	
Warnings:					
Information:					
2	NPL Documents	HENKEL_Analog_Codes_for_Peak-to-Average_Ratio_Reduction.pdf	350745 2c1b320e0b94c6d90f5c272e2987ed97d0eaf570	no	5
Warnings:					
Information:					
3	NPL Documents	NARAHASHI_New_phasing_scheme_of_N_multiple_carriers.pdf	147248 8c45df546b08740ad1dd0eb9b327bfe403aa268c	no	2
Warnings:					
Information:					
4	NPL Documents	TELLADO_Revisiting_DMTs_peak-to-average_ratio.pdf	972642 df9cb589d6b86d63ba05051c152c86e9cff542a1	no	14
Warnings:					
Information:					
5	NPL Documents	TELLAMBURA_A_coding_technique_for_reducing_peak-to-average.pdf	277399 4933268ef1c93386e1aacd07f8691a3022929b4c	no	5
Warnings:					
Information:					
6	NPL Documents	TELLAMBURA_Phase_optimisation_criterion_for_reducing_peak-to-average.pdf	231957 dbae4da1faf4a5eeac61904a7b28c8b9d2088382	no	2
Warnings:					
Information:					
7	NPL Documents	VAN_EETVELT_Peak_to_average_power_reduction.pdf	193140 13b49ed5b534c38620bc3af3fd93c2ac1ea4afac	no	2
Warnings:					
Information:					
8	NPL Documents	5550-47-PCT_Written_Opinion_2001-12-18.pdf	184614 bedc3d6d7e70564f2cf26bfc6fa7930a6e0a678d	no	6
Warnings:					
Information:					

9	NPL Documents	5550-47_OA_2004-05-04.pdf	351958 09508213fd8563650b43804c9bea1773825 80dfa	no	12
Warnings:					
Information:					
10	NPL Documents	5550-47_NOA_2005-07-05.pdf	292063 25f50caab184e8ea497aa1c7adebaca49522 cd65	no	7
Warnings:					
Information:					
11	NPL Documents	5550-47- CON_NOA_2007-09-06.pdf	324363 54030f7d58e87f1b18590eac89b2b086d1d 4d7a7	no	8
Warnings:					
Information:					
		Total Files Size (in bytes):	3775304		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 2611
TZANNES, Marcos C.	)	Confirmation No.: 5967
Serial No.: 11/860,080	)	Examiner: Not Yet Assigned
Filed: September 24, 2007	)	
Atty. File No.: 5550-47-CON-DIV	)	SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
Entitled: "System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System"	)	Electronically Submitted

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. ___________ filed ________________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and/or in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☐ Examiner's attention is drawn to the following related applications:

Serial No. _________ filed _________ (Attorney Ref. No. ______)

Serial No. _________ filed _________ (Attorney Ref. No. ______)

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfied by one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☒ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 31 May 11

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Complete if Known	
Application Number	11/860,080
Filing Date	September 24, 2007
First Named Inventor	Marcos C. Tzannes
Art Unit	2611
Examiner Name	Not yet assigned
Attorney Docket Number	5550-47-CON-DIV

Sheet	1	of	1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	6519292	02/11/03	Sakoda et al.	
	2	6519929	02/18/03	Ahrendt	
	3	12/783725		Tzannes (05-20-2010)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	4	Notice of Allowance for U.S. Patent Application No. 12/255,713, mailed May 18, 2010 (Attorney's File No. 5550-47-CON-3)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt

EFS ID:	7852239
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	21-JUN-2010
Filing Date:	24-SEP-2007
Time Stamp:	10:54:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_06.pdf	331763 3831a8b9ec4826821c738b456a02f16ba73b7a85	yes	4

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	3	
	Information Disclosure Statement (IDS) Filed (SB/08)		4	4	
Warnings:					
Information:					
2	NPL Documents	5550-47-CON-3_NOA_5-18-10.pdf	881767 ee99c4b0d143cc258a1a401185159623090621eb	no	22
Warnings:					
Information:					
		Total Files Size (in bytes):	1213530		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 2611
Marcos C. Tzannes	)	Confirmation No.: 5967
Serial No.: 11/860,080	)	Examiner: Not yet assigned
Filed: September 24, 2007	)	
Atty. File No.: 5550-47-CON-DIV	)	INFORMATION DISCLOSURE STATEMENT
Entitled: "System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System"	)	Electronically Submitted

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. ___________ filed _________________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following related applications:

Serial No. 12/783725 filed 05-20-2010 (Attorney's Ref. No. 5550-47-CON-4)

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfied by one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☒ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 18 Jan '18

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	September 24, 2007
				First Named Inventor	Marcos C. Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	1	of	1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	4069392	01/17/78	Goldenberg et al.	
	2	6967997	11/22/05	Humphrey	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	3	Official Action for U.S. Patent Application No. 12/255,713, mailed October 15, 2009 (Attorney's File No. 5550-47-CON-3)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt

EFS ID:	6827858
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	18-JAN-2010
Filing Date:	24-SEP-2007
Time Stamp:	13:48:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_05.pdf	329361 c734a97f08012f1829c33acb8fe1ca3f15480ff3	yes	4

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	3	
	Information Disclosure Statement (IDS) Filed (SB/08)		4	4	
Warnings:					
Information:					
2	NPL Documents	5550-47-CON-3_OA_10-15-09.pdf	573466 dc8a44f661c43463a4823ee9ea3538767aa66aa0	no	17
Warnings:					
Information:					
			Total Files Size (in bytes):	902827	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 2611
Marcos C. Tzannes	)	Confirmation No.: 5967
Serial No.: 11/860,080	)	Examiner: Not yet assigned
Filed: September 24, 2007	)	
Atty. File No.: 5550-47-CON-DIV	)	INFORMATION DISCLOSURE STATEMENT
Entitled: "System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System"	)	Electronically Submitted

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. ___________ filed _________________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☐ Examiner's attention is drawn to the following related applications:

Serial No. __________filed __________(Attorney's Ref. No. ______)
Serial No. __________filed __________(Attorney's Ref. No. ______)

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfied by one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☒ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ______________________

Jason H. Vick
Registration No. 45285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 18 Jan '10

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 2611
Tzannes	)	Confirmation No.: 5967
Serial No.: 11/860,080	)	Examiner: Not yet assigned
Filed: 09-24-2007	)	INFORMATION DISCLOSURE STATEMENT
Atty. File No.: 5550-47-CON-DIV	)	Electronically Submitted
For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	)	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. _________ filed ___________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☒ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications,:

Serial No. 12/255713 filed 10-22-2008 (Attorney's Ref. No. 5550-47-CON-3)

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☒ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By:____________________

Jason H. Vick
Registration No. 45285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 25 Nov '08

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	1	of	1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	12/255713		Tzannes (10-22-2008)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	2	Decision of Refusal (including translation) for Japanese Patent Application No. 2001-537217, date of dispatch, November 4, 2008 (Attorney's Ref. No. 5550-47-PJP)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt

EFS ID:	4353355
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	25-NOV-2008
Filing Date:	24-SEP-2007
Time Stamp:	15:31:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_04.pdf	326906 6efb66b204231d4f798dfa6b858207755a86c9b9	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Information Disclosure Statement Letter	1	3
	Information Disclosure Statement (IDS) Filed (SB/08)	4	4

Warnings:

Information:

2	NPL Documents	5550-47-PJP_OA_11-4-08.pdf	137000 46159ab02ab5c03caf5c5b33b9a18e570e17f14f	no	3

Warnings:

Information:

Total Files Size (in bytes):	463906

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11860080
	Filing Date	2007-09-24
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
	Attorney Docket Number	5550-47-CON-DIV

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11860080
	Filing Date	2007-09-24
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
	Attorney Docket Number	5550-47-CON-DIV

	1	Notice of Allowance for U.S. Patent Application No. 11/863,581, mailed October 8, 2008 (Attorney's File No. 5550-47-CON-2)	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11860080
	Filing Date	2007-09-24
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
	Attorney Docket Number	5550-47-CON-DIV

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Jason H. Vick/	Date (YYYY-MM-DD)	2008-10-17
Name/Print	Jason H. Vick	Registration Number	45285

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	4134417
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	17-OCT-2008
Filing Date:	24-SEP-2007
Time Stamp:	16:25:58
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	IDS_03.pdf	763139 37d827e86146966725ca276c25a2d3a1ea9bfd83	no	4

Warnings:

Information:

A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.

2	NPL Documents	5550-47-CON-2_OA_10-08-08.pdf	315738 84b7306f5676758faedbf784984cb640103bafc5	no	6

Warnings:

Information:

Total Files Size (in bytes):	1078877

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	) Group Art Unit: 2611
Tzannes	) Confirmation No.: 5967
Serial No.: 11/860,080	) Examiner: Not yet assigned
Filed: 09-24-2007	) INFORMATION DISCLOSURE STATEMENT
Atty. File No.: 5550-47-CON-DIV	) Electronically Submitted
For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☐ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. _________ filed ___________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications,:

Serial No. 11/863581 filed 09-28-2007

☐ Other:______________________________

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☒ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ____________________

Jason H. Vick
Registration No. 45285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 31 Apr '18

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	11/860,080
	Filing Date	09-24-2007
	First Named Inventor	Tzannes
	Art Unit	2611
	Examiner Name	Not yet assigned
Sheet 1 of 1	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5,682,376	10/28/97	Hayashino et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	2	JP H10(1998)-084329	03/31/98	NIPPON HOSO KYOKAI		(Translated Abstract and partial translation)
	3	JP H08(1996)-321820	12/03/96	MATSUSHITA ELECTRIC IND CO LTD		(Translated Abstract)

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	4	Notification of Reasons for Refusal (including translation) for Japanese Patent Application No. 2001-537217, date of dispatch, March 3, 2008 (Attorney's Ref. No. 5550-47-PJP)
	5	Official Action for U.S. Patent Application No. 11/863,581, mailed February 6, 2008 (Attorney's File No. 5550-47-CON-2)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-084329
(43)Date of publication of application : 31.03.1998

(51)Int.Cl. H04J 11/00

(21)Application number : 08-238917
(22)Date of filing : 10.09.1996

(71)Applicant : NIPPON HOSO KYOKAI <NHK>
(72)Inventor : SATO SHOE
SAITO TOMOHIRO
MORIYAMA SHIGEKI

(54) **TRANSMISSION METHOD FOR OFDM MODULATION SIGNAL, OFDM TRANSMITTER AND RECEIVER**

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent production of distortion by spreading a reference phase of each carrier of the frequency orthogonal division multiplex (OFDM) system and changing the amplitude of each carrier of the OFDM without giving effect on transmitted information so as to suppress a peak level of signals.
SOLUTION: After multiplying a complex code series ejsk (Sk=pk2, p is an optional real number not being zero, 0≤k≤N, N is a total carrier number) with an input coded signal, inverse FFT is applied to the product to generate an OFDM modulation signal and it is transmitted. At a receiver side, a complex code series ejsk (Sk is the same as above) is multiplied with a signal resulting from FFT processing to a received signal and an OFDM demodulation signal is obtained. The information relating to the ejsk required for demodulation is included in the input coded information, or sent in advance from the transmitter side to the receiver side through other transmission line. Thus, the reference phases of each carrier of the OFDM are hardly arranged and the level of transmission signals is suppressed and the resulting signal is sent, then an operating point of amplifiers is set higher.

CLAIMS

[Claim(s)]
[Claim 1]In the transmitting side, it is a complex code sequence to an input encoded signal. [External Character 1]
e^{jS_k}

(-- the signal which they generated the OFDM modulation signal here and transmitted to it as reverse FFT of $S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and the N was carried out after they carried out the multiplication of total number of careers) here, and carried out FFT of the input signal in the receiver -- a complex code sequence [External Character 2]
e^{-jS_k}

A transmission method of an OFDM modulation signal carrying out the multiplication of (S_k is the same here to said S_k), and acquiring an OFDM demodulation signal.
[Claim 2]Said complex code sequence required for an OFDM recovery [in / on a transmission method of the OFDM signal according to claim 1, and / a receiver] [External Character 3]
e^{-jS_k}

the arbitrary real numbers $S_k=pk^2$ and whose p are not zero here. A transmission method of an OFDM modulation signal, wherein 0 <=k<=N and N include the information about the total number of careers in said input encoded signal or transmit it to a receiver beforehand from the transmitting side in transmission lines other than the transmission line for OFDM transmission concerned.
[Claim 3]It is a complex code sequence to an input encoded signal at least. [External Character 4]
e^{jS_k}

(-- the OFDM sending set which $S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and N are provided with the means which carries out the multiplication of total number of careers) here, and is characterized by things.
[Claim 4]It is a complex code sequence to a signal which carried out FFT of the input signal at least. [External Character 5]
e^{-jS_k}

(-- the OFDM receiving set which $S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and N are provided with the means which carries out the multiplication of total number of careers) here, and is characterized by things.
[Claim 5]In a transmission method of an OFDM modulation signal which generates a modulating signal of either BPSKOFDM and a QPSKOFDM modulating signal, and is transmitted, After carrying out the multiplication of two or more constants which make equal amplitude of positive [of a phase which said one of modulating signals can take], and a negative ingredient in an

amplitude peak period of one of said modulating signals according to a value of an input encoded signal, respectively, A transmission method of an OFDM modulation signal characterized by carrying out reverse FFT, generating an OFDM modulation signal, and making it transmit.
[Claim 6]In an OFDM sending set which generates a modulating signal of either BPSKOFDM and a QPSKOFDM modulating signal, and transmits, An OFDM sending set which is provided with a means which carries out the multiplication of two or more constants which make equal amplitude of positive [of a phase which said one of modulating signals can take at least], and a negative ingredient in an amplitude peak period of one of said modulating signals according to a value of an input encoded signal, respectively, and is characterized by things.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]In a broadcasting satellite, in order to use the generating electric power by a solar cell, the output of a relay amplifier has restriction, but. This invention, A transmission method and an OFDM sending set of a frequency rectangular cross division multiplex (OFDM:Orthogonal Frequency Division Multiplexing) modulating signal suitable for using it for digital broadcasting in such a satellite system (as opposed to a ground system), etc., It is related with a receiving set.
[0002]
[Problem(s) to be Solved by the Invention]Conventionally, there are phase modulations, such as BPSK and QPSK, in the modulation method of each career of OFDM. In these modulation methods, the reference phase of each career by which multiplex was carried out is constant, and, in the case of BPSK, in the case of a binary and QPSK, the phase which each modulating signal can take is restricted with four value. Therefore, in the phase of each career, by this method, the peak of amplitude may occur on a set or the OFDM time base signal which becomes empty.
[0003]For example, in the relay amplifier for broadcast, while generating electric power and amplifier efficiency have restriction, in order to secure the rate of a service period, and the rate of a place, it is used near the saturation region. In order to secure the rate of a service period, and the rate of a place also in digital broadcasting using an OFDM modulation method, to take the high operating point of an amplifier is desired. However, it is one side, and if the high operating point is taken in this way, in the amplitude peak of an OFDM modulation signal, it will become easy to generate distortion.
[0004]In the situation which has restriction in the above generating electric power and amplifier efficiency, the purpose of this invention is to suppress the amplitude peak of an OFDM signal and to perform little transmission in the high operating point.
[0005]
[Means for Solving the Problem]It is going to control an amplitude peak of a signal by diffusing a reference phase of OFDM each career, or changing amplitude of OFDM each career, without affecting information which should be transmitted in this invention, in order to attain the above-mentioned purpose. In order to make diffusion of these reference phases thru/or change of amplitude perform, in this invention, the multiplication of the specific signal (S) is carried out so that an input encoded signal may not be affected at transmitted data (a case where it amends by a receiver so that it may not be affected is included), OFDM modulation is performed based on it, and each career is transmitted.
[0006]When carrying out signal (S) multiplication and diffusing a reference phase of each career now, a phase of each career becomes difficult to gather and can be transmitted by suppressing a peak of amplitude. In this case, in a receiver, the multiplication of the signal (S^*) corresponding to a signal (S) which carried out multiplication at the above-mentioned transmitting side is carried out to an OFDM demodulation signal, and right information is restored.
[0007]When each career does not have information in amplitude directions, such as BPSK and QPSK, in carrying out the multiplication of the signal (S) at the transmitting side, transmission

which suppressed a signal peak is performed by choosing a signal (S) which carries out multiplication so that amplitude of a career with which phases produce an amplitude peak together, and a career with an ingredient of an opposite phase may be enlarged -- things can be carried out. Here, since multiplication of a signal (S) can be performed only by calculation by a discrete time, it can respond flexibly with software.
[0008]That is, a transmission method of this invention OFDM modulation signal is a complex code sequence to an input encoded signal in the transmitting side. [External Character 6]
e^{jS_k}

(-- a signal which they generated an OFDM modulation signal here and transmitted to it as reverse FFT of $S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and the N was carried out after they carried out the multiplication of total number of careers) here, and carried out FFT of the input signal in a receiver -- a complex code sequence [External Character 7]
e^{-jS_k}

The multiplication of (S_k is the same here to said S_k) is carried out, and the OFDM demodulation signal was acquired.
[0009]Said complex code sequence which needs the transmission method of this invention OFDM modulation signal for the OFDM recovery in a receiver [External Character 8]
e^{-jS_k}

the arbitrary real numbers $S_k=pk^2$ and whose p are not zero here. 0 <=k<=N and N include the information about the total number of careers in said input encoded signal, or transmitted it to the receiver beforehand from the transmitting side in transmission lines other than the transmission line for OFDM transmission concerned.
[0010]this invention OFDM sending set is a complex code sequence to an input encoded signal at least. [External Character 9]
e^{jS_k}

($S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and N are provided with the means which carries out the multiplication of total number of careers) here
[0011]this invention OFDM receiving set is a complex code sequence to the signal which carried out FFT of the input signal at least. [External Character 10]
e^{-jS_k}

($S_k=pk^2$, the arbitrary real numbers whose p is not zero, 0 <=k<=N, and N are provided with the means which carries out the multiplication of total number of careers) here
[0012]A transmission method of this invention OFDM modulation signal, In a transmission method of an OFDM modulation signal which generates a modulating signal of either BPSKOFDM and a QPSKOFDM modulating signal, and is transmitted, After carrying out the multiplication of two or more constants which make equal amplitude of positive [of a phase which said one of modulating signals can take], and a negative ingredient in an amplitude peak period of one of said modulating signals according to a value of an input encoded signal, respectively, Reverse FFT is carried out, an OFDM modulation signal is generated, and it was made to transmit.
[0013]In an OFDM sending set which this invention OFDM sending set generates a modulating signal of either BPSKOFDM and a QPSKOFDM modulating signal, and transmits, It has a means which carries out the multiplication of two or more constants which make equal amplitude of positive [of a phase which said one of modulating signals can take at least], and a negative ingredient in an amplitude peak period of one of said modulating signals according to a value of an input encoded signal, respectively.
[0014]
[Embodiment of the Invention]With reference to an accompanying drawing, this invention is explained in detail based on an embodiment of the invention below. Drawing 1 is a transmission

code series (input encoded signal).
[External Character 11]

$\dot{X}_k$

**** – To the signal which carried out the parallel conversion, it is an example of a numerals system. [External Character 12]

$\dot{S}_k$

(book specification preceding paragraph shows one embodiment of the OFDM sending set by this invention which only carries out the multiplication of (having expressed with S)), and is transmitted. This embodiment is an embodiment which diffuses a phase to BPSKOFDM and controls a signal peak.
[0015]In drawing 1, it is a code sequence as an input encoded signal. [External Character 13]

$\dot{X}_k$

Direct in the serial/parallel conversion machine 1 – Carry out a parallel conversion and it is made a parallel signal, Furthermore, an OFDM modulation signal is acquired from an output terminal of the converter 3 via reverse FFT circuit (Invers Fast Fourier Transform circuit) 2 and the parallel serial change machine 3. It is a process of the usual OFDM modulation signal generation so far (however, when there is no multiplier 4 in drawing 1).
[0016]On the other hand, a code sequence which the multiplier 4 is inserted, respectively between each parallel line between the serial/parallel conversion machine 1 and the reverse FFT (IFFT) circuit 2, and is an input encoded signal as this invention is shown in drawing 1[External Character 14]

$\dot{X}_k$

Code sequence [External Character 15]

$\dot{S}_k$

Multiplication is performed in between and the multiplication result is supplied to reverse FFT circuit 2. The composition of drawing 1 is [in / are an example and / this invention] a code sequence. [External Character 16]

$\dot{X}_k$

It is alike and a code sequence. [External Character 17]

$\dot{S}_k$

What is necessary is just the composition by which multiplication is carried out to ******, and it is not necessary to follow circuit arrangement shown in drawing 1.
[0017]Here, it is an input code sequence. [External Character 18]

$\dot{X}_k$

It is a code sequence of ** and the binary (–either 1 or 1 is taken) of N pieces, and is a code sequence. [External Character 19]

$\dot{S}_k$

********** [External Character 20]

$\dot{X}_k$

A complex code sequence at least for ** to diffuse a phase [External Character 21]

e^{jS_k}

It comes out. S_k is a known series beforehand in a receiver, for example, the time delay of each career is proportional to frequency -- as [Equation 1]
$S_k = p k^2$

However, the arbitrary real numbers whose p is not zero, 0 <=K<=N, and N are the total numbers of careers.
In this way, the input code sequence of a binary [External Character 22]
$\dot{X}_k$

A compound code sequence for ** and phase diffusion [External Character 23]
e^{iS_k}

Multiplication is mutually carried out by the multiplier 4. The OFDM modulation signal by which phase diffusion was carried out as a result of multiplication
[External Character 24]
$\dot{T}_k$

It is obtained by the output terminal of the ** parallel serial converter 3.
[0018]Drawing 2 (a) and (b) is a code sequence (complex code sequence) to the BPSKOFDM modulating-signal generate time mentioned above.
[External Character 25]
$\dot{S}_k$

An example of a constellation of each career of a modulating signal a time (the usual BPSKOFDM) of not carrying out multiplication and when multiplication is carried out by this invention is shown, respectively. Drawing 3 (a) and (b) shows an example of a signal wave form of an OFDM modulation signal corresponding to them, respectively. It turns out that it is transmitted as a signal (drawing 3 (b)) with which a phase of each career becomes difficult to gather compared with a case where phase diffusion of the time base waveform of a signal by which phase diffusion was carried out is not carried out (drawing 2 (b)), and a peak of amplitude was suppressed from drawing 2 and drawing 3.
[0019]A signal which carried out FFT of the input signal with which drawing 4 received a signal (that is, phase diffusion was carried out and transmitted) transmitted by an above-mentioned method
[External Character 26]
$\dot{R}_k$

It is alike and is a complex code sequence. [External Character 27]
$\dot{S}_k^*$

(-- this specification preceding paragraph -- only (S*) -- a table -- the bottom --) -- carrying out multiplication -- a right received code series [External Character 28]
$\dot{X}_k$

One embodiment of an OFDM receiving set by this invention to restore is shown.
[0020]In drawing 4, it is an input signal.
[External Character 29]
$\dot{R}_k$

Direct in the serial/parallel conversion machine 5 - A parallel conversion is carried out, it is made a parallel signal, and an OFDM recovery is further carried out in FFT circuit 6. It is a complex code sequence to this OFDM demodulation signal to which it restored. [External

Character 30]

$\dot{S}_k^*$

Each multiplier 7 for carrying out multiplication is arranged between FFT circuit (fast Fourier Transform circuit) 6 and the parallel serial conversion circuit 8.
[0021]Complex code sequence [External Character 31]

$\dot{S}_k^*$

It is a complex code sequence at ** and the transmitting side at the time of OFDM modulation.
[External Character 32]

e^{jS_k}

The signal with which phase diffusion also of the receiver was carried out since multiplication was carried out and phase diffusion of the modulated wave was carried out will be received, and it is a right received code series as it is. [External Character 33]

$\dot{X}_k$

Specifically at the code sequence for carrying out reverse correction of it becoming impossible to restore, it is a complex code sequence. [External Character 34]

e^{-jS_k}

(S_k is a known series beforehand in a receiver, for example, is $S_k=k^2$;, however 0<=K<=N(N: total number of careers)). A code sequence restored eventually [External Character 35]

$\dot{X}_k$

It is a code sequence of 1 or 1 [−] of k **.
[0022]Thereby, it is an input signal.
[External Character 36]

$\dot{R}_k$

FFT is carried out by FFT6 through the ** serial/parallel conversion 5, and it is inputted into the multiplication terminal of the multiplier 7. On the other hand, it is a code sequence of a reverse correction sake about phase diffusion. [External Character 37]

$\dot{S}_k^*$

In ********, it is known beforehand and is inputted into a multiplication terminal of the multiplier 7. In an output multiplier, it is a received code series of a binary (−1, 1). [External Character 38]

$\dot{X}_k$

It ****** and is taken out via the parallel serial converter 8.
[0023]The complex code sequence which is needed above by a receiver for a right OFDM recovery [External Character 39]

e^{-jS_k}

It must be transmitted to a receiver in ** and a certain form. This is a complex code sequence.
[External Character 40]

e^{-jS_k}

The very thing is not transmitted but information which it can reproduce by a receiver should just be sent. As a transmission method, it is made to contain in an input encoded signal at the transmitting side, and transmits in a transmitted symbol, or may transmit in a transmission line different from it.
[0024]A code sequence used in this invention when performing OFDM modulation and a recovery

by drawing 1 and drawing 4, respectively [External Character 41]

$\dot{S}_k$

[External Character 42]

$\dot{S}_k^*$

** -- a transmission code series a peak is still more apt to break off even if this changes a transmission code series for every symbol by a known method at the transmitting side, and transmits by performing phase diffusion and it is made to carry out reverse correction by a receiver, although it was considered as a regularity (it does not change) thing in time [External Character 43]

$\dot{X}_k$

Being spread is possible.
[0025]In consideration of the case where the amplitude of each career of an OFDM signal has information in the above-mentioned example (actually, in BPSKOFDM of the above-mentioned example, it does not have, but in the case of the multiple value QAMOFDM, it has information), it is the transmitting side and is a complex code sequence. [External Character 44]

$\dot{S}_k$

Since multiplication is carried out, and the topology will be lost if phase diffusion is carried out, in order to recover this, it is a receiver, and it is a complex code sequence. [External Character 45]

$\dot{S}_k^*$

Multiplication was carried out.
[0026]On the other hand, in BPSKOFDM and QPSKOFDM, there is information only in the phase of each career and it does not have information in the amplitude direction of each career. Then, in BPSKOFDM, it is drawing 1, for example. [External Character 46]

$\dot{S}_k$

It carries out and is a transmission code series. [External Character 47]

$\dot{X}_k$

case $N/(2N_1)$ of ** 1, and a case of 1 [-] -- $N/(2N_2)$ -- the multiplication of the constant shall be carried out to a transmission code series (equivalent to an input encoded signal), respectively It is here, and N is symbol length and N_1 and N_2 is in a symbol, respectively.
[External Character 48]

$\dot{X}_k$

It is the number of ** 1 and-1. By carrying out like this, it is a transmission signal.
[External Character 49]

$\dot{T}_k$

Since a size of an ingredient 1, -1 or positive, and negative becomes equal at a ****** peak period, a peak of amplitude can be suppressed and transmitted like the above-mentioned example. In this case, in a receiver, since it does not have information in an amplitude direction of each career, reverse correction of career diffusion for right decoding is not needed.
[0027]
[Effect of the Invention]According to this invention, as explained above, also in the amplifier which has restriction in generating electric power, such as satellite broadcasting, it has the purpose of securing a hour rate and the rate of a place, and even if it makes it operate in the

higher operating point, it becomes possible to carry out little distorted OFDM transmission.

[Translation done.]

(19)日本国特許庁（JP）　(12) 公開特許公報（A）　(11)特許出願公開番号

特開平10－84329

(43)公開日　平成10年(1998) 3月31日

(51)Int.Cl.⁶	識別記号	庁内整理番号	FI		技術表示箇所
H04J　11/00			H04J　11/00	Z	

審査請求　未請求　請求項の数6　OL　（全 7 頁）

(21)出願番号　特願平8－238917

(22)出願日　平成8年(1996) 9月10日

(71)出願人　000004352
日本放送協会
東京都渋谷区神南2丁目2番1号

(72)発明者　佐藤　庄衛
東京都世田谷区砧1丁目10番11号　日本放送協会　放送技術研究所内

(72)発明者　斉藤　知弘
東京都世田谷区砧1丁目10番11号　日本放送協会　放送技術研究所内

(72)発明者　森山　繁樹
東京都世田谷区砧1丁目10番11号　日本放送協会　放送技術研究所内

(74)代理人　弁理士　杉村　暁秀　（外3名）

(54)【発明の名称】　OFDM変調信号の伝送方法およびOFDM送信装置、受信装置

(57)【要約】　（修正有）

【課題】　OFDM変調方式を用いたディジタル放送において、サービス時間率、場所率を確保するためには増幅器の動作点を高くとると、OFDM変調信号のピークにおいて歪みを発生し易くなる。

【解決手段】　送信側においては、入力符号化信号

$\dot{X}_k$

に複素符号系列

e^{jS_k}

（ここに、$S_k = pk^2$，pはゼロでない任意の実数、$0 \leq k \leq N$, Nは総キャリア数）を乗算（4）した後逆FFT（2）するようにしてOFDM変調信号

$\dot{T}_k$

を生成して送信し、受信側においては、受信信号をFFTした信号に複素符号系列

e^{-jS_k}

（ここに、S_k は上記S_k に同じ）を乗算してOFDM復調出力信号を得るようにした。

1

【特許請求の範囲】

【請求項1】　送信側においては、入力符号化信号に複素符号系列

【外1】

$$e^{jS_k}$$

（ここに、$S_k=pk^2$，pはゼロでない任意の実数、$0\leqq k\leqq N$，Nは総キャリア数）を乗算した後逆ＦＦＴするようにしてＯＦＤＭ変調信号を生成して送信し、

受信側においては、受信信号をＦＦＴした信号に複素符号系列

【外2】

$$e^{-jS_k}$$

（ここに、S_kは前記S_kに同じ）を乗算してＯＦＤＭ復調信号を得るようにしたことを特徴とするＯＦＤＭ変調信号の伝送方法。

【請求項2】　請求項1記載のＯＦＤＭ信号の伝送方法において、受信側におけるＯＦＤＭ復調のために必要な前記複素符号系列

【外3】

$$e^{-jS_k}$$

（ここに、$S_k=pk^2$，pはゼロでない任意の実数、$0\leqq k\leqq N$，Nは総キャリア数）に関する情報を、前記入力符号化信号に含ませ、または当該ＯＦＤＭ伝送用伝送路以外の伝送路にて送信側から受信側に予め伝送するようにしたことを特徴とするＯＦＤＭ変調信号の伝送方法。

【請求項3】　少なくとも入力符号化信号に複素符号系列

【外4】

$$e^{jS_k}$$

（ここに、$S_k=pk^2$，pはゼロでない任意の実数、$0\leqq k\leqq N$，Nは総キャリア数）を乗算する手段を具えてなることを特徴とするＯＦＤＭ送信装置。

【請求項4】　少なくとも受信信号をＦＦＴした信号に複素符号系列

【外5】

$$e^{-jS_k}$$

（ここに、$S_k=pk^2$，pはゼロでない任意の実数、$0\leqq k\leqq N$，Nは総キャリア数）を乗算する手段を具えてなることを特徴とするＯＦＤＭ受信装置。

【請求項5】　ＢＰＳＫＯＦＤＭおよびＱＰＳＫＯＦＤＭ変調信号のいずれかの変調信号を生成して送信するＯＦＤＭ変調信号の伝送方法において、前記いずれかの変調信号がとりうる位相の正と負の成分の振幅を、前記いずれかの変調信号の振幅ピーク時において等しくするような複数の定数を入力符号化信号の値に応じてそれぞれ乗算した後、逆ＦＦＴしてＯＦＤＭ変調信号を生成して送信するようにしたことを特徴とするＯＦＤＭ変調信号の伝送方法。

【請求項6】　ＢＰＳＫＯＦＤＭおよびＱＰＳＫＯＦＤＭ変調信号のいずれかの変調信号を生成して送信するＯＦＤＭ送信装置において、少なくとも前記いずれかの変調信号がとりうる位相の正と負の成分の振幅を、前記いずれかの変調信号の振幅ピーク時において等しくするような複数の定数を入力符号化信号の値に応じてそれぞれ乗算する手段を具えてなることを特徴とするＯＦＤＭ送信装置。

2

【発明の詳細な説明】

【0001】

【発明の属する技術分野】放送衛星においては、太陽電池による発生電力を使用するため、中継増幅器の出力に制限があるが、本発明は、そのような衛星系（地上系に対して）でのディジタル放送等に使用するのに適している周波数直交分割多重（ＯＦＤＭ：Orthogonal Frequency Division Multiplexing）変調信号の伝送方法およびＯＦＤＭ送信装置、受信装置に関する。

【0002】

【発明が解決しようとする課題】従来、ＯＦＤＭの各キャリアの変調方式には、ＢＰＳＫ，ＱＰＳＫなどの位相変調がある。これらの変調方式では多重された各キャリアの基準位相は一定であり、各変調信号のとりうる位相はＢＰＳＫの場合2値、ＱＰＳＫの場合4値と限られている。従って、この方式では各キャリアの位相がそろいやすく、ＯＦＤＭ時間軸信号上に振幅のピークが発生する場合がある。

【0003】例えば、放送用中継増幅器においては、発生電力、増幅器効率に制限があるなかでサービス時間率、場所率を確保するために飽和領域付近で使用されている。また、ＯＦＤＭ変調方式を用いたディジタル放送においてもサービス時間率、場所率を確保するためには増幅器の動作点を高くとることが望まれる。しかし一方で、このように動作点を高くとると、ＯＦＤＭ変調信号の振幅ピークにおいて歪みを発生し易くなる。

【0004】本発明の目的は、上記のような発生電力、増幅器効率に制限がある状況において、ＯＦＤＭ信号の振幅ピークを抑え高い動作点で歪みの少ない伝送を行うことにある。

【0005】

【課題を解決するための手段】上記目的を達成するため、本発明においては、伝送すべき情報に影響を与えることなく、ＯＦＤＭ各キャリアの基準位相を拡散させ、または、ＯＦＤＭ各キャリアの振幅を変化させることによって信号の振幅ピークを抑制しようとするものである。これら基準位相の拡散、ないし振幅の変化を行わせるために、本発明では、入力符号化信号に伝送情報に影響を与えないように（受信側で、影響を与えないように補正する場合を含む）特定の信号（Ｓ）を乗算し、それをもとにＯＦＤＭ変調を行い、各キャリアの伝送を行う。

【0006】いま、信号（Ｓ）乗算して各キャリアの基

準位相を拡散させる場合、各キャリアの位相はそろいにくくなり、振幅のピークを抑えて伝送を行うことができる。この場合、受信側において、上記送信側で乗算した信号（S）に対応した信号（S^*）をＯＦＤＭ復調信号に乗算して正しい情報を復元するようにする。

【０００７】また、各キャリアがＢＰＳＫ，ＱＰＳＫなど振幅方向に情報を持たない場合、送信側で信号（S）を乗算するにあたり、位相がそろって振幅ピークを生じるキャリアと逆位相の成分を持つキャリアの振幅を大きくするように乗算する信号（S）を選ぶことによって、信号ピークを抑えた伝送を行うことできる。ここで、信号（S）の乗算は離散時間での計算だけで行うことができるため、ソフトウェアによって柔軟に対応することができる。

【０００８】すなわち、本発明ＯＦＤＭ変調信号の伝送方法は、送信側においては、入力符号化信号に複素符号系列

【外６】

$$e^{jS_k}$$

（ここに、$S_k = pk^2$，ｐはゼロでない任意の実数、$0 \leqq k \leqq N$，Ｎは総キャリア数）を乗算した後逆ＦＦＴするようにしてＯＦＤＭ変調信号を生成して送信し、受信側においては、受信信号をＦＦＴした信号に複素符号系列

【外７】

$$e^{-jS_k}$$

（ここに、S_k は前記S_k に同じ）を乗算してＯＦＤＭ復調信号を得るようにしたことを特徴とするものである。

【０００９】また、本発明ＯＦＤＭ変調信号の伝送方法は、受信側におけるＯＦＤＭ復調のために必要な前記複素符号系列

【外８】

$$e^{-jS_k}$$

（ここに、$S_k = pk^2$，ｐはゼロでない任意の実数、$0 \leqq k \leqq N$，Ｎは総キャリア数）に関する情報を、前記入力符号化信号に含ませ、または当該ＯＦＤＭ伝送用伝送路以外の伝送路にて送信側から受信側に予め伝送するようにしたことを特徴とするものである。

【００１０】また、本発明ＯＦＤＭ送信装置は、少なくとも入力符号化信号に複素符号系列

【外９】

$$e^{jS_k}$$

（ここに、$S_k = pk^2$，ｐはゼロでない任意の実数、$0 \leqq k \leqq N$，Ｎは総キャリア数）を乗算する手段を具えてなることを特徴とするものである。

【００１１】また、本発明ＯＦＤＭ受信装置は、少なくとも受信信号をＦＦＴした信号に複素符号系列

【外１０】

$$e^{-jS_k}$$

（ここに、$S_k = pk^2$，ｐはゼロでない任意の実数、$0 \leqq k \leqq N$，Ｎは総キャリア数）を乗算する手段を具えてなることを特徴とするものである。

【００１２】また、本発明ＯＦＤＭ変調信号の伝送方法は、ＢＰＳＫＯＦＤＭおよびＱＰＳＫＯＦＤＭ変調信号のいずれかの変調信号を生成して送信するＯＦＤＭ変調信号の伝送方法において、前記いずれかの変調信号がとりうる位相の正と負の成分の振幅を、前記いずれかの変調信号の振幅ピーク時において等しくするような複数の定数を入力符号化信号の値に応じてそれぞれ乗算した後、逆ＦＦＴしてＯＦＤＭ変調信号を生成して送信するようにしたことを特徴とするものである。

【００１３】また、本発明ＯＦＤＭ送信装置は、ＢＰＳＫＯＦＤＭおよびＱＰＳＫＯＦＤＭ変調信号のいずれかの変調信号を生成して送信するＯＦＤＭ送信装置において、少なくとも前記いずれかの変調信号がとりうる位相の正と負の成分の振幅を、前記いずれかの変調信号の振幅ピーク時において等しくするような複数の定数を入力符号化信号の値に応じてそれぞれ乗算する手段を具えてなることを特徴とするものである。

【００１４】

【発明の実施の形態】以下に添付図面を参照し、発明の実施の形態に基づいて本発明を詳細に説明する。図１は、送信符号系列（入力符号化信号）

【外１１】

$$\dot{X}_k$$

を直－並列変換した信号に、符号系列

【外１２】

$$\dot{S}_k$$

（本明細書前段では、単に（S）にて表した）を乗算して伝送する本発明によるＯＦＤＭ送信装置の一実施形態を示している。なお、本実施形態は、ＢＰＳＫＯＦＤＭに位相の拡散を行って信号ピークを抑制する実施形態である。

【００１５】図１において、入力符号化信号としての符号系列

【外１３】

$$\dot{X}_k$$

をシリアル－パラレル変換器１において直－並列変換して並列信号にし、さらに逆ＦＦＴ回路（Invers Fast Fourier Transform circuit）２およびパラレル－シリアル変化器３を介して変換器３の出力端子からＯＦＤＭ変調信号が得られる。ここまでは通常のＯＦＤＭ変調信号発生のプロセスである（但し、図１において乗算器４がない場合）。

【００１６】これに対し、本発明においては、図１に示すように、シリアル－パラレル変換器１と逆ＦＦＴ（Ｉ

ＦＦＴ）回路２との間の各並列線の間にそれぞれ乗算器４を介挿し、入力符号化信号である符号系列

【外１４】

$$\dot{X}_k$$

と符号系列

【外１５】

$$\dot{S}_k$$

との間で乗算を行い、その乗算結果が逆ＦＦＴ回路２に供給されるようにする。なお、図１の構成は一例であり、本発明においては、符号系列

【外１６】

$$\dot{X}_k$$

に符号系列

【外１７】

$$\dot{S}_k$$

が相互に乗算されるような構成であればよく、図１に示す回路配置に従う必要はない。

【００１７】ここで、入力符号系列

【外１８】

$$\dot{X}_k$$

は、Ｎ個の２値（１，－１のいずれかをとる）の符号系列であり、符号系列

【外１９】

$$\dot{S}_k$$

は符号系列

【外２０】

$$\dot{X}_k$$

の位相を拡散するための複素符号系列

【外２１】

$$e^{jS_k}$$

である。（S_k は受信側で予め既知の系列であり、例えば、各キャリアの遅れ時間が周波数に比例するように、

【数１】

$$S_k = p k^2$$

ただし、ｐはゼロでない任意の実数、０≦Ｋ≦Ｎ，Ｎは総キャリア数である。）

こうして、２値の入力符号系列

【外２２】

$$\dot{X}_k$$

は、位相拡散のための複合符号系列

【外２３】

$$e^{jS_k}$$

と乗算器４によって相互に乗算される。乗算の結果、位相拡散されたＯＦＤＭ変調信号

【外２４】

$$\dot{T}_k$$

がパラレルーシリアル変換器３の出力端子に得られる。

【００１８】図２（ａ），（ｂ）は、上述したＢＰＳＫＯＦＤＭ変調信号生成時に符号系列（複素符号系列）

【外２５】

$$\dot{S}_k$$

を乗算しない（通常のＢＰＳＫＯＦＤＭ）ときと、本発明によって乗算したときの変調信号の各キャリアのコンスタレーションの一例をそれぞれ示している。また、図３（ａ），（ｂ）は、それらに対応したＯＦＤＭ変調信号の信号波形の一例をそれぞれ示している。図２および図３から、位相拡散された信号の時間軸波形は、位相拡散されない場合に比べ各キャリアの位相がそろいにくくなり（図２（ｂ））、振幅のピークが抑えられた信号（図３（ｂ））として伝送されることが分かる。

【００１９】図４は、上述の方法で送信された（すなわち、位相拡散して送信された）信号を受信した受信信号をＦＦＴした信号

【外２６】

$$\dot{R}_k$$

に複素符号系列

【外２７】

$$\dot{S}_k^*$$

（本明細書前段では、単に（S^*）で表した）を乗算して正しい受信符号系列

【外２８】

$$\dot{X}_k$$

を復元する本発明によるＯＦＤＭ受信装置の一実施形態を示している。

【００２０】図４において、受信信号

【外２９】

$$\dot{R}_k$$

をシリアルーパラレル変換器５において直ー並列変換して並列信号にし、さらにＦＦＴ回路６においてＯＦＤＭ復調する。この復調されたＯＦＤＭ復調信号に複素符号系列

【外３０】

$$\dot{S}_k^*$$

を乗算するための各乗算器７がＦＦＴ回路（fast Fourier Transform circuit）６とパラレルーシリアル変換回

路８との間に配置される。

【００２１】複素符号系列

【外３１】

$$\dot{S}_k^*$$

は、送信側でＯＦＤＭ変調時に複素符号系列

【外３２】

$$e^{j S_k}$$

を乗算し、変調波を位相拡散させたため、受信側でも位相拡散された信号が受信されてしまい、そのままでは正しい受信符号系列

【外３３】

$$\dot{X}_k$$

を復元できなくなるのを逆補正するための符号系列で、具体的には、複素符号系列

【外３４】

$$e^{-j S_k}$$

（S_k は受信側で予め既知の系列であり、例えば、$S_k = k^2$ ；ただし$0 \leqq K \leqq N$（Ｎ：総キャリア数））である。また、最終的に復元される符号系列

【外３５】

$$\dot{X}_k$$

はｋ個の１または−１の符号系列である。

【００２２】これにより、受信信号

【外３６】

$$\dot{R}_k$$

はシリアル−パラレル変換５を経てＦＦＴ６によりＦＦＴされ乗算器７の被乗算端子に入力される。一方、位相拡散を逆補正ための符号系列

【外３７】

$$\dot{S}_k^*$$

は受信側において予め既知であり、乗算器７の乗算端子に入力される。乗算器出力には２値（−１，１）の受信符号系列

【外３８】

$$\dot{X}_k$$

が復元され、パラレル−シリアル変換器８を介して取り出される。

【００２３】以上において、正しいＯＦＤＭ復調のために受信側で必要となる複素符号系列

【外３９】

$$e^{-j S_k}$$

は、何らかのかたちで受信側に伝送されなければならない。これは複素符号系列

【外４０】

$$e^{-j S_k}$$

そのものを伝送するのでなく、それが受信側で再現できる情報が送られればよい。伝送方法としては、送信側で入力符号化信号に含ませ、伝送済みのシンボルの中で伝送しておくか、それとは別の伝送路で伝送してもよい。

【００２４】また、図１、図４でそれぞれＯＦＤＭ変調および復調を行う際に本発明において使用する符号系列

【外４１】

$$\dot{S}_k$$

【外４２】

$$\dot{S}_k^*$$

は時間的に一定（変化しない）ものとしたが、これは、送信符号系列を送信側で既知の方法でシンボルごとに変化させ位相拡散を行って伝送し、受信側で逆補正するようにしても、なおピークのたちやすい送信符号系列

【外４３】

$$\dot{X}_k$$

を拡散することが可能である。

【００２５】上述例においては、ＯＦＤＭ信号の各キャリアの振幅が情報をもつ場合を考慮して（実際には、上述例のＢＰＳＫＯＦＤＭの場合はもたないが、多値ＱＡＭＯＦＤＭの場合には情報をもつ）、送信側で複素符号系列

【外４４】

$$\dot{S}_k$$

を乗算して位相拡散させると、その位相情報が失われるため、これを回復させるために受信側で複素符号系列

【外４５】

$$\dot{S}_k^*$$

を乗算した。

【００２６】これに対し、ＢＰＳＫＯＦＤＭ，ＱＰＳＫＯＦＤＭなどでは各キャリアの位相のみに情報があり、各キャリアの振幅方向には情報をもたない。そこで、例えばＢＰＳＫＯＦＤＭの場合、図１の

【外４６】

$$\dot{S}_k$$

として、送信符号系列

【外４７】

$$\dot{X}_k$$

が１の場合$N/(2N_1)$、また、−１の場合$N/(2N_2)$なる定数をそれぞれ送信符号系列（入力符号化信号に相当）に乗算するものとする。ここで、Ｎはシンボル長、N_1，N_2 はそれぞれシンボル中の

【外４８】

$$\dot{X}_k$$

の１，−１の個数である。こうすることにより、伝送信号

【外４９】

$$\dot{T}_k$$

の振幅ピーク時には１と−１あるいは正と負の成分の大きさが等しくなるため、前述例と同様に振幅のピークを抑えて伝送することができる。この場合、受信側では、各キャリアの振幅方向には情報をもたないため、正しい符号復元のためのキャリア拡散の逆補正を必要としない。

【００２７】

【発明の効果】以上説明したように、本発明によれば、衛星放送などの発生電力に制限のある増幅器においても、時間率、場所率を確保する目的をもって、より高い＊動作点で動作させても歪の少ないＯＦＤＭ伝送をすることが可能となる。

【図面の簡単な説明】

【図１】本発明によるＯＦＤＭ送信装置の一実施形態を示している。

【図２】従来および本発明によるＯＦＤＭ変調信号の各キャリアのコンスタレーションの一例を示している。

【図３】従来および本発明によるＯＦＤＭ変調信号の信号波形の一例を示している。

【図４】本発明によるＯＦＤＭ受信装置の一実施形態を示している。

【符号の説明】

１，５　シリアル−パラレル変換器

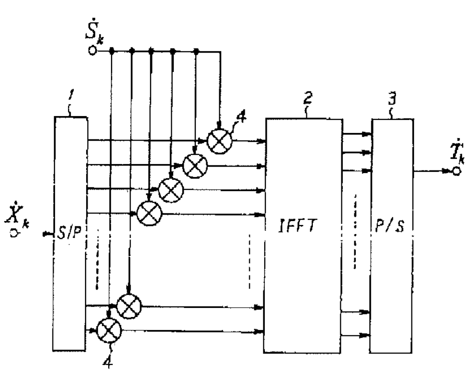
２　逆ＦＦＴ回路

３，８　パラレル−シリアル変換器

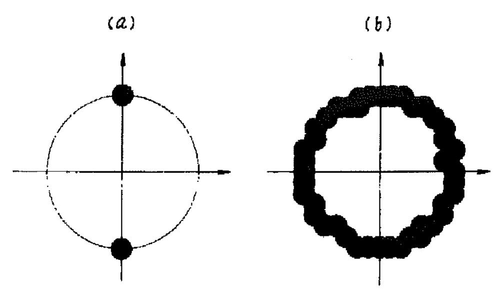
４，７　乗算器

６　ＦＦＴ回路

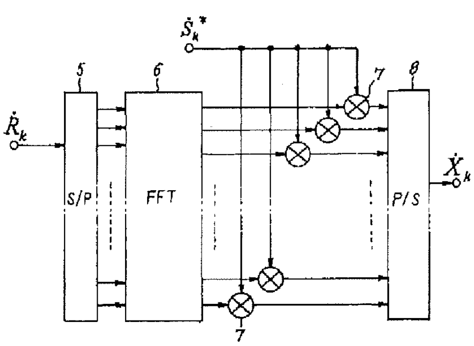
【図１】



【図２】

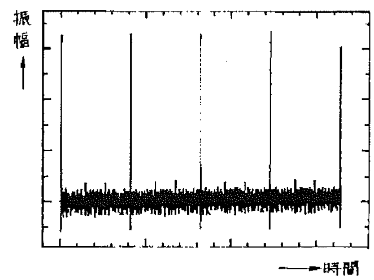


【図４】

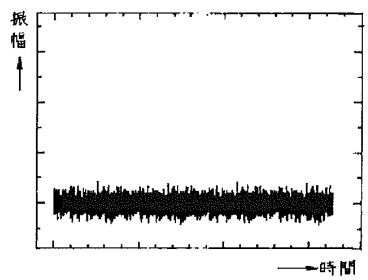


【図3】

(a)



(b)



(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: **08321820 A**
(43) Date of publication of application: **03.12.1996**

(51) Int. Cl **H04J 11/00**
H04J 1/00

(21) Application number: **07325996**
(22) Date of filing: **14.12.1995**
(30) Priority: **20.12.1994 JP 06316900**
20.03.1995 JP 07 60732

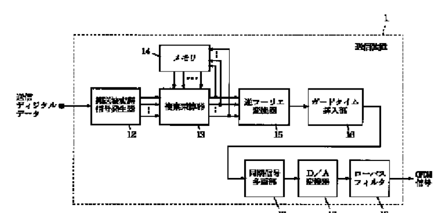
(71) Applicant: **MATSUSHITA ELECTRIC IND CO LTD**
(72) Inventor: **HAYASHINO YUJI**
UNO YASUHIRO
HARADA YASUO
KIMURA TOMOHIRO
OUE YUJI

(54) **TRANSMISSION METHOD FOR ORTHOGONAL FREQUENCY DIVISION/ MULTIPLEX SIGNAL AND ITS TRANSMITTER AND/RECEIVER**

(57) Abstract:

PURPOSE: To effectively remove waveform distortion occurred in a data component on the frequency axis of respective symbols by means of a multipath and the like at the time of transmitting an OFDM signals.

CONSTITUTION: In a transmission device 1, a complex multiplier 13 complex-multiplies a carrier modulation signal group by a complex number signal group which has a previously decided special pattern and in which the phase changes at random. An inverse Fourier transformer 15 executes inverse Fourier transform against the output of the complex multiplier 13, and transforms a digital signal multiplexed on the frequency axis into the OFDM signal of a time axis. A guard time insertion part 16 adds front guard time to the front parts of the respective symbols of the OFDM signal and rear guard time to rear parts. Data similar to the trailing end part of the corresponding symbol is included in front guard time, and data similar to the front end part of the corresponding symbol is included in rear guard time. The OFDM signals to which front guard time and rear guard time are added are transformed into analog signals and are transmitted to a reception-side. The reception-side executes a processing inverse to a transmission-side and therefore distortion owing to time delay is removed.



(19)日本国特許庁（ＪＰ）　　(12) **公開特許公報**（Ａ）　　(11)特許出願公開番号

特開平8－321820

(43)公開日　平成８年(1996)12月３日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０４Ｊ　11/00			Ｈ０４Ｊ　11/00	Ｚ
1/00			1/00	

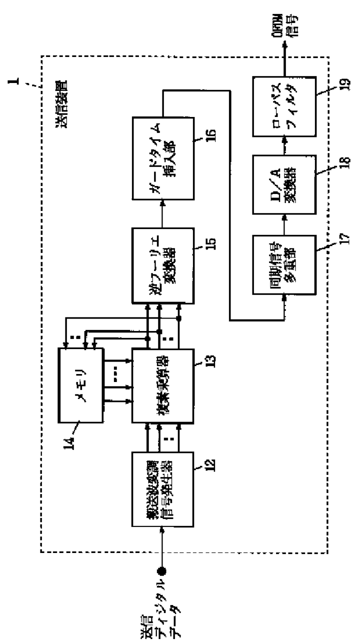
審査請求　未請求　請求項の数12　ＯＬ　（全 14 頁）

(21)出願番号	特願平7－325996	(71)出願人	000005821 松下電器産業株式会社 大阪府門真市大字門真1006番地
(22)出願日	平成７年(1995)12月14日	(72)発明者	林野　裕司 大阪府門真市大字門真1006番地　松下電器産業株式会社内
(31)優先権主張番号	特願平6－316900	(72)発明者	宇野　矢壽弘 大阪府門真市大字門真1006番地　松下電器産業株式会社内
(32)優先日	平６(1994)12月20日	(72)発明者	原田　泰男 大阪府門真市大字門真1006番地　松下電器産業株式会社内
(33)優先権主張国	日本（ＪＰ）	(74)代理人	弁理士　小笠原　史朗
(31)優先権主張番号	特願平7－60732		
(32)優先日	平７(1995)３月20日		
(33)優先権主張国	日本（ＪＰ）		

最終頁に続く

(54)【発明の名称】　直交周波数分割多重信号の伝送方法ならびにその送信装置および受信装置

(57)【要約】
【課題】　ＯＦＤＭ信号を伝送する際に、マルチパス等によって各シンボルの周波数軸上のデータ成分に生じる波形歪みを効果的に除去することである。
【解決手段】　送信装置において、複素乗算器１３は、搬送波変調信号群と、予め定められた特定パターンを有しかつその位相がランダムに変化している複素数信号群とを複素乗算する。逆フーリエ変換器１５は、複素乗算器１３の出力に対して逆フーリエ変換を施し、周波数軸上で多重されたディジタル信号を、時間軸上のＯＦＤＭ信号に変換する。ガードタイム挿入部１６は、ＯＦＤＭ信号の各シンボルの前部に前部ガードタイムを、後部に後部ガードタイムを付加する。前部ガードタイムには対応するシンボルの後端部と同じデータが含められ、後部ガードタイムには対応するシンボルの前端部と同じデータが含められる。前部ガードタイムおよび後部ガードタイムが付加されたＯＦＤＭ信号は、アナログ信号に変換された後、受信側に伝送される。受信側で送信側と逆の処理を行うことにより、時間遅延による歪みが除去される。



【特許請求の範囲】

【請求項１】　有線または無線の伝送路を介し、送信側から受信側に対して、所定長のシンボル毎に直交周波数分割多重信号を伝送する方法であって、

周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定する搬送波変調信号群をシンボル毎に逆フーリエ変換することにより、時間軸上の前記直交周波数分割多重信号に変換する第１のステップと、

前記直交周波数分割多重信号の各シンボルに対し、その前部にその後端部と同じデータを含む前部ガードタイムを付加するとともに、その後部にその前端部と同じデータを含む後部ガードタイムを付加して、前記受信側に送信する第２のステップとを備える、直交周波数分割多重信号の伝送方法。

【請求項２】　前記搬送波変調信号群と、基準複素数信号群とを周波数軸上で複素乗算する第３のステップをさらに備え、

前記第１のステップは、前記第３のステップで得られた複素乗算結果を、前記直交周波数分割多重信号に変換する、請求項１に記載の直交周波数分割多重信号の伝送方法。

【請求項３】　前記第３のステップは、前記搬送波変調信号群の各シンボルについて、その一定シンボル前に複素乗算した結果を、前記基準複素数信号群として各前記搬送波変調信号群に複素乗算する、請求項２に記載の直交周波数分割多重信号の伝送方法。

【請求項４】　予め定められた特定パターンを有し、かつ各信号の位相がランダムに変化している複素数信号群をシンボル毎に発生する第４のステップをさらに備え、

前記第３のステップは、前記搬送波変調信号群の各シンボルについて、前記第４のステップで得られた複素数信号群を、前記基準複素数信号群として使用し、

前記第１のステップは、常時は前記第３のステップで得られた複素乗算結果を前記直交周波数分割多重信号に変換し、定期的に前記基準複素数信号群を前記直交周波数分割多重信号に変換する、請求項２に記載の直交周波数分割多重信号の伝送方法。

【請求項５】　所定長のシンボル毎に前記送信側から送信されてきた前記直交周波数分割多重信号を、前記搬送波変調信号群に対応する受信搬送波変調信号群に変換する第５のステップと、

前記第５のステップで得られた受信信号群を、所定の基準複素数信号群により、周波数軸上で複素除算する第６のステップとを備える、請求項２に記載の直交周波数分割多重信号の伝送方法。

【請求項６】　有線または無線の伝送路を介し、受信側に、所定長のシンボル毎に直交周波数分割多重信号を送信する装置であって、

基準複素数信号群を記憶するメモリ手段と、

周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定する搬送波変調信号群と、前記メモリ手段に記憶された前記基準複素数信号群とを周波数軸上で複素乗算し、送信搬送波変調信号群を出力する複素乗算手段と、

前記複素乗算手段から出力される送信搬送波変調信号群に対して、各シンボル毎に逆フーリエ演算を施すことにより、当該送信搬送波変調信号群を、時間軸上の前記直交周波数分割多重信号に変換する逆フーリエ変換手段と、

前記逆フーリエ変換手段から出力される前記直交周波数分割多重信号の各シンボルに対し、その前部にその後端部と同じデータを含む前部ガードタイムを付加するとともに、その後部にその前端部と同じデータを含む後部ガードタイムを付加するガードタイム付加手段と、

前記前部ガードタイムおよび前記後部ガードタイムの付加された前記直交周波数分割多重信号を、各シンボル毎に前記受信側に送信する送信手段とを備える、直交周波数分割多重信号の送信装置。

【請求項７】　前記メモリ手段は、前記複素乗算手段の一定シンボル前の複素乗算結果を、前記基準複素数信号群として記憶する、請求項６に記載の直交周波数分割多重信号の送信装置。

【請求項８】　前記メモリ手段は、予め定められた複素数信号群を、前記基準複素数信号群として記憶し、

前記複素乗算手段は、前記搬送波変調信号群と、前記メモリ手段に記憶された前記基準複素数信号群とを周波数軸上で複素乗算して出力し、

前記逆フーリエ変換手段は、常時はシンボル毎に前記複素乗算手段から出力された複素乗算結果を前記直交周波数分割多重信号に変換し、定期的に前記メモリ手段から出力された前記基準複素数信号群を前記直交周波数分割多重信号に変換する、請求項６に記載の直交周波数分割多重信号の送信装置。

【請求項９】　前記メモリ手段は、前記基準複素数信号群として疑似雑音信号を発生する疑似雑音信号発生手段の出力を保持していることを特徴とする、請求項８に記載の直交周波数分割多重信号の送信装置。

【請求項１０】　前記メモリ手段は、前記基準複素数信号群として周波数掃引信号を発生する周波数掃引信号発生手段の出力を保持していることを特徴とする、請求項８に記載の直交周波数分割多重信号の送信装置。

【請求項１１】　有線または無線の伝送路を介し、送信側から所定長のシンボル毎に送信されてくる直交周波数分割多重信号を受信する装置であって、

時間軸上の前記直交周波数分割多重信号に対して、シンボル毎にフーリエ変換演算を施すことにより、当該直交周波数分割多重信号を、周波数軸上の受信搬送波変調信号群に変換するフーリエ変換手段と、

前記フーリエ変換手段から一定シンボル毎に出力された受信搬送波変調信号群を、受信基準複素数信号群として

記憶するメモリ手段と、
前記フーリエ変換手段から出力された受信搬送波変調信号群を、前記メモリ手段に記憶された受信基準複素数信号群により、周波数軸上で複素除算する複素除算手段とを備える、直交周波数分割多重信号の受信装置。

【請求項１２】　有線または無線の伝送路を介し、送信側から受信側に対して、所定長のシンボル毎に直交周波数分割多重信号を伝送する方法であって、
周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定するための搬送波変調信号群をシンボル毎に生成する第１のステップと、
予め定められた特定パターンを有し、かつ各信号の位相がランダムに変化している複素数信号群を発生する第２のステップと、
前記搬送波変調信号群と前記複素数信号群とをシンボル毎に周波数軸上で複素乗算することにより、当該搬送波変調信号群の各信号の位相をランダム化する第３のステップと、
常時は前記第３のステップで各信号の位相がランダム化された搬送波変調信号群をシンボル毎に逆フーリエ変換して時間軸上の前記直交周波数分割多重信号に変換し、定期的に前記複素数信号群を逆フーリエ変換して前記直交周波数分割多重信号に変換し、それぞれを前記受信側に送信する第４のステップとを備える、直交周波数分割多重信号の伝送方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、直交周波数分割多重（Ｏｒｔｈｏｇｏｎａｌ　ＦｒｅｑｕｅｎｃｙＤｉｖｉｓｉｏｎ　Ｍｕｌｔｉｐｌｅｘｉｎｇ；以下、ＯＦＤＭと称す）伝送方法に関し、より特定的には、有線または無線の伝送路を介し、送信側と受信側との間で、所定長のシンボルと当該シンボル間に配置された所定長のガードタイムとを含む直交周波数分割多重信号を用いてデータを伝送する方法に関する。

【０００２】

【従来の技術】周知のごとく、ＯＦＤＭ伝送方式は、符号化したデータを分割して、数百以上の搬送波に振り分け、これを多重して伝送する方式である。近年、移動体向けディジタル音声放送や、地上ディジタルテレビ放送等において、ＯＦＤＭ信号を用いた通信が着目されている。なぜならば、ＯＦＤＭ信号は、多量のデータの高速伝送が可能で、波形等価器なしでも反射波による特性劣化が少なく、その信号波形がランダム雑音に近い形となるので、他のサービスに混信妨害を与えにくい等の特質を有しているからである。

【０００３】このようなＯＦＤＭ信号を用いた伝送方式は、１９９３年１０月１日付け発行のＮＩＫＫＥＩ　ＥＬＥＣＴＲＯＮＩＣＳ　ＢＯＯＫＳ「データ圧縮とディジタル変調」の第２０７～２２２頁において、郵政省，通信総合研究所の福地一により書かれた「数百以上の搬送波を使うＯＦＤＭディジタル放送の移動受信に向く」に開示されている。

【０００４】図１３は上記先行文献に開示された従来のＯＦＤＭ信号の送信装置の構成を示すブロック回路図であり、図１４は図１３の送信装置から送信されるＯＦＤＭ信号の構成を示す図である。図１３において、送信装置５は、直並列変換器５２と、逆フーリエ変換器５３と、並直列変換器５４と、Ｄ／Ａ変換器５５と、ローパスフィルタ５６とを備える。なお、図１４において、（ａ）はＯＦＤＭ信号の直接波を示し、（ｂ）はＯＦＤＭ信号の反射波を示し、（ｃ）はＯＦＤＭ信号の合成波を示し、（ｄ）は時間窓Ｗを示している。

【０００５】送信装置５の直並列変換器５２には、入力シンボル列が供給されている。入力シンボル列は、ディジタル変調された送信データであり、１伝送シンボル中には複数のデータ値が含まれている。なお、ディジタル変調方式としては、ＱＰＳＫ（ｑｕａｄｒｉｐｈａｓｅ　ｐｈａｓｅ　ｓｈｉｆｔ　ｋｅｙｉｎｇ）変調や、１６ＱＡＭ（ｑｕａｄｒａｔｕｒｅ　ａｍｐｌｉｔｕｄｅ　ｍｏｄｕｌａｔｉｏｎ）等が採用される。直並列変換器５２は、入力シンボル列を、１シンボル毎に、直並列変換して、より低速な複数のシンボル列にする。ここでの並列度は、逆フーリエ変換回路５３で使用する複数の搬送波（相互に位相が直交している）の数（数十～数千、たとえば５１２）と同じになる。このような操作により、直並列変換器５２は、逆フーリエ変換回路５３で使用する複数の搬送波のそれぞれの振幅および位相を決定するための搬送波変調信号群を出力する。

【０００６】逆フーリエ変換回路５３は、搬送波変調信号群を、１シンボル毎に、周波数軸上に並ぶ各搬送波に割り当て（これによって、１シンボル分のデータが周波数軸上で多重された信号となる）、これらに対して一括的に逆フーリエ変換を施すことにより、時間軸上の多重信号（この段階では、並列のディジタル信号である）に変換する。

【０００７】並直列変換器５４は、時間軸上の多重信号を並直列変換することにより、離散的なＯＦＤＭ信号を生成する。Ｄ／Ａ変換回路５５は、離散的なＯＦＤＭ信号を、アナログのＯＦＤＭベースバンド信号に変換する。ローパスフィルタ５６は、エイリアシングによるチャネル間干渉が生じないようにするため、ＯＦＤＭベースバンド信号に帯域制限をかける。

【０００８】上記のような一連の操作の結果、送信装置５は、伝送路に対し、図１４に示すようなガードタイムG_mとシンボルS_mとを含むＯＦＤＭ信号を出力する。図示しない復調装置は、伝送路を介して受信したＯＦＤＭ信号に対して変調装置５と逆の信号処理を行い、入力シンボル列と同じ出力シンボル列を再生する。

【０００９】

【発明が解決しようとする課題】ところで、伝送路上では、いわゆるマルチパスが発生する。このため、受信装置側では、送信装置から送信されてきたＯＦＤＭ信号の直接波と、直接波から時間遅延した反射波とを重なって受信する。シンボルＳm を例にとると、直接波（図１４（ａ）参照）にマルチパスによる反射波（図１４（ｂ）参照）が重なった場合、合成波（図１４（ｃ）参照）のシンボルＳm の前端部に反射波のガードタイムＧm との干渉部αm が生じ、ガードタイムＧm の前端部に反射波のシンボルＳm-1 との干渉部βm が生じる。このとき、干渉部βm は、時間窓Ｗからはずれているため、シンボルＳm のフーリエ変換には影響を及ぼさない。しかしながら、干渉部αm は、時間窓Ｗ内に生じ、かつガードタイムＧm のデータ成分が「０」であるため、フーリエ変換後の各シンボルＳm の周波数軸上のデータ成分に波形歪みを生じるという第１の問題点があった。

【００１０】また、伝送路の遅延特性や、送信側のＤ／Ａ変換器および受信側のＡ／Ｄ変換器のクロックが一致していないことに起因してサンプリングのタイミングにずれが生じる等の理由から、送信装置から受信装置に到達するまでの間に、ＯＦＤＭ信号に時間遅延が発生する。このため、受信装置では、時間窓Ｗを時間軸上で調整する必要があるという第２の問題点もあった。

【００１１】また、直並列変換器５２から出力される搬送波変調信号群は、その位相が相互に異なっているだけでなく、その位相がすべて同一の場合もありうる。例えば、ディジタル音声放送では無音状態を１シンボル期間を超えて送信する場合に、地上ディジタルテレビ放送では一色の映像を１シンボル期間を超えて送信する場合に、搬送波変調信号群の位相がすべて同一になる。また、有音状態を送信する場合や、多色の映像を送信する場合においても、ＱＰＳＫ変調や、１６ＱＡＭ等のようなディジタル変調方式では、位相の異なる信号点の配点数が限られるため、搬送波変調信号群の位相がすべて同一になりやすい。

【００１２】このように、搬送波変調信号群の位相がすべて同一になった場合、この搬送波変調信号群を逆フーリエ変換すると、時間軸上で各搬送波の節が一致し、加算増加箇所が時間軸上で一箇所に集中するため、時間軸上のＯＦＤＭ信号の信号波形がインパルス状になり、電力集中が生じる。この様子を図１５に示す。

【００１３】図１５（ａ）は、相互に直交するｎ本の搬送波をそれぞれ変調するｎ個の搬送波変調信号群の複素平面上での位相がすべて同一の場合を示している。図１５（ｂ）は、図１５（ａ）のｎ個の搬送波変調信号群で変調されたｎ本の搬送波を時間軸上で多重した状態を示している。このように搬送波変調信号群の位相がすべて同一の場合には、ＯＦＤＭ信号は、インパルス状の波形信号になる。なお、図１５（ｃ）は、相互に直交するｎ本の搬送波をそれぞれ変調するｎ個の搬送波変調信号群の複素平面上での位相がランダムな場合を示している。また、図１５（ｄ）は、図１５（ｃ）のｎ個の搬送波変調信号群で変調されたｎ本の搬送波を時間軸上で多重した状態を示している。このように、搬送波変調信号群の位相がすべて異なる場合には、ＯＦＤＭ信号は、時間軸上に平均的に拡散され、ランダム状の波形信号になる。

【００１４】上記のように、搬送波変調信号群の位相がすべて同一になった場合、ＯＦＤＭ信号がインパルス状になり、最大電力が極端に大きくなるため、ＯＦＤＭ信号は、送受信装置や伝送路に含まれる中継増幅器（衛星やＣＡＴＶなど）等の非線形性の影響を受けやすくなるという第３の問題点もあった。この場合、ＯＦＤＭ信号がインパルス状になっても、非線形性の影響を与えないように、送受信装置や中継増幅器等のダイナミックレンジを大きくすることも考えられるが、送受信装置や中継増幅器等が高価になるという別の問題が発生する。

【００１５】それ故に、本発明の目的は、マルチパスにより反射波が直接波に重なった場合でも、フーリエ変換後の各シンボルの周波数軸上のデータ成分に波形歪みを生じないＯＦＤＭ信号の伝送方法ならびにその送信装置および受信装置を提供することである。本発明の他の目的は、送信側から受信側に到達するまでの間に、ＯＦＤＭ信号に時間遅延が発生しても、時間窓の時間軸上での調整が容易なＯＦＤＭ信号の伝送方法ならびにその送信装置および受信装置を提供することである。本発明のさらに他の目的は、安価な構成で、ＯＦＤＭ信号に対する非線形性の影響を軽減したＯＦＤＭ信号の伝送方法ならびにその送信装置および受信装置を提供することである。

【００１６】

【課題を解決するための手段および発明の効果】本発明の第１の局面は、有線または無線の伝送路を介し、送信側から受信側に対して、所定長のシンボル毎に直交周波数分割多重信号を伝送する方法に向けられており、周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定する搬送波変調信号群をシンボル毎に逆フーリエ変換することにより、時間軸上の直交周波数分割多重信号に変換する第１のステップと、直交周波数分割多重信号の各シンボルに対し、その前部にその後端部と同じデータを含む前部ガードタイムを付加するとともに、その後部にその前端部と同じデータを含む後部ガードタイムを付加して、受信側に送信する第２のステップとを備えている。

【００１７】上記のように、第１の局面では、ＯＦＤＭ信号の各シンボルを送信する際に、各シンボルの前部および後部に、そのシンボルの一部と同じデータを含む前部ガードタイムおよび後部ガードタイムを付加するようにしているので、受信側では、フーリエ変換時における時間窓が受信信号のシンボル区間から多少ずれても、時間軸上に並ぶ１シンボル区間内のすべてのデータ成分を

再生することができる。従って、送信側から受信側に到達するまでの間に、ＯＦＤＭ信号に時間遅延が発生しても、時間窓をシンボル区間に正確に一致させる必要がなくなり、時間窓の時間軸上での調整が容易になる。また、マルチパスにより直接波のシンボル区間と反射波のガードタイムとが重なっても、受信側でフーリエ変換後の周波数軸上に現れる各データ成分の振幅位相歪みは、各シンボル間ですべて一様なものとなる。したがって、簡単な演算処理（乗算、加算等）によって、受信側での１シンボル区間の周波数軸上のデータ成分から、容易にそれらの波形歪みを除去することが可能となる。

【００１８】上記第１の局面において、好ましい実施形態では、搬送波変調信号群と基準複素数信号群とを周波数軸上で複素乗算し、この複素乗算結果をＯＦＤＭ信号に変換して、受信側に伝送するようにしている。また、受信側では、送信側から送信されてきたＯＦＤＭ信号を受信搬送波変調信号群に変換し、この受信搬送波変調信号群を、基準複素数信号群により、周波数軸上で複素除算するようにしている。これによって、送信側と受信側との間でＯＦＤＭ信号に時間遅延が発生しても、受信側で時間遅延の影響のない復調データを得ることができる。

【００１９】なお、搬送波変調信号群に複素乗算される基準複素数信号群としては、搬送波変調信号群の各シンボルについて、その一定シンボル前に複素乗算した結果を用いても良い。

【００２０】また、予め定められた特定パターンを有し、かつ各信号の位相がランダムに変化している複素数信号群を、基準複素数信号群として用いても良い。ただし、この場合、常時は第３のステップで得られた複素乗算結果がＯＦＤＭ信号に変換され、定期的に基準複素数信号群がＯＦＤＭ信号に変換される。これによって、搬送波変調信号群の各信号の絶対基準位相がランダムな値になり、逆フーリエ変換によって得られたＯＦＤＭ信号に電力の時間集中がおこるのを抑制できる。従って、送信装置、受信装置および伝送路のダイナミックレンジを大きくする必要がなく、安価な構成で、送受信器や中継増幅器等の非線形性がＯＦＤＭ信号に与える影響を軽減することができる。

【００２１】本発明の第２の局面は、有線または無線の伝送路を介し、受信側に、所定長のシンボル毎に直交周波数分割多重信号を送信する装置に向けられており、基準複素数信号群を記憶するメモリ手段と、周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定する搬送波変調信号群と、メモリ手段に記憶された基準複素数信号群とを周波数軸上で複素乗算し、送信搬送波変調信号群を出力する複素乗算手段と、複素乗算手段から出力される送信搬送波変調信号群に対して、各シンボル毎に逆フーリエ演算を施すことにより、当該送信搬送波変調信号群を、時間軸上の直交周波数分割多重信号に変換する逆フーリエ変換手段と、逆フーリエ変換手段から出力される直交周波数分割多重信号の各シンボルに対し、その前部にその後端部と同じデータを含む前部ガードタイムを付加するとともに、その後部にその前端部と同じデータを含む後部ガードタイムを付加するガードタイム付加手段と、前部ガードタイムおよび後部ガードタイムの付加された直交周波数分割多重信号を、各シンボル毎に受信側に送信する送信手段とを備えている。

【００２２】上記第２の局面において、好ましい実施形態では、メモリ手段は、複素乗算手段の一定シンボル前の複素乗算結果を、基準複素数信号群として記憶している。

【００２３】上記第２の局面において、他の好ましい実施形態では、メモリ手段は、予め定められた複素数信号群を、基準複素数信号群として記憶する。また、複素乗算手段は、搬送波変調信号群と、メモリ手段に記憶された基準複素数信号群とを周波数軸上で複素乗算して出力する。さらに、逆フーリエ変換手段は、常時はシンボル毎に複素乗算手段から出力された複素乗算結果を直交周波数分割多重信号に変換し、定期的にメモリ手段から出力された基準複素数信号群を直交周波数分割多重信号に変換する。

【００２４】上記第２の局面において、メモリ手段は、基準複素数信号群として、疑似雑音信号を発生する疑似雑音信号発生手段の出力を保持しても良いし、周波数掃引信号を発生する周波数掃引信号発生手段の出力を保持しても良い。

【００２５】本発明の第３の局面は、有線または無線の伝送路を介し、送信側から所定長のシンボル毎に送信されてくる直交周波数分割多重信号を受信する装置に向けられており、時間軸上の直交周波数分割多重信号に対して、シンボル毎にフーリエ変換演算を施すことにより、当該直交周波数分割多重信号を、周波数軸上の受信搬送波変調信号群に変換するフーリエ変換手段と、フーリエ変換手段から一定シンボル毎に出力された受信搬送波変調信号群を、受信基準複素数信号群として記憶するメモリ手段と、フーリエ変換手段から出力された受信搬送波変調信号群を、メモリ手段に記憶された受信基準複素数信号群により、周波数軸上で複素除算する複素除算手段とを備えている。

【００２６】本発明の第４の局面は、有線または無線の伝送路を介し、送信側から受信側に対して、所定長のシンボル毎に直交周波数分割多重信号を伝送する方法に向けられており、周波数軸上で互いに直交する複数のキャリアの位相と振幅とを決定するための搬送波変調信号群をシンボル毎に生成する第１のステップと、予め定められた特定パターンを有し、かつ各信号の位相がランダムに変化している複素数信号群を発生する第２のステップと、搬送波変調信号群と複素数信号群とをシンボル毎に周波数軸上で複素乗算することにより、当該搬送波変調

信号群の各信号の位相をランダム化する第３のステップと、常時は第３のステップで各信号の位相がランダム化された搬送波変調信号群をシンボル毎に逆フーリエ変換して時間軸上の直交周波数分割多重信号に変換し、定期的に複素数信号群を逆フーリエ変換して直交周波数分割多重信号に変換し、それぞれを受信側に送信する第４のステップとを備えている。

【００２７】

【発明の実施の形態】以下、本発明の実施形態に係るＯＦＤＭ信号の伝送方法ならびその送信装置および受信装置について、図面を参照しながら説明する。

【００２８】図１は本発明の第１の実施形態の送信装置を示すブロック図であり、図２は本発明の第１の実施形態の受信装置の構成を示すブロック図であり、図３は本発明で用いるＯＦＤＭ信号の構成の一例を示す図である。なお、図３において、（ａ）はＯＦＤＭ信号の直接波を示し、（ｂ）はＯＦＤＭ信号の反射波を示し、（ｃ）は時間遅延が生じた場合のＯＦＤＭ信号の直接波を示し、（ｄ）は時間遅延が生じた場合のＯＦＤＭ信号の反射波を示し、（ｅ）は時間窓Ｗを示している。

【００２９】図１の送信装置１と、図２の受信装置２とは、同軸ケーブルや、光ファイバケーブル等の伝送路（図示せず）で接続されている。このような送信装置１および受信装置２は、たとえばディジタルＣＡＴＶシステムにおいて用いられる。送信装置１は、ＯＦＤＭ信号を用い、受信装置２に対して、たとえばテレビの多チャンネル分の映像データを伝送するように構成されている。

【００３０】図１において、送信装置１は、搬送波変調信号発生器１２と、複素乗算器１３と、メモリ１４と、逆フーリエ変換器１５と、ガードタイム挿入部１６と、同期信号多重部１７と、Ｄ／Ａ変換器１８と、ローパスフィルタ１９とを備えている。

【００３１】送信装置１の搬送波変調信号発生器１２には、受信装置２に送信すべき送信ディジタルデータ（ビットストリーム信号）が入力されている。搬送波変調信号発生器１２は、入力された送信ディジタルデータを、ディジタル変調すると共に、１シンボル区間毎に直並列変換し、相互に直交するｎ本（ｎ＝数十～数千、たとえば５１２）の搬送波を変調するためのｎ個の搬送波変調信号を含む搬送波変調信号群に変換する。なお、ディジタル変調方式としては、ＱＰＳＫ変調や、１６ＱＡＭ等が採用される。この段階での搬送波変調信号群は、従来の直並列変換器５２（図１３参照）から出力される搬送波変調信号群と同様である。搬送波変調信号発生器１２から出力される搬送波変調信号群は、複素乗算器１３に与えられる。メモリ１４は、複素乗算器１３から出力される搬送波変調信号群Ｄ’$_m$ を１シンボル分記憶することができる。また、メモリ１４は、複素乗算器１３に搬送波変調信号群Ｄ$_m$ が入力されたときに、内部に記憶している１シンボル前の搬送波変調信号群Ｄ’$_{m-1}$ を、所定の基準複素数信号群として、複素乗算器１３に出力する。複素乗算器１３は、入力された送信信号群Ｄ$_m$ と、１シンボル前の基準複素数信号群Ｄ’$_{m-1}$ とを、周波数軸上で、複素乗算することにより、搬送波変調信号群

Ｄ’$_m$ （Ｄ’$_m$ ＝Ｄ$_m$ ×Ｄ’$_{m-1}$ ）

を作成する。

【００３２】より具体的に説明すると、複素乗算器１３に入力された搬送波変調信号群（ｎ個の搬送波変調信号を含む）のうち、ｋ（ｋ＝１，２，…，ｎ）番目の搬送波変調信号の実数部をＤ$_m$ ［ｋ］ｒｅａｌとし、その虚数部をＤ$_m$ ［ｋ］ｉｍａｇとし、メモリ１４に記憶したｋ番目の搬送波変調信号の実数部をＤ’$_{m-1}$ ［ｋ］ｒｅａｌとし、その虚数部をＤ’$_{m-1}$ ［ｋ］ｉｍａｇとした場合、複素乗算器１３は、各搬送波変調信号の実数部および虚数部それぞれについて、乗算処理を行い、

Ｄ’$_m$ ［ｋ］ｒｅａｌ＝Ｄ$_m$ ［ｋ］ｒｅａｌ×Ｄ’$_{m-1}$ ［ｋ］ｒｅａｌ

Ｄ’$_m$ ［ｋ］ｉｍａｇ＝Ｄ$_m$ ［ｋ］ｉｍａｇ×Ｄ’$_{m-1}$ ［ｋ］ｉｍａｇ

を出力する。メモリ１４は、複素乗算器１３から出力された実数および虚数の搬送波変調信号Ｄ’$_m$ （Ｄ’$_m$ ［ｋ］ｒｅａｌおよびＤ’$_m$ ［ｋ］ｉｍａｇを含む）を記憶保持する。図４に示すように、メモリ１４および複素乗算器１３は、上記のような動作を繰り返し実行する。

【００３３】逆フーリエ変換器１５は、複素乗算器１３から出力される搬送波変調信号群Ｄ’$_m$ 中のそれぞれの搬送波変調信号を、シンボル区間毎に、順次周波数軸上に並ぶ各搬送波に割り当て、これらに対して一括的に逆フーリエ変換を施し、さらに並直列変換を行うことにより、周波数軸上で各データ成分が多重された搬送波変調信号群を、時間軸上で各データ成分が多重されたＯＦＤＭ信号Ｄ’$_{mt}$に変換する。

【００３４】ガードタイム挿入部１６は、逆フーリエ変換器１５から出力されるディジタルのＯＦＤＭ信号Ｄ’$_{mt}$を、各シンボル区間毎に、一旦、内部のバッファに蓄える。次に、ガードタイム挿入回路１６は、各シンボルＳ$_m$ に対して、その前部に前部ガードタイムＧ$_{hm}$を、その後部に後部ガードタイムＧ$_{em}$を、それぞれ付加する（図３参照）。なお、前部ガードタイムＧ$_{hm}$の時間長ｔｇ１および後部ガードタイムＧ$_{em}$の時間長ｔｇ２は、それぞれ伝送路で発生するマルチパスによる直接波と間接波との時間差および送信装置１のＤ／Ａ変換器１８と受信装置２のＡ／Ｄ変換器２２との間のサンプリングのずれによる時間遅延を考慮して定められる。また、前部ガードタイムＧ$_{hm}$には、対応するシンボルＳ$_m$ の後端部Ｓ$_{em}$と同じデータＤ’$_{emt}$ が含められ、後部ガードタイムＧ$_{em}$には、対応するシンボルＳ$_m$ の前端部Ｓ$_{hm}$と同じデータＤ’$_{hmt}$ が含められる。これにより、実質的なシン

ボル長が、ｔｇ１＋ｔｓ＋ｔｇ２に延長されることになる。ガードタイム挿入部１６は、前部ガードタイムGhm、シンボルＳm 、後部ガードタイムＧemを使用して、データD’emt 、D’m 、D’hmt を順次出力する。

【００３５】同期信号多重部１７は、シンボルの区切りを示すため、シンボル毎に、同期信号を、ガードタイムの付加されたＯＦＤＭ信号に時間軸上で多重し、D／A変換器１８に出力する。同期信号は、たとえば、図５（ａ）に示すようにＯＦＤＭ信号に対し、周期的に既知の無変調搬送波と抑圧信号等とから構成する。

【００３６】D／A変換器１８は、同期信号多重部１７から出力される、ガードタイムおよび同期信号が付加されたディジタルデータのＯＦＤＭ信号を、アナログのＯＦＤＭベースバンド信号に変換する。ローパスフィルタ１９は、エイリアシングによるチャネル間干渉が生じないようにするため、ＯＦＤＭベースバンド信号に帯域制限をかける。

【００３７】上記のような一連の操作の結果、送信装置１は、伝送路に対して、ガードタイムおよび同期信号を含むＯＦＤＭ信号を出力する。

【００３８】図２において、受信装置２は、ローパスフィルタ２１と、A／D変換器２２と、エンベロープ検波器２３と、同期再生部２４と、フーリエ変換器２５と、メモリ２６と、複素除算器２７と、送信データ再生器２８とを備えている。

【００３９】ローパスフィルタ２１は、伝送路を介して受信したＯＦＤＭ信号から、不要な高周波域のスペクトル成分を除去する。

【００４０】ここで、マルチパスや伝送路の遅延特性等による時間遅延Δｔを考慮し、受信装置２において受信したＯＦＤＭ信号をＺD’mtとする。なお、Ｚは、

Ｚ＝ｅｘｐｊ２πｆｃΔｔ

であり、信号の遅延分を表している。

【００４１】A／D変換器２２は、アナログのＯＦＤＭ信号の前部ガードタイムGhm、シンボルＳm 、後部ガードタイムGemにそれぞれ含まれるデータＺD’emt 、ＺD’mt、ＺD’hmt を、ディジタルのＯＦＤＭ信号に変換する。

【００４２】エンベロープ検波器２３は、ＯＦＤＭ信号をエンベロープ検波することにより、図５（ｂ）に示すエンベロープ検波信号を、シンボル毎に出力する。同期再生部２４は、エンベロープ検波器２３から出力されたエンベロープ検波信号に基づいて、図５（ｃ）に示す基準タイミング信号を、シンボル毎に出力する。この基準タイミング信号は、フーリエ変換器２５およびメモリ２６に入力される。

【００４３】フーリエ変換器２５は、基準タイミング信号に同期して、A／D変換器２２から出力されるＯＦＤＭ信号を、シンボル長ｔｓと同じ長さの時間窓Ｗ（図３（ｅ）参照）を介して覗くことにより、各シンボルの必要なデータ部分だけを抽出する。また、フーリエ変換器２５は、この抽出されたデータ部分に対して、フーリエ変換演算を施すことにより、時間軸上のＯＦＤＭ信号を、周波数軸上の受信搬送波変調信号群に変換する。

【００４４】メモリ２６は、フーリエ変換器２５から出力される受信搬送波変調信号群を、１シンボル分記憶する。ここで、送信装置１からデータD’m が送られてきた場合、メモリ２６には、それに対応するデータとして、データＺD’m が格納されることになる。データＺD’m は、データD’m にマルチパスや伝送路等によって生じた時間遅延分Ｚを加えたものである。すなわち、

ＺD’m ＝D’m ×ｅｘｐｊ２πｆｃΔｔ

となる。メモリ２６は、基準タイミング信号に同期して、データＺD’m を複素除算器２７に出力する。複素除算器２７は、同期を確立した上で、フーリエ変換器２５から出力されるシンボルＳm+1 のデータＺD’m+1 を、メモリ２６に保持されているデータＺD’m によって複素除算する。すなわち、複素除算器２７は、

ＺD’m+1 ／ＺD’m ＝D’m+1 ／D’m ＝Dm+1

の演算を行う。図６に示すように、フーリエ変換器２５、メモリ２６および複素除算器２７は、上記のような動作を繰り返し実行する。

【００４５】前述したように、マルチパスに起因して、図３（ａ）に示す直接波と図３（ｂ）に示す反射波との間に、相対的な時間遅延が生じる。また、送信装置１のD／A変換器１８と受信装置２のA／D変換器２２とにおけるサンプリングタイミングが異なることに起因して、直接波および反射波にそれぞれ固有の時間遅延が発生する（図３（ｃ）および図３（ｄ）参照）。フーリエ変換器２５において、基準タイミング信号は、これらの時間遅延を考慮していないため、図３（ｅ）に示すように、時間軸上における受信側の時間窓Ｗの位置は、受信信号のシンボル区間からずれている。

【００４６】しかしながら、受信側のフーリエ変換器２５で、時間窓Ｗが正確なシンボル区間からずれていても、前部ガードタイムGhmおよび後部ガードタイムGemには、それぞれデータＺD’emt およびＺD’hmt が含まれているため、時間窓Ｗを介して覗いたデータには、１シンボル区間に本来含まれるべき時間軸上のすべてのデータＺD’mtが含まれていることになる。このため、この時間遅延および反射波の重なりは、周波数軸上において各データ成分毎に一様な振幅位相歪みとなって現れる。また、時間遅延および反射波の特性が一様であれば、各シンボル区間毎に振幅位相歪みの大きさは等しくなる。本実施形態では、複素除算器２７は、フーリエ変換器２５から出力されたシンボルＳm+1 のデータＺD’m+1 を、メモリ２６に保持されているデータＺD’m で複素除算することにより、データの遅延分Ｚをキャンセルし、遅延の無い元の搬送波変調信号群Dm+1 を得ている。すなわち、複素除算器２７が、

$ZD'_{m+1} / ZD'_{m} = D'_{m+1} / D'_{m} = D_{m+1}$
の演算を行うことにより、振幅位相歪みは打ち消されることとなり、各シンボルについて、位相・振幅歪みのないデータD_m が得られる。

【００４７】以上のように、上記実施形態では、各シンボルの前後にそのシンボルの後端部および前端部と同じデータを含むガードタイムを付加して送信するようにしているので、受信側では、時間窓W内に直接波および反射波の両方について、時間軸上に並ぶ１シンボル区間内のすべてのデータ成分を再生することができる。このため、マルチパスにより反射波が直接波に重なり、直接波のシンボル区間と反射波のガードタイムとが重なっても、フーリエ変換後に周波数軸上に現れる各データ成分の振幅位相歪みは、すべて一様なものとなる。したがって、送信側および受信側で適当な演算処理（乗算、除算）を実行することで、１シンボル区間の周波数軸上の受信搬送波変調信号群から、容易に波形歪みを除去することができる。

【００４８】また、上記実施形態では、送信側と受信側との間で、ＯＦＤＭ信号に時間遅延が発生しても、周波数軸上で受信搬送波変調信号群を所定の基準複素数信号群で複素乗算、複素除算することにより、時間遅延のない復調データを得ることができる。その結果、時間窓をシンボル区間に正確に一致させる必要がなくなる。

【００４９】送信データ再生器２８は、複素除算器２７から出力された受信搬送波変調信号群D_m の信号点を複素平面上にマッピングし、信号点を判定することにより、送信装置１の送信ディジタル信号群と同値の受信ディジタル信号群を得る。前述したように、受信搬送波変調信号群D_m からは、位相歪みや振幅歪みが除去されている。したがって、送信データ再生器２８は、複素平面上へのマッピング位置から、正確かつ容易に元のデータを判定することができる。

【００５０】なお、本願発明者は、計算機を使用して、マルチパスによる遅延波の影響と、時間軸遅延の影響とについて、従来のシステムと本実施形態のシステムとを比較するシミュレーションを行った。なお、このシミュレーションは、キャリア数が５１２本、２５６番目のキャリアのデータだけが振幅「1」，位相「0」、他のキャリアのデータはすべて「0」を条件として実施された。

【００５１】図７は、マルチパスによる遅延波の影響について、従来のシステムと本実施形態のシステムとを比較したシミュレーション結果を示す図である。なお、図７において、（a），（b），（c），（d）は、それぞれ、従来のシステムにおける直接波，間接波，合成波，合成波をフーリエ演算することにより周波数軸上の信号に変換した場合のデータ歪みを示している。また、図７において、（e），（f），（g），（h）は、それぞれ、本実施形態のシステムにおける直接波，間接波，合成波，合成波をフーリエ演算することにより周波数軸上の信号に変換した場合のデータ歪みを示している。

【００５２】従来のシステムでは、ガードタイムにいかなるデータも挿入されていないため（図７（b）のα１参照）、合成波の時間窓W中に干渉部α２が発生している（図７（c）参照）。したがって、合成波を時間窓Wでフーリエ演算することにより周波数軸上の信号に変換すると、図７（d）に示すように、２５６番目のキャリアのデータのスペクトルが拡がるとともに、他のキャリアの本来「0」であったはずのデータに歪みが生じる。したがって、送信データ再生器２８で誤判定が起き易くなる。さらに、他のキャリアについても、送信データ再生器２８で誤判定が起き易くなる。一方、本実施形態のシステムでは、ガードタイムにデータが挿入されているので、他のキャリアのデータに影響を及ぼさない。

【００５３】図８は、伝送路等による時間遅延の影響について、従来のシステムと本実施形態のシステムとを比較したシミュレーション結果を示す図である。図８において、（a）は２５６番目のキャリアのデータだけが振幅「1」，位相「0」の場合のスペクトルを示し、（b）は（a）のデータを逆フーリエ演算することにより時間軸上の信号に変換した場合の信号波形を示している。また、図８において、（c），（d）は、それぞれ、従来のシステムにおける時間遅延を生じた合成波，合成波をフーリエ演算することにより周波数軸上の信号に変換した場合のデータ歪みを示している。また、図８において、（e），（f）は、それぞれ、本実施形態のシステムにおける時間遅延を生じた合成波，合成波をフーリエ演算することにより周波数軸上の信号に変換した場合のデータ歪みを示している。

【００５４】従来のシステムでは、ガードタイムにいかなるデータも挿入されていないため（図８（c）のα１参照）、図７（c）の場合と同様に、合成波の時間窓W中に干渉部α２が発生する。したがって、図８（d）に示すように、合成波を時間窓Wでフーリエ演算することにより周波数軸上の信号に変換すると、２５６番目のキャリアのデータのスペクトルが拡がるとともに、他のキャリアの本来「0」であったはずのデータに歪みが生じる。したがって、他のキャリアについても、送信データ再生器２８で誤判定が起こり易くなる。一方、本実施形態では、ガードタイムにデータが挿入されているので、他のキャリアのデータに影響を及ぼさない。

【００５５】図９は、本発明の第２の実施形態の送信装置の構成を示すブロック図である。なお、図９の送信装置３において、図１の送信装置１の構成と対応する部分には、同一の参照番号を付し、その説明を省略する。図９の実施形態で注目すべき点は、メモリ１４が、特定パターン発生器３１の出力、すなわち、予め定められた特定パターンを有し、かつ各信号の位相が相互にランダム

に変化している複素数信号群D0 を保持していることである。このような複素数信号群D0 は、たとえば0～1の間のレベルの疑似ランダム信号を発生するＰＮ系列疑似ランダム信号発生器と、この疑似ランダム信号と２πとを乗算する乗算器とを備え、位相が0から２π間でランダムな値を持ち、かつ振幅が１の単位ベクトル信号を生成する疑似雑音信号発生器により形成することができる。また、このような複素数信号群は、位相が0から２πまでのランダムな値を持った既知の周波数掃引信号を発生する、周波数掃引信号発生器により形成することもできる。

【００５６】複素乗算器１３は、各シンボル区間のデータDm が入力される毎に、データDm とデータD0 とを周波数軸上で複素乗算して、データＤ’ｍ （Ｄ’ｍ＝Ｄｍ ×Ｄ０ ）を作成し、搬送波変調信号群中の各搬送波変調信号の相互の位相を特定パターンにランダム化する。

【００５７】図１０は、複素乗算器１３における複素乗算の動作を示す図である。特に、図１０（ａ）は変調方式に１６値ＱＡＭを用いた場合の搬送波変調信号の取り得る信号点配置を示し、図１０（ｂ）は位相がランダムに変化する単位ベクトルｉを示し、図１０（ｃ）は位相を特定パターンにランダム化された搬送波変調信号を示している。

【００５８】図１０（ａ）において、今、一つの搬送波に割り当てられる搬送波変調信号群中の一つの搬送波変調信号が、複素平面上の信号点Ａに配点されたと仮定する。信号点Ａは、その実数部が３、その虚数部が１の大きさを持つ。また、単位ベクトルｉは、この時、位相角３π／４を持ったと仮定する。複素乗算の結果、図１０（ｃ）に示す搬送波変調信号Ａ’が得られる。搬送波変調信号Ａ’は、実数部が－２．８、虚数部が１．４となり、１６値ＱＡＭの配置にはない信号点をとることになる。このように、単位ベクトルｉの位相がランダムに変化するため、搬送波変調信号発生器１２から出力された搬送波変調信号群中の各搬送波変調信号の位相が、たとえ同一であっても、複素乗算器１３は、位相が相互にランダム化された搬送波変調信号群を、逆フーリエ変換器１５に出力する。

【００５９】複素乗算器１３は、このような動作を所定の期間繰り返す。また、複素乗算器１３は、定期的にデータD0 だけを出力する。この時の一連の動作を、図１１に示す。すなわち、データD0 が挿入されるシンボルをS0 とすると、送信装置３は、図１２に示すように、定期的にシンボルS0 のデータD0 を、その他の場合はシンボルSm のデータＤ’ｍ を出力することになる。逆フーリエ変換器１５は、搬送波変調信号群Ｄ’ｍ を、シンボル毎に、周波数軸上に並ぶ各搬送波に割り当て、これらに対して一括的に逆フーリエ変換および並直列変換を施すことにより、ディジタルのＯＦＤＭ信号に変換する。この結果、搬送波変調信号群の絶対基準位相が、０から２πまでのランダムな値になり、逆フーリエ変換器１５から出力されたＯＦＤＭ信号に電力集中が起こるのを抑制できる。したがって、送信装置、受信装置のダイナミックレンジを大きくする必要がなく、安価な構成で、ＯＦＤＭ信号への送受信器や中継増幅器等の非線形性からの影響を軽減することができる。送信装置３における他の回路ブロック、すなわちガードタイム挿入部１６～ローパスフィルタ１９は、送信装置１の場合と同様に動作する。

【００６０】なお、ガードタイム挿入部１６は、シンボルSm の場合と同様に、シンボルS0 の後端部と同じデータ成分D0 を対応する前部ガードタイムに挿入するとともに、シンボルS0 の前端部と同じデータ成分を対応する後部ガードタイムに挿入している。

【００６１】図９に示す送信装置３を用いた場合、基本的には、図２に示す受信装置２と同じ構成の受信装置を用いることができる。ただし、受信装置のメモリ２６には、送信装置３のメモリ１４に記憶される基準複素数信号群D0 の受信データＺD0を記憶させることになる。

【００６２】上記した図９の実施形態においても、前述した第１の実施形態と同様の効果が得られる。すなわち、マルチパスにより反射波が直接波に重なり、直接波のシンボル区間と反射波のガードタイムとが重なっても、フーリエ変換後に周波数軸上に現れる受信搬送波変調信号群の振幅位相歪みがすべて一様なものとなり、その除去を簡単な演算処理（乗算、除算）で行える。また、送信側と受信側との間でＯＦＤＭ信号に時間遅延が発生しても、時間遅延の影響のない復調データを得ることができ、時間窓の時間軸上の調整が容易になる。

【００６３】なお、上述の各実施形態は、有線の伝送路を介してデータを伝送するようにしているが、本発明はこれに限定されることなく、無線の伝送路を介してデータを伝送するようにしてもよい。また、上述の各実施形態では、多チャンネル分のテレビの映像データを各搬送波に乗せるようにしたが、１チャンネル分の映像データを時間分割して並列に並び替え、各搬送波に割り当てるようにしてもよい。さらに、映像データに替えて、音声データ、テキストデータ等を各搬送波にのせるようにしてもよい。さらに、ＣＡＴＶに替えて、ＬＡＮ、ＷＡＮ等の他のシステムにおいて本発明を実施してもよい。

【００６４】さらに、図９の送信装置３では、メモリ１４から出力された基準複素数信号群を、定期的に、複素乗算器１３を介して逆フーリエ変換器１５に入力するようにしたが、基準複素数信号群を、逆フーリエ変換器１５に直接入力してもよい。

【００６５】さらに、図９の送信装置３では、搬送波変調信号群に含める基準複素数信号群として、予め定められた特定パターンを有し、かつその位相が相互にランダムに変化している複素数信号群D0 を使用したが、ＯＦＤＭ信号に生じる電力集中が生じないような状況下で

は、搬送波変調信号群に含める基準複素数信号群として、予め定められた特定パターンを有し、かつ各信号の位相が相互に同一の複素数信号群を使用しても良い。この場合でも、第１の実施形態と同様、簡単な演算処理（乗算、除算）を行うことで、振幅位相歪みを除去できる。

【図面の簡単な説明】

【図１】本発明の第１の実施形態の送信装置の構成を示すブロック図である。

【図２】本発明の第１の実施形態の受信装置の構成を示すブロック図である。

【図３】図１の送信装置１から送信されるＯＦＤＭ信号の構成を示す図である。

【図４】図１のメモリ１４と、複素乗算器１３との動作を示す図である。

【図５】図１の送信装置１から出力されたＯＦＤＭ信号に対する受信装置２のエンベロープ検波器２３と同期再生部２４との動作を示す図である。

【図６】図２のメモリ２６と、複素除算器２７との動作を示す図である。

【図７】マルチパスによる遅延波の影響について、従来のシステムと第１の実施形態のシステムとを比較したシミュレーション結果を示す図である。

【図８】伝送路等による時間遅延の影響について、従来のシステムと第１の実施形態のシステムとを比較したシミュレーション結果を示す図である。

【図９】本発明の第２の実施形態の送信装置の構成を示すブロック図である。

【図１０】図９の複素乗算器１３における搬送波変調信号群と複素数信号群との複素乗算の様子を示す図である。

【図１１】図９のメモリ１４と複素乗算器１３との動作を示す図である。

【図１２】図９のＯＦＤＭ信号の送信装置から送信されるＯＦＤＭ信号の構成を示す信号構成図である。

【図１３】従来のＯＦＤＭ信号の送信装置の構成を示すブロック図である。

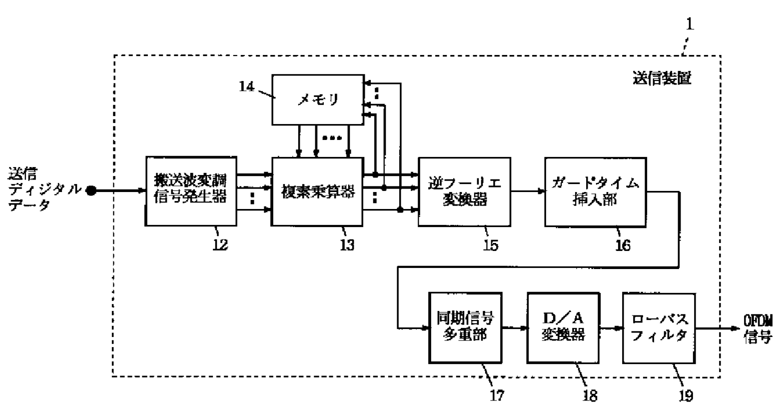
【図１４】図１３の送信装置５から送信されるＯＦＤＭ信号の構成を示す図である。

【図１５】相互に直交する搬送波に割り当てられた搬送波変調信号群の位相状態とＯＦＤＭ信号との関係を示す信号波形図である。

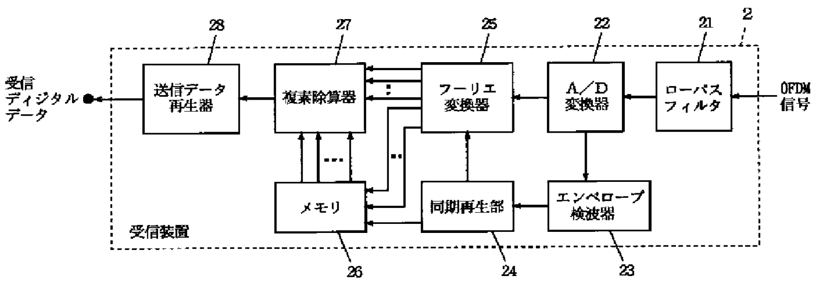
【符号の説明】

１，３…送信装置
１２…搬送波変調信号発生器
１３…複素乗算器
１４…メモリ
１５…逆フーリエ変換器
１６…ガードタイム挿入部
１７…同期信号多重部
１８…Ｄ／Ａ変換器
１９…ローパスフィルタ
３１…特定パターン発生器
２…受信装置
２１…ローパスフィルタ
２２…Ａ／Ｄ変換器
２３…エンベロープ検波器
２４…同期再生部
２５…フーリエ変換器
２６…メモリ
２７…複素除算器
２８…送信データ再生器

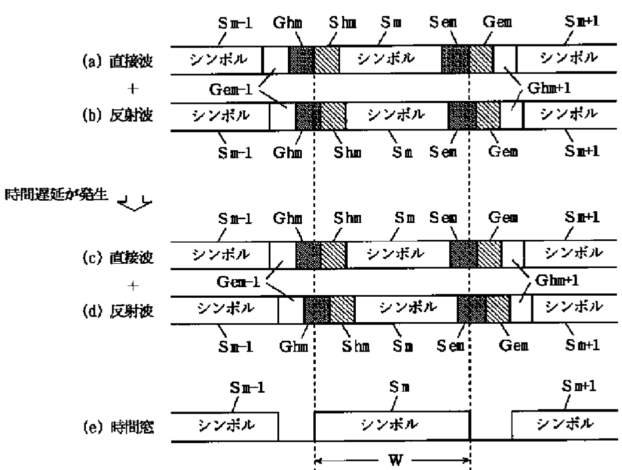
【図１】



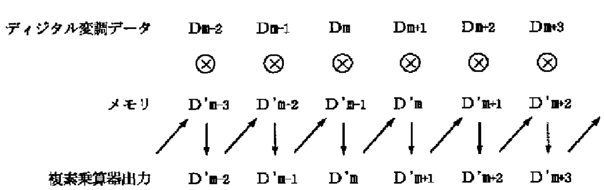
【図2】



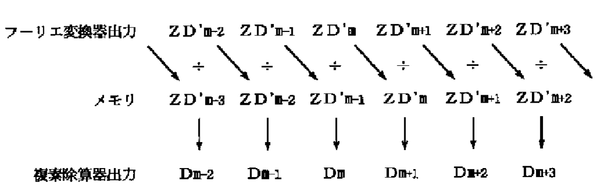
【図3】



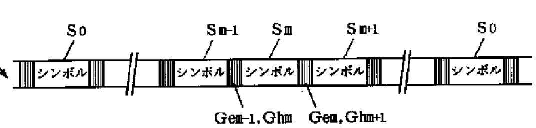
【図4】



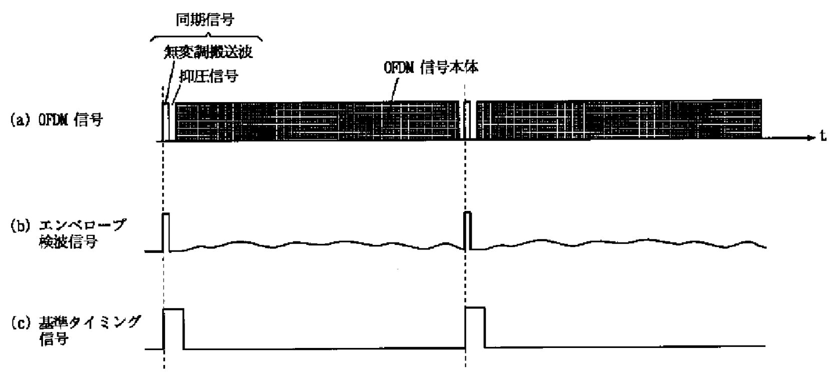
【図6】



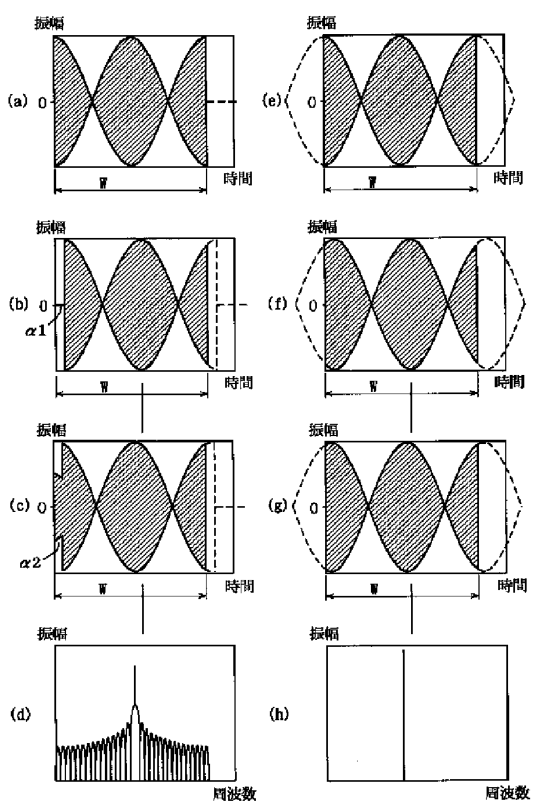
【図12】



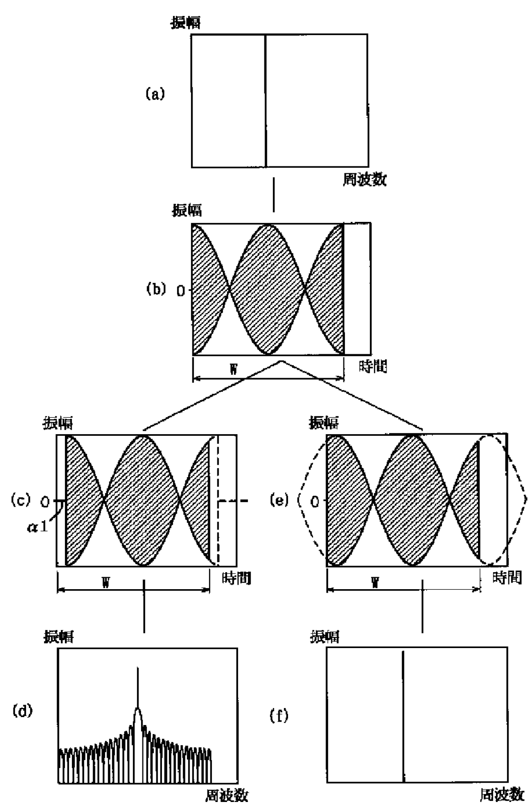
【図５】


同期信号
無変調搬送波
抑圧信号
OFDM 信号本体
(a) OFDM 信号
t
(b) エンベロープ検波信号
(c) 基準タイミング信号

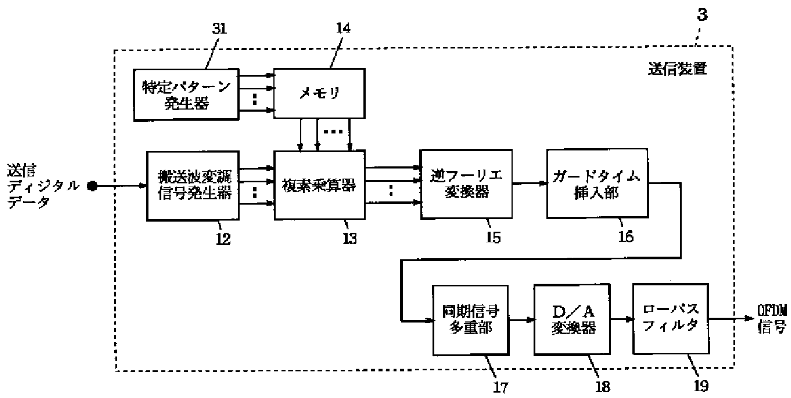
【図７】


振幅
(a) 0
W
時間
(b) 0
α1
(c) 0
α2
(d)
周波数
(e) 0
(f) 0
(g) 0
(h)

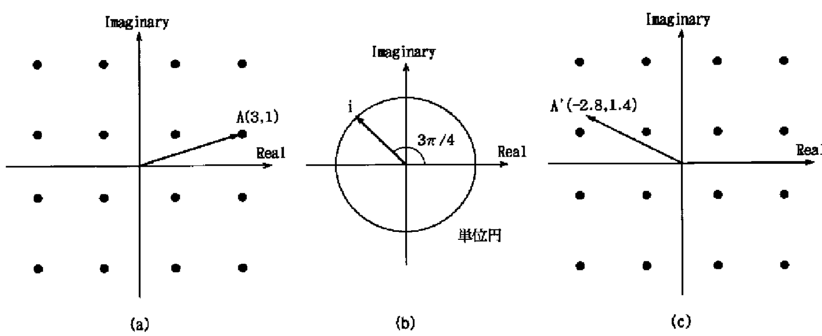
【図８】


(a)
振幅
周波数
(b) 0
W
時間
(c) 0
α1
(d)
(e) 0
(f)

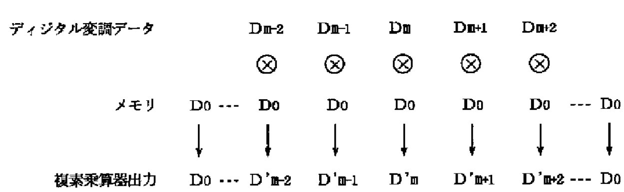
【図９】



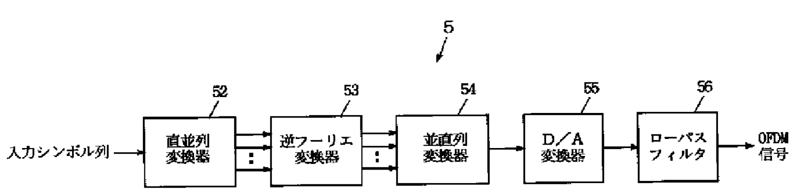
【図１０】



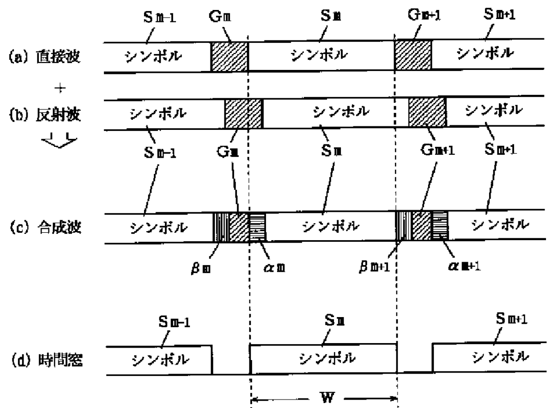
【図１１】



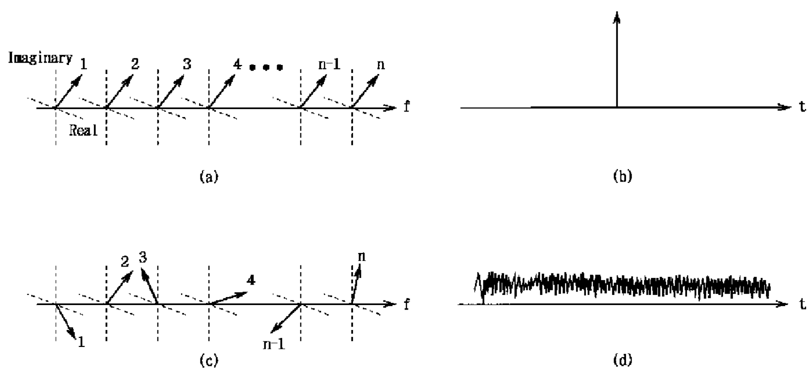
【図１３】



【図１４】



【図１５】



フロントページの続き

(72)発明者　木村　知弘
大阪府門真市大字門真1006番地　松下電器産業株式会社内

(72)発明者　大植　裕司
大阪府門真市大字門真1006番地　松下電器産業株式会社内

Electronic Acknowledgement Receipt

EFS ID:	3233819
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	30-APR-2008
Filing Date:	24-SEP-2007
Time Stamp:	15:53:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_02.pdf	348240 7b22bdee47fd3463ff126acd2c86fe958b8d81c8	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Information Disclosure Statement Letter	1	3
	Information Disclosure Statement (IDS) Filed	4	4

Warnings:

Information:

2	Foreign Reference	JP_H10_1998_-084329.pdf	1648963 40c9155ecb0146a20291f62f095a0a7d62cf0c00	no	18

Warnings:

Information:

3	Foreign Reference	JP8321820A.pdf	1472960 24ac2b63d7fa8eb73096977d4f0bb76e9ad5da48	no	15

Warnings:

Information:

4	NPL Documents	5550-47-PJP_OA_3-3-08.pdf	239891 51dea09ec4c4130a741e3d331e1e8cfa31a67233	no	4

Warnings:

Information:

5	NPL Documents	5550-47-CON-2_OA_2-6-08.pdf	381810 bb3a2d806d1e7caaeda7cd7eade83670b6f23749	no	10

Warnings:

Information:

Total Files Size (in bytes):	4091864

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/860,080	09/24/2007	2611	1000	5550-47-CON-DIV	1	1

CONFIRMATION NO. 5967

UPDATED FILING RECEIPT

OC000000027231790

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Date Mailed: 12/17/2007

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Marcos C. Tzannes, Orinda, CA;

Assignment For Published Patent Application

AWARE, INC., Bedford, MA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a DIV of 11/211,535 08/26/2005 PAT 7,292,627
which is a CON of 09/710,310 11/09/2000 PAT 6,961,369
which claims benefit of 60/164,134 11/09/1999

Foreign Applications

Projected Publication Date: To Be Determined - pending completion of Security Review

Non-Publication Request: No

Early Publication Request: No

Title

SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Preliminary Class

375

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 2611
Tzannes	)	Confirmation No.: 5967
Serial No.: 11/860,080	)	Examiner: Not yet assigned
Filed: 09-24-2007	)	INFORMATION DISCLOSURE STATEMENT
Atty. File No.: 5550-47-CON-DIV	)	Electronically Submitted
For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	)	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of cited non-patent and/or foreign references nos. 22-24 are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☒ Copies of cited references nos. 14-21 are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. 11/211535 filed 08-26-2005, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications,:

Serial No. 11/211535 filed 08-26-2005

Serial No. 11/863581 filed 09-28-2007

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☒ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☐ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By:______________________

Jason H. Vick
Registration No. 45285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 6 Dec '07

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	1	of	2	Attorney Docket Number	5550-47-CON-DIV

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	3,955,141	05/01/76	Lyon et al.	
	2	4,985,900	01/01/91	Rhind et al.	
	3	5,748,677	05/01/98	Kumar	
	4	6,256,355	07/03/01	Sakoda et al.	
	5	6,507,585	01/01/03	Dobson	
	6	6,590,860	07/08/03	Sakoda et al.	
	7	6,704,317	03/01/04	Dobson	
	8	6,961,369	11/01/05	Tzannes	
	9	2005/0141410	06/30/05	Zhang et al.	
	10	2006/0002454	01/05/06	Tzannes	
	11	2006/0092902	05/04/06	Schmidt	
	12	2006/0140288	06/29/06	Holden	
	13	11/863581		Tzannes (09-28-2007)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	14	EP 0584534	03/02/94	ALCATEL ITALIA		
	15	EP 0719004	06/26/96	MATSUSHITA ELECTRIC IND CO LTD		
	16	GB 2330491	04/21/99	BRITISH BROADCASTING CORP		
	17	WO 98/32065	07/23/98	FORTRESS TECHNOLOGIES INC		
	18	WO 99/22463	05/06/99	MOTOROLA INC		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	11/860,080
				Filing Date	09-24-2007
				First Named Inventor	Tzannes
				Art Unit	2611
				Examiner Name	Not yet assigned
Sheet	2	of	2	Attorney Docket Number	5550-47-CON-DIV

	19	WO 99/29078	06/10/99	TELIA AB		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
	20	Bauml R. W. et al.: "Reducing The Peak-To-Average Power Ratio Of Multicarrier Modulation By Selected Mapping" Electronics Letters, GB, IEE Stevenage, vol. 32, No. 22, Oct. 24, 1996, pp. 2056-2057, XP000643915 ISSN: 0013-5194
	21	Copy of Annex to Form PCT/ISA/206 for PCT/US00/30958, Mar. 23, 2001 (5550-47-PCT)
	22	International Search Report for International (PCT) Patent Application No. PCT/US00/30958, completed June 12, 2001 (5550-47-PCT)
	23	International Preliminary Examination Report for International (PCT) Patent Application No. PCT/US00/30958, completed March 4, 2002 (5550-47-PCT)
	24	Notice of Preliminary Rejection for Korean Patent Application No. 7005830/2002 dated November 22, 2006 (Attorney's Ref. No. 5550-47-PKR)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt

EFS ID:	2558394
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Debra Kesner
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	06-DEC-2007
Filing Date:	24-SEP-2007
Time Stamp:	17:44:50
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_01.pdf	463631 8dcd917aaf35f9714bd4509fff9049c0dd76d061	yes	5

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Information Disclosure Statement Letter		1	3	
	Information Disclosure Statement (IDS) Filed		4	5	
Warnings:					
Information:					
2	NPL Documents	5550-47-PCT_Search_Report.pdf	207210 fde804da2cecf174e0d00f3a5556afa753bd2afb	no	6
Warnings:					
Information:					
3	NPL Documents	5550-47-PCT_IPER.pdf	254373 f0cc0f24d93aaf6927e25ae3344f3755192fcc91	no	6
Warnings:					
Information:					
4	NPL Documents	5550-47-PKR_Rejection.pdf	293800 ab883fb5d197f76d615b217a2a822de34cd82c6b	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	1219014		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: TZANNES	Group Art Unit: 2611
Serial No.: 11/860,080	Confirmation No.: **5967**
Filed: September 24, 2007	
Atty. File No.: 5550-47-CON-DIV	RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS
For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

In response to the Notice to File Corrected Application Papers mailed October 9, 2007, in connection with the above-identified application, enclosed for filing is a substitute specification. The margins and erasure marks have been removed and amendments from the parent case have been incorporated. The substitute specification contains no new matter in accordance with 37 CFR § 1.125(b). Please charge any underpayment or credit any overpayment to Deposit Account No. 19-1970.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: ____________________
Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 5 Dec 07

A System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

FIG. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

FIG. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in FIG. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 36 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase scrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

FIG. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1-PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

format change

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3,}$ modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3} (\text{mod } 2\pi) = \frac{2}{3}\pi$. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3}$ (mod2π)=π. The carrier signal with the carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N+M)\times\frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+8)\times\frac{\pi}{4}$ (mod 2π)=$\frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+9)\times\frac{\pi}{4}$ (mod 2π) $=\frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}$, mod 2π, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{3\pi}{2}$ (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{5\pi}{6}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70' for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment, the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10^{-7} for the time domain transmission signal 38 can therefore operate with a 10^{-5} probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10^{-5} probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

Electronic Acknowledgement Receipt

EFS ID:	2550785
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Christine Jacquet
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	05-DEC-2007
Filing Date:	24-SEP-2007
Time Stamp:	16:06:42
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		RESP_CORRECTED_APP_CLEAN_SPEC.pdf	1749978 b14c3d94876e756aa4fc8cfbc1db2168db7242db	yes	16

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Applicant Response to Pre-Exam Formalities Notice	1	1
	Specification	2	16
Warnings:			
Information:			
	Total Files Size (in bytes):	1749978	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/860,080	09/24/2007	2611	1000	5550-47-CON-DIV	1	1

CONFIRMATION NO. 5967

FILING RECEIPT

62574
SHERIDAN ROSS P C
SUITE 1200
1560 BROADWAY
DENVER, CO80202

Date Mailed: 10/09/2007

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Marcos C. Tzannes, Orinda, CA;

Assignment For Published Patent Application

AWARE, INC., Bedford, MA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a DIV of 11/211,535 08/26/2005
which is a CON of 09/710,310 11/09/2000 PAT 6,961,369
which claims benefit of 60/164,134 11/09/1999

Foreign Applications

If Required, Foreign Filing License Granted:

Projected Publication Date: To Be Determined - pending completion of Corrected Papers

Non-Publication Request: No

Early Publication Request: No

Title

SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Preliminary Class

375

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/860,080	09/24/2007	Marcos C. Tzannes	5550-47-CON-DIV

CONFIRMATION NO. 5967

FORMALITIES LETTER

62574
SHERIDAN ROSS P C
SUITE 1200
1560 BROADWAY
DENVER, CO 80202

Date Mailed: 10/09/2007

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification excluding claims in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125 is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). Since a preliminary amendment was present on the filing date of the application and such amendment is part of the original disclosure of the application, the substitute specification must include all of the desired changes made in the preliminary amendment. See 37 CFR 1.115 and 1.215.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199
PART 3 - OFFICE COPY

Attorney Docket No. 5550-47-CON-DIV

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application for:

First Named Inventor: Marcos C. Tzannes **Art Unit:**

Appln. No.: Not yet assigned **Examiner:**

For: SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

* * *

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Prior to the initial review of the above-identified patent application by the Examiner, please enter the following Preliminary Amendment. Please charge any fees to Deposit Account 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Specification begin on page 2

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks begin on page 4 of this paper.

Amendments to the Specification:

Please amend the paragraph at page 13, line 2 as follows:

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}, \bmod 2\pi,$ where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, . . .] has a phase shift added to the phase characteristic of the carrier signal that is equal to $\cancel{(9)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{\pi}{3}}$ $\underline{(9)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{3\pi}{2}}$. (Note that 9 is the 5^{th} value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $\cancel{(5)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{5\pi}{3}}$ $\underline{(5)\times\frac{\pi}{6}(\bmod 2\pi)=\frac{5\pi}{6}}$.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1-19. (Canceled)

20. (Original) In a multicarrier modulation system including a first transceiver in communication with a second transceiver using a transmission signal having a plurality of carrier signals for demodulating an input bit stream, each carrier signal having a phase characteristic with the input bit stream, a method for scrambling the phase characteristics of the carrier signals comprising:

associating each carrier signal with a value determined independently of any input bit value carried by that carrier signal;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

demodulating the transmission signal using the phase shift computed for each carrier signal.

REMARKS

The specification has also been amended to correct a mathematical calculation mistake as was done in the parent application.

This application is directed toward the distinct invention of claim 20 with the remaining claims being cancelled without prejudice or disclaimer.

Applicant believes that the pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

Respectfully submitted,

Date: 24 Sept '07

By: ______________________
Jason H. Vick
Reg. No. 45,285

SHERIDAN ROSS P. C.
1560 BROADWAY, SUITE 1200
DENVER, COLORADO 80202
TELEPHONE: 303-863-9700
FAX: 303-863-0223

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Filer:	Jason Vick/Christine Jacquet
Attorney Docket Number:	5550-47-CON-DIV

Filed as Large Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	300	300
Utility Search Fee	1111	1	500	500
Utility Examination Fee	1311	1	200	200
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1000**

Electronic Acknowledgement Receipt

EFS ID:	2232898
Application Number:	11860080
International Application Number:	
Confirmation Number:	5967
Title of Invention:	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM
First Named Inventor/Applicant Name:	Marcos C. Tzannes
Customer Number:	62574
Filer:	Jason Vick/Christine Jacquet
Filer Authorized By:	Jason Vick
Attorney Docket Number:	5550-47-CON-DIV
Receipt Date:	24-SEP-2007
Filing Date:	
Time Stamp:	15:44:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$1000
RAM confirmation Number	12068
Deposit Account	191970

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_FORM.pdf	1130699 7f187741fd208052807860c572881f035b6fdc81	no	4
Warnings:					
Information:					
2		PAT_APP_DRAW_DEC.pdf	2195089 9a1468bfb8e29768cf0a1574ba49e8b970a188c9	yes	27

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	18
Claims	19	21
Abstract	22	22
Drawings	23	24
Oath or Declaration filed	25	27

Warnings:					
Information:					
3		AMEND_PRELIM.pdf	232775 241f0a6e9a02e7599fe41922a307c46fe7730a62	yes	4

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Specification	2	2
Claims	3	3
Preliminary Amendment	4	4

Warnings:					
Information:					
4	Fee Worksheet (PTO-06)	fee-info.pdf	8427 6bf099df3bb6beffad780416fb64e201bab1bb00	no	2
Warnings:					

Information:	
Total Files Size (in bytes):	3566990

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5550-47-CON-DIV
	Application Number	
Title of Invention	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ◯ Legal Representative under 35 U.S.C. 117 ◯ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marcos	C.	Tzannes	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

City	Orinda	State/Province	CA	Country of Residence i	US
Citizenship under 37 CFR 1.41(b) i	US				

Mailing Address of Applicant:

Address 1	121 La Espiral		
Address 2			
City	Orinda	State/Province	CA
Postal Code	94563	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	62574	
Email Address	srlaw@sheridanross.com	Add Email Remove Email

Application Information:

Title of the Invention	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM		
Attorney Docket Number	5550-47-CON-DIV	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	2	Suggested Figure for Publication (if any)	

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5550-47-CON-DIV
	Application Number	
Title of Invention	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	◯ US Patent Practitioner	◯ Limited Recognition (37 CFR 11.9)
Customer Number	62574		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Division of	11211535	2005-08-26
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
11211535	Continuation of	09710310	2000-11-09
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
09710310	non provisional of	60164134	1999-11-09

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

			Remove
Application Number	Country i	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◉ Yes ◯ No

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5550-47-CON-DIV
	Application Number	

Title of Invention	SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. [Add]

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 [Remove]

If the Assignee is an Organization check here. ☒

Organization Name	Aware, Inc.		
Mailing Address Information:			
Address 1	40 Middlesex Turnpike		
Address 2			
City	Bedford	**State/Province**	MA
Country i	US	Postal Code	01730
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button. [Add]

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Jason H. Vick/			Date (YYYY-MM-DD)	2007-09-24
First Name	Jason H.	Last Name	Vick	Registration Number	45285

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

A System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System

Related Application

This application claims the benefit of the filing date of copending U.S. Provisional Application, Serial No. 60/164,134, filed November 9, 1999, entitled "A Method For Randomizing The Phase Of The Carriers In A Multicarrier Communications System To Reduce The Peak To Average Power Ratio Of The Transmitted Signal," the entirety of which provisional application is incorporated by reference herein.

Field of the Invention

This invention relates to communications systems using multicarrier modulation. More particularly, the invention relates to multicarrier communications systems that lower the peak-to-average power ratio (PAR) of transmitted signals.

Background of the Invention

In a conventional multicarrier communications system, transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system. An input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution. A bit scrambler is often used in the DMT transmitter to scramble the input data bits before the bits are modulated to assure that the transmitted data bits are random and, consequently, that the modulation of those bits produces a DMT transmission signal with a Gaussian probability distribution.

With an appropriate allocation of transmit power levels to the carriers or sub-channels, such a system provides a desirable performance. Further, generating a transmission signal with a Gaussian probability distribution is important in order to transmit a transmission signal with a low peak-to-average ratio (PAR), or peak-to-average power ratio. The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter. In DMT systems, the PAR of the transmitted signal is determined by the probability of the random transmission signal reaching a certain peak voltage during the time interval required for a certain number of symbols. An example of the PAR of a transmission signal transmitted from a DMT transmitter is 14.5 dB, which is equivalent to having a 1E-7 probability of clipping. The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication system's total power consumption and component linearity requirements of the system.

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value for a data bit corresponds to a –90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.

Summary of the Invention

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.

In another aspect, the invention features a method wherein a value is associated with each carrier signal. The value is determined independently of any input bit value carried by that carrier signal. A phase shift for each carrier signal is computed based on the value associated with that carrier signal. The transmission signal is demodulated using the phase shift computed for each carrier signal.

In another aspect, the invention features a system comprising a phase scrambler that computes a phase shift for each carrier signal based on a value associated with that carrier signal. The phase scrambler also combines the phase shift computed for each carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signals. In one embodiment, a modulator, in communication with the phase scrambler, modulates bits of an input signal onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced PAR.

Description of the Drawings

The invention is pointed out with particularity in the appended claims. The advantages of the invention described above, as well as further advantages of the invention, may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram of an embodiment of a digital subscriber line communications system including a DMT (discrete multitone modulation) transceiver, in communication with a remote transceiver, having a phase scrambler for substantially scrambling the phase characteristics of carrier signals; and

Fig. 2 is a flow diagram of an embodiment of a process for scrambling the phase characteristics of the carrier signals in a transmission signal.

Detailed Description

Fig. 1 shows a digital subscriber line (DSL) communication system 2 including a discrete multitone (DMT) transceiver 10 in communication with a remote transceiver 14 over a communication channel 18 using a transmission signal 38 having a plurality of carrier signals. The DMT transceiver 10 includes a DMT transmitter 22 and a DMT receiver 26. The remote transceiver 14 includes a transmitter 30 and a receiver 34. Although described with respect to discrete multitone modulation, the principles of the invention apply also to other types of multicarrier modulation, such as, but not limited to, orthogonally multiplexed quadrature amplitude modulation (OQAM), discrete wavelet multitone (DWMT) modulation, and orthogonal frequency division multiplexing (OFDM).

The communication channel 18 provides a downstream transmission path from the DMT transmitter 22 to the remote receiver 34, and an upstream transmission path from the remote transmitter 30 to the DMT receiver 26. In one embodiment, the communication channel 18 is a pair of twisted wires of a telephone subscriber line. In other embodiments, the communication channel 18 can be a fiber optic wire, a quad cable, consisting of two pairs of twisted wires, or a quad cable that is one of a star quad cable, a Dieselhorst-Martin quad cable, and the like. In a wireless communication system wherein the transceivers 10, 14 are wireless modems, the communication channel 18 is the air through which the transmission signal 38 travels between the transceivers 10, 14.

By way of example, the DMT transmitter 22 shown in Fig. 1 includes a quadrature amplitude modulation (QAM) encoder 42, a modulator 46, a bit allocation table (BAT) 44, and a phase scrambler 66. The DMT transmitter 22 can also include a bit scrambler 74, as described further below. The remote transmitter 30 of the remote transceiver 14 comprises equivalent components as the DMT transmitter 22. Although this embodiment specifies a detailed description of the DMT transmitter 22, the inventive concepts apply also to the receivers 34, 36 which have similar components to that of the DMT transmitter 22, but perform inverse functions in a reverse order.

The QAM encoder 42 has a single input for receiving an input serial data bit stream 54 and multiple parallel outputs to transmit QAM symbols 58 generated by the QAM encoder 42 from the bit stream 54. In general, the QAM encoder 42 maps the input serial bit-stream 54 in the time domain into parallel QAM symbols 58 in the frequency domain. In particular, the QAM encoder 42 maps the input serial data bit stream 54 into N parallel quadrature amplitude modulation (QAM) constellation points 58, or QAM symbols 58, where N represents the number of carrier signals generated by the modulator 46. The BAT 44 is in communication with the QAM encoder 42 to specify the number of bits carried by each carrier signal. The QAM symbols 58 represent the amplitude and the phase characteristic of each carrier signal.

The modulator 46 provides functionality associated with the DMT modulation and transforms the QAM symbols 58 into DMT symbols 70 each comprised of a plurality of time-domain samples. The modulator 46 modulates each carrier signal with a different QAM symbol 58. As a result of this modulation, carrier signals have phase and amplitude characteristics based on the QAM symbol 58 and therefore based on the input-bit stream 54. In particular, the modulator 46 uses an inverse fast Fourier transform (IFFT) to change the QAM symbols 58 into a transmission signal 38 comprised of a sequence of DMT symbols 70. The modulator 46 changes the QAM symbols 58 into DMT symbols 70 through modulation of the carrier signals. In another embodiment, the modulator 46 uses the inverse discrete Fourier transform (IDFT) to change the QAM symbols 58 into DMT symbols 70. In one embodiment, a pilot tone is included in the transmission signal 38 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the transmission signal 38.

The modulator 46 also includes a phase scrambler 66 that combines a phase shift computed for each QAM-modulated carrier signal with the phase characteristic of that carrier signal. Combining phase shifts with phase characteristics, in accordance with the principles of the invention, substantially scrambles the phase characteristics of the carrier signals in the transmission signal 38. By scrambling the phase characteristics of the carrier signals, the resulting transmission signal 38 has a substantially minimized peak-to-average (PAR) power ratio. The phase scrambler 66 can be part of or external to the modulator 46. Other embodiments of the phase scrambler 66 include, but are not limited to, a software program that is stored in local memory and is executed on the modulator 46, a digital signal processor (DSP) capable of performing mathematical functions and algorithms, and the like. The remote receiver 34 similarly includes a phase scrambler 66' for use when demodulating carrier signals that have had their phase characteristics adjusted by the phase scrambler 66 of the DMT transceiver 10.

To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler 66 associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudo-random number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like, as described in more detail below. Irrespective of the technique used to produce each value, the same technique is used by the DMT transmitter 22 and the remote receiver 34 so that the value associated with a given carrier signal is known at both ends of the communication channel 18.

The phase scrambler 66 then solves a predetermined equation to compute a phase shift for the carrier signal, using the value(s) associated with that carrier signal as input that effects the output of the equation. Any equation suitable for computing phase shifts can be used to compute the phase shifts. When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.

In one embodiment (shown in phantom), the DMT transmitter 22 includes a bit scrambler 74, which receives the input serial bit stream 54 and outputs data bits 76 that are substantially scrambled. The substantially scrambled bits 76 are then passed to the QAM encoder 42. When the bit scrambler 74 is included in the DMT transmitter 22, the operation of the phase scrambler 66 further assures that the transmission signal 38 has a Gaussian probability distribution and, therefore, a substantially minimized PAR.

Fig. 2 shows embodiments of a process used by the DMT transmitter 22 for adjusting the phase characteristic of each carrier signal and combining these carrier signals to produce the transmission signal 38. The DMT transmitter 22 generates (step 100) a value that is associated with a carrier signal. Because the value is being used to alter the phase characteristics of the carrier signal, both the DMT transmitter 22 and the remote receiver 34 must recognize the value as being associated with the carrier signal. Either the DMT transmitter 22 and the remote receiver 34 independently derive the associated value, or one informs the other of the associated value. For example, in one embodiment the DMT transmitter 22 can derive the value from a pseudo-RNG and then transmit the generated value to the remote receiver 34. In another embodiment, the remote receiver 34 similarly derives the value from the same pseudo-RNG and the same seed as used by the transmitter (i.e., the transmitter pseudo-RNG produces the same series of random numbers as the receiver pseudo-RNG).

As another example, the DMT transmitter 22 and the remote receiver 34 can each maintain a symbol counter for counting DMT symbols. The DMT transmitter 22 increments its symbol counter upon transmitting a DMT symbol; the remote receiver 34 upon receipt. Thus, when the DMT transmitter 22 and the remote receiver 34 both use the symbol count as a value for computing phase shifts, both the DMT transmitter 22 and remote receiver 34 "know" that the value is associated with a particular DMT symbol and with each carrier signal of that DMT symbol.

Values can also be derived from other types of predefined parameters. For example, if the predefined parameter is the DMT carrier number, then the value associated with a particular carrier signal is the carrier number of that signal within the DMT symbol. The number of a carrier signal represents the location of the frequency of the carrier signal relative to the frequency of other carrier signals within a DMT symbol. For example, in one embodiment the DSL communication system 2 provides 256 carrier signals, each separated by a frequency of 4.3125 kHz and spanning the frequency bandwidth from 0 kHz to 1104 kHz. The DMT transmitter 22 numbers the carrier signals from 0 to 255. Therefore, "DMT carrier number 50" represents the 51st DMT carrier signal which is located at the frequency of 215.625 kHz (i.e., 51 x 4.3125 kHz).

Again, the DMT transmitter 22 and the remote receiver 34 can know the value that is associated with the carrier signal because both the DMT transmitter 22 and the remote receiver 34 use the same predefined parameter (here, the DMT carrier number) to make the value-carrier signal association. In other embodiments (as exemplified above with the transmitter pseudo-RNG), the DMT transmitter 22 can transmit the value to the remote receiver 34 (or vice versa) over the communication channel 18.

In other embodiments, other predefined parameters can be used in conjunction with the symbol count. One example of such a predefined parameter is the superframe count that increments by one every 69 DMT symbols. One exemplary implementation that achieves the superframe counter is to perform a modulo 68 operation on the symbol count. As another example, the DMT transmitter 22 can maintain a hyperframe counter for counting hyperframes. An exemplary implementation of the hyperframe count is to perform a modulo 255 operation on the superframe count. Thus, the hyperframe count increments by one each time the superframe count reaches 255.

Accordingly, it is seen that some predefined parameters produce values that vary from carrier signal to carrier signal. For example, when the predefined parameter is the DMT carrier number, values vary based on the frequency of the carrier signal. As another example, the pseudo-RNG generates a new random value for each carrier signal.

Other predefined parameters produce values that vary from DMT symbol 70 to DMT symbol 70. For example, when the predefined parameter is the symbol count, the superframe count, or hyperframe count, values vary based on the numerical position of the DMT symbol 70 within a sequence of symbols, superframes, or hyperframes. Predefined parameters such as the pseudo-RNG, symbol count, superframe count, and superframe can also be understood to be parameters that vary values over time. Any one or combination of the predefined parameters can provide values for input to the equation that computes a phase shift for a given carrier signal.

In one embodiment, the phase scrambling is used to avoid clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. In this embodiment, the DMT transmitter 22 uses a value based on a predefined parameter that varies over time, such as the symbol count, to compute the phase shift. It is to be understood that other types of predefined parameters that vary the values associated with carrier signals can be used to practice the principles of the invention. As described above, the transceivers 10, 14 may communicate (step 110) the values to synchronize their use in modulating and demodulating the carrier signals.

The DMT transmitter 22 then computes (step 115) the phase shift that is used to adjust the phase characteristic of each carrier signal. The amount of the phase shift combined with the phase characteristic of each QAM-modulated carrier signal depends upon the equation used and the one or more values associated with that carrier signal.

The DMT transmitter 22 then combines (step 120) the phase shift computed for each carrier signal with the phase characteristic of that carrier signal. By scrambling the phase characteristics of the carrier signals, the phase scrambler 66 reduces (with respect to unscrambled phase characteristics) the combined PAR of the plurality of carrier signals and, consequently, the transmission signal 38. The following three phase shifting examples, PS #1 – PS #3, illustrate methods used by the phase scrambler 66 to combine a computed phase shift to the phase characteristic of each carrier signal.

Phase Shifting Example #1

Phase shifting example #1 (PS #1) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $N \times \frac{\pi}{3}$, modulo (mod) 2π. In this example, a carrier signal having a carrier number N equal to 50 has a phase shift added to the phase characteristic of that carrier signal equal to $50 \times \frac{\pi}{3} (\bmod 2\pi) = \frac{2}{3}\pi$. The carrier signal with a carrier number N equal to 51 has a phase shift added to the phase characteristic of that carrier signal equal to $51 \times \frac{\pi}{3} (\bmod 2\pi) = \pi$. The carrier signal with a carrier number N equal to 0 has no phase shift added to the phase characteristic of that carrier signal.

Phase Shifting Example #2

Phase shifting example #2 (PS #2) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(N + M) \times \frac{\pi}{4}$, mod 2π, where M is the symbol count. In this example, a carrier signal having a carrier number N equal to 50 on DMT symbol count M equal to 8 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+8) \times \frac{\pi}{4} (\bmod 2\pi) = \frac{\pi}{2}$. The carrier signal with the same carrier number N equal to 50 on the next DMT symbol count M equal to 9 has a phase shift added to the phase characteristic of that carrier signal equal to $(50+9) \times \frac{\pi}{4} (\bmod 2\pi) = \frac{3\pi}{4}$.

Phase Shifting Example #3

Phase shifting example #3 (PS #3) corresponds to adjusting the phase characteristic of the QAM-modulated carrier signal associated with a carrier number N by $(X_N)\times\frac{\pi}{6}$, mod 2π, where X_N is an array of N pseudo-random numbers. In this example, a carrier signal having a carrier number N equal to 5 and X_N equal to [3, 8, 1, 4, 9, 5, ...] has a phase shift added to the phase characteristic of the carrier signal that is equal to $(9)\times\frac{\pi}{6}(\text{mod}\,2\pi)=\frac{\pi}{3}$. (Note that 9 is the 5th value in X_N.) The carrier signal with a carrier number N equal to 6 has a phase shift added to the phase characteristic of the carrier signal equal to $(5)\times\frac{\pi}{6}(\text{mod}\,2\pi)=\frac{5\pi}{3}$.

It is to be understood that additional and/or different phase shifting techniques can be used by the phase scrambler 66, and that PS #1, #2, and #3 are merely illustrative examples of the principles of the invention. The DMT transmitter 22 then combines (step 130) the carrier signals to form the transmission signal 38. If the transmission signal is not clipped, as described below, the DMT transmitter 22 consequently transmits (step 160) the transmission signal 38 to the remote receiver 34.

Clipping of Transmission Signals

A transmission signal 38 that has high peak values of voltage (i.e., a high PAR) can induce non-linear distortion in the DMT transmitter 22 and the communication channel 18. One form of this non-linear distortion of the transmission signal 38 that may occur is the limitation of the amplitude of the transmission signal 38 (i.e., clipping). For example, a particular DMT symbol 70 clips in the time domain when one or more time domain samples in that DMT symbol 70 are larger than the maximum allowed digital value for the DMT symbols 70. In multicarrier communication systems when clipping occurs, the transmission signal 38 does not accurately represent the input serial data bit signal 54.

In one embodiment, the DSL communication system 2 avoids the clipping of the transmission signal 38 on a DMT symbol 70 by DMT symbol 70 basis. The DMT transmitter 22 detects (step 140) the clipping of the transmission signal 38. If a particular DMT symbol 70 clips in the time domain to produce a clipped transmission signal 38, the DMT transmitter 22 substitutes (step 150) a predefined transmission signal 78 for the clipped transmission signal 38.

The predefined transmission signal 78 has the same duration as a DMT symbol 70 (e.g., 250 ms) in order to maintain symbol timing between the DMT transmitter 22 and the remote receiver 34. The predefined transmission signal 78 is not based on (i.e., independent of) the modulated input data bit stream 54; it is a bit value pattern that is recognized by the remote receiver 34 as a substituted signal. In one embodiment, the predefined transmission signal 78 is a known pseudo-random sequence pattern that is easily detected by the remote receiver 34. In another embodiment, the predefined transmission signal 78 is an "all zeros" signal, which is a zero voltage signal produced at the DMT transmitter 22 output (i.e., zero volts modulated on all the carrier signals). In addition to easy detection by the remote receiver 34, the zero voltage signal reduces the power consumption of the DMT transmitter 22 when delivered by the DMT transmitter 22. Further, a pilot tone is included in the predefined transmission signal 78 to provide a reference signal for coherent demodulation of the carrier signals in the remote receiver 34 during reception of the predefined transmission signal 78.

After the remote receiver 34 receives the transmission signal 38, the remote receiver 34 determines if the transmission signal 38 is equivalent to the predefined transmission signal 78. In one embodiment, when the remote receiver 34 identifies the predefined transmission signal 78, the remote receiver 34 ignores (i.e., discards) the predefined transmission signal 78.

Following the transmission of the predefined transmission signal 78, the phase scrambler 66 shifts (step 120) the phase characteristic of the QAM-modulated carrier signals (based on one of the predefined parameters that varies over time). For example, consider that a set of QAM symbols 58 produces a DMT symbol 70 comprising a plurality of time domain samples, and that one of the time domain samples is larger than the maximum allowed digital value for the DMT symbol 70. Therefore, because the transmission signal 38 would be clipped when sent to the remote receiver 34, the DMT transmitter 22 sends the predefined transmission signal 78 instead.

After transmission of the predefined transmission signal 78, the DMT transmitter 22 again attempts to send the same bit values that produced the clipped transmission signal 38 in a subsequent DMT symbol 70'. Because the generation of phase shifts in this embodiment is based on values that vary over time, the phase shifts computed for the subsequent DMT symbol 70' are different than those that were previously computed for the DMT symbol 70 with the clipped time domain sample. These different phase shifts are combined to the phase characteristics of the modulated carrier signals to produce carrier signals of the subsequent DMT symbol 70' with different phase characteristics than the carrier signals of the DMT symbol 70 with the clipped time domain sample.

DMT communication systems 2 infrequently produce transmission signals 38 that clip (e.g., approximately one clip every 10^7 time domain samples 70). However, if the subsequent DMT symbol 70' includes a time domain sample that clips, then the predefined transmission signal 78 is again transmitted (step 150) to the remote receiver 34 instead of the clipped transmission signal 38. The clipping time domain sample may be on the same or on a different carrier signal than the previously clipped DMT symbol 70. The DMT transmitter 22 repeats the transmission of the predefined transmission signal 78 until the DMT transmitter 22 produces a subsequent DMT symbol 70' that is not clipped. When the DMT transmitter 22 produces a DMT symbol 70' that is not clipped, the DTM transmitter 22 transmits (step 160) the transmission signal 38 to the remote receiver 34. The probability of a DMT symbol 70 producing a transmission signal 38 that clips in the time domain depends on the PAR of the transmission signal 38.

For example, the following phase shifting example, PST #4, illustrates the method used by the phase scrambler 66 to combine a different phase shift to the phase characteristic of each carrier signal to avoid the clipping of the transmission signal 38.

Phase Shifting Example #4

Phase shifting example #4 (PS #4) corresponds to adjusting the phase characteristic of the carrier signal associated with a carrier number N by $\frac{\pi}{3} \times (M + N)$, mod 2π, where M is the DMT symbol count. In this example, if the DMT symbol 70 clips when the DMT symbol count M equals 5, the predefined transmission signal 78 is transmitted instead of the current clipped transmission signal 38. On the following DMT symbol period, the DMT count M equals 6, thereby causing a different set of time domain samples to be generated for the subsequent DMT symbol 70', although the QAM symbols 58 used to produce both DMT symbols 70, 70' are the same.

If this different set of time domain samples (and consequently the transmission signal 38) is not clipped, the DMT transmitter 22 sends the transmission signal 38. If one of the time domain samples in the different set of time domain samples 70 (and consequently the transmission signal 38) is clipped, then the DMT transmitter 22 sends the predefined transmission signal 78 again. The process continues until a DMT symbol 70 is produced without a time domain sample 70 that is clipped. In one embodiment, the transmitter 22 stops attempting to produce a non-clipped DMT symbol 70'for the particular set of QAM symbols 58 after generating a predetermined number of clipped DMT symbols 70'. At that moment, the transmitter 22 can transmit the most recently produced clipped DMT symbol 70' or the predetermined transmission signal 78.

The PAR of the DSL communication system 2 is reduced because the predefined transmission signal 78 is sent instead of the transmission signal 38 when the DMT symbol 70 clips. For example, a DMT communication system 2 that normally has a clipping probability of 10^{-7} for the time domain transmission signal 38 can therefore operate with a 10^{-5} probability of clipping and a lower PAR equal to 12.8 dB (as compared to 14.5 dB). When operating at a 10^{-5} probability of clipping, assuming a DMT symbol 70 has 512 time-domain samples 70, the DMT transmitter 22 experiences one clipped DMT symbol 70 out of every $\frac{10^5}{512}$, or 195 DMT symbols 70. This results in the predefined (non-data carrying) transmission signal 78 being transmitted, on average, once every 195 DMT symbols. Although increasing the probability of clipping to 10^{-5} results in approximately a 0.5% (1/195) decrease in throughput, the PAR of the transmission signal 38 is reduced by 1.7 dB, which reduces transmitter complexity in the form of power consumption and component linearity.

While the invention has been shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. For example, although the specification uses DSL to describe the invention, it is to be understood that various form of DSL can be used, e.g., ADSL, VDSL, SDSL, HDSL, HDSL2, or SHDSL. It is also to be understood that the principles of the invention apply to various types of applications transported over DSL systems (e.g., telecommuting, video conferencing, high speed Internet access, video-on demand).

What is Claimed:

1. In a multicarrier modulation system including a first transceiver in communication with a second transceiver using a transmission signal having a plurality of carrier signals for modulating an input bit stream, each carrier signal having a phase characteristic associated with the input bit stream, a method for scrambling the phase characteristics of the carrier signals comprising:

associating each carrier signal with a value determined independently of any input bit value carried by that carrier signal;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

combining the phase shift computed for each carrier signal with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals.

2. The method of claim 1 further comprising modulating bits of the input bit stream onto the carrier signals having the substantially scrambled phase characteristics to produce a transmission signal with a reduced peak-to-average power ratio (PAR).

3. The method of claim 1 further comprising independently deriving the value associated with each carrier signal at each transceiver.

4. The method of claim 1 further comprising transmitting the value associated with each carrier signal from one transceiver to the other transceiver.

5. The method of claim 1 further comprising maintaining synchronization between the transceivers using the value associated with each carrier signal.

6. The method of claim 1 wherein the value varies with each carrier signal.

7. The method of claim 1 wherein the value varies with each DMT symbol.

8. The method of claim 1 wherein the value is derived from a predetermined parameter.

9. The method of claim 8 wherein the predefined parameter is a carrier number.

10. The method of claim 8 wherein the predefined parameter is a symbol count.

11. The method of claim 8 wherein the predefined parameter is a hyperframe count.

12. The method of claim 8 wherein the predefined parameter is a superframe count.

13. The method of claim 1 further comprising scrambling the bits of the input bit stream.

14. The method of claim 1 further comprising transmitting a predetermined transmission signal when the amplitude of the transmission signal exceeds a certain level.

15. The method of claim 14 wherein the predetermined transmission signal comprises a predetermined pattern of bits.

16. The method of claim 14 wherein the predetermined transmission signal comprises a pilot tone.

17. The method of claim 16 wherein the pilot tone is used to maintain timing synchronization between the first transceiver and the second transceiver.

18. The method of claim 15 wherein each bit value in the predetermined pattern of bits is a zero value.

19. The method of claim 15 wherein the predetermined pattern of bits is a pseudo-random sequence pattern.

20. In a multicarrier modulation system including a first transceiver in communication with a second transceiver using a transmission signal having a plurality of carrier signals for modulating an input bit stream, each carrier signal having a phase characteristic with the input bit stream, a method for scrambling the phase characteristics of the carrier signals comprising:

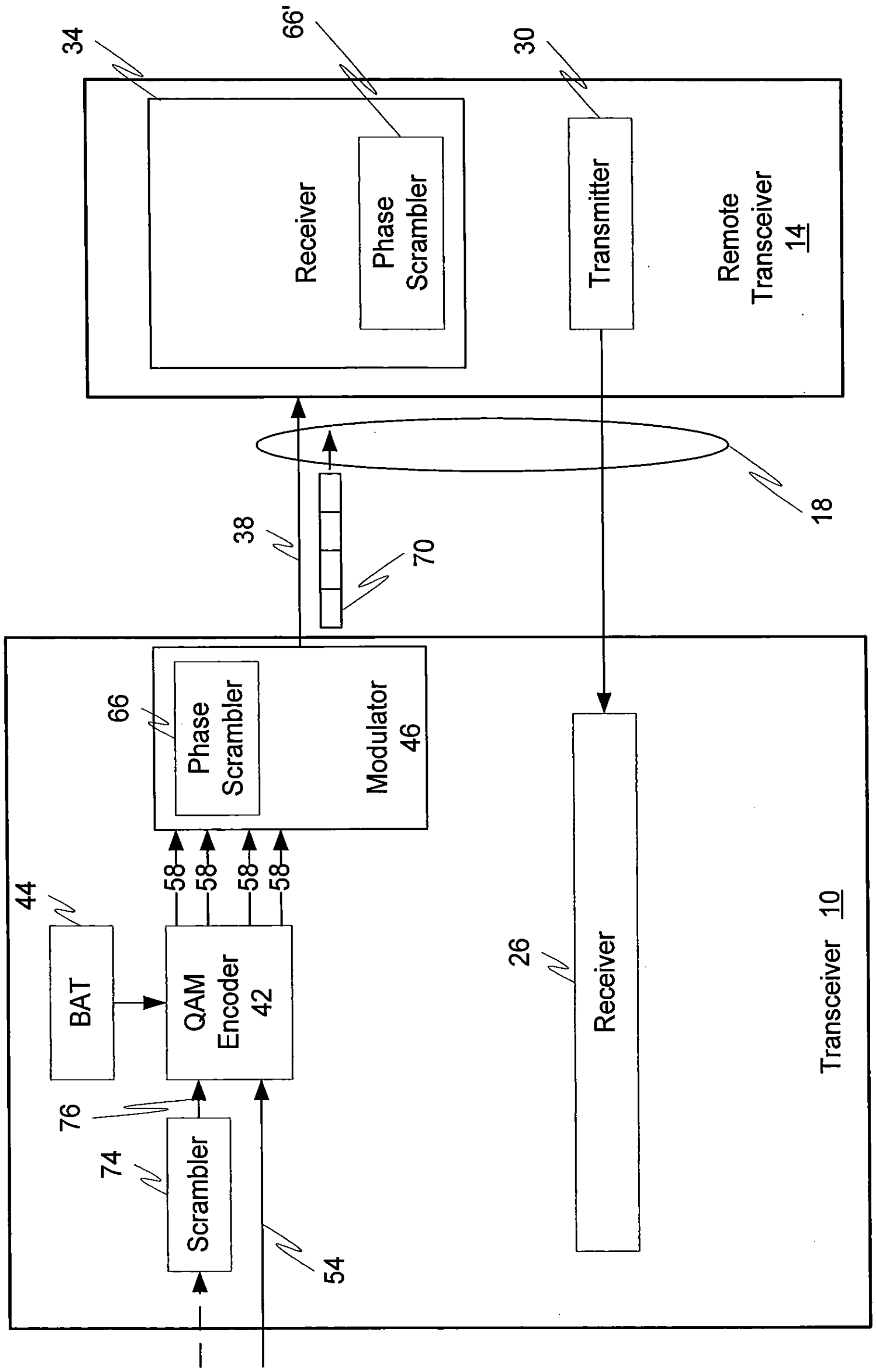
associating each carrier signal with a value determined independently of any input bit value carried by that carrier signal;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

demodulating the transmission signal using the phase shift computed for each carrier signal.

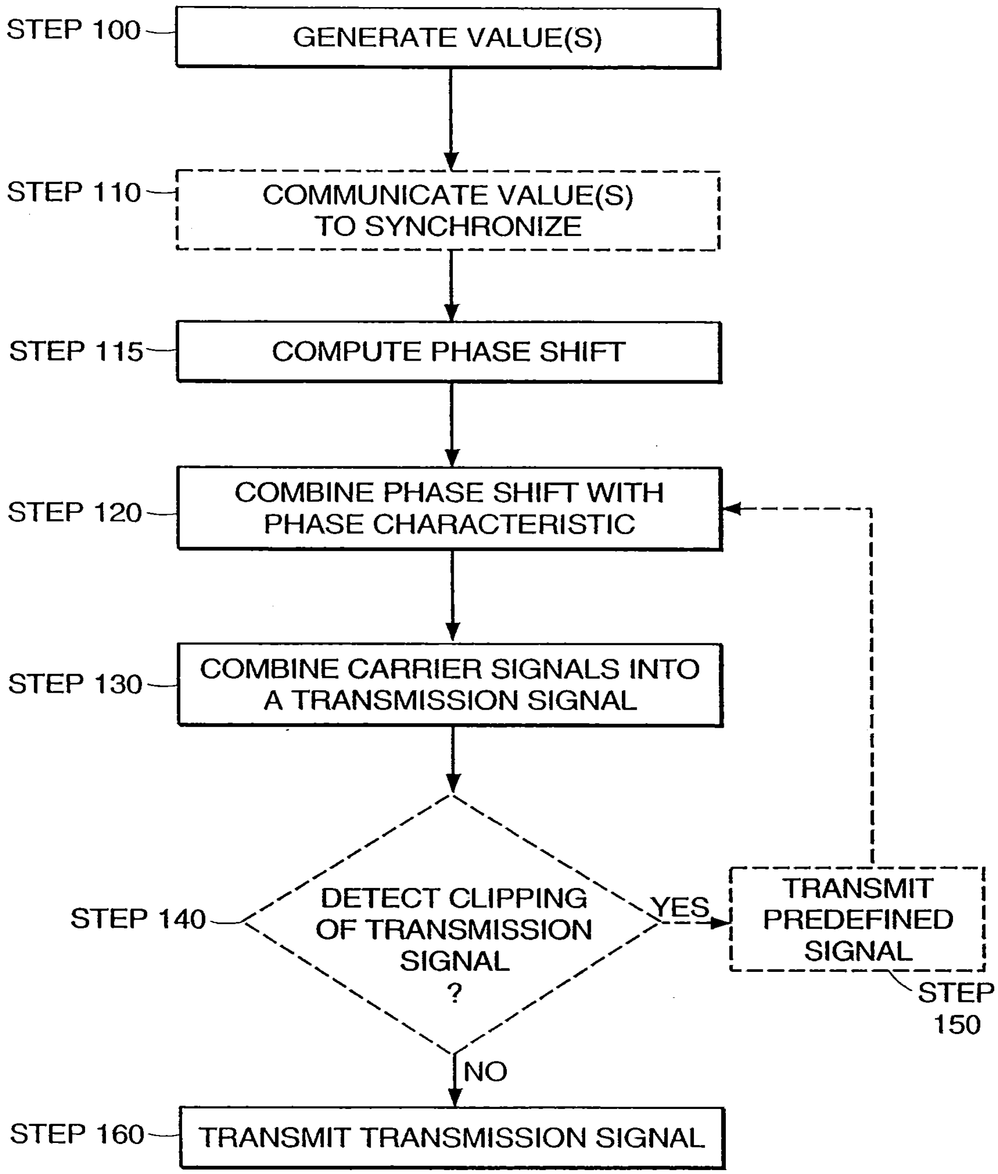
Abstract

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.



34
66'
30
Receiver
Phase
Scrambler
Transmitter
Remote
Transceiver
14
18
38
70
66
Phase
Scrambler
Modulator
46
44
BAT
58
58
58
58
QAM
Encoder
42
26
Receiver
76
74
Scrambler
54
Transceiver 10

Fig. 1



STEP 100
GENERATE VALUE(S)
STEP 110
COMMUNICATE VALUE(S) TO SYNCHRONIZE
STEP 115
COMPUTE PHASE SHIFT
STEP 120
COMBINE PHASE SHIFT WITH PHASE CHARACTERISTIC
STEP 130
COMBINE CARRIER SIGNALS INTO A TRANSMISSION SIGNAL
STEP 140
DETECT CLIPPING OF TRANSMISSION SIGNAL ?
YES
TRANSMIT PREDEFINED SIGNAL
STEP 150
NO
STEP 160
TRANSMIT TRANSMISSION SIGNAL

FIG. 2

DECLARATION AND POWER OF ATTORNEY FOR UTILITY OR DESIGN PATENT APPLICATION	Attorney Docket No.	AWR-017 (457/19)
☒ Declaration Submitted with Initial Filing ☐ Declaration Submitted after Initial Filing (surcharge 37 CFR 1.16(e) required)	First Named Inventor	Tzannes
	COMPLETE IF KNOWN	
	Application Serial Number	Not Yet Assigned
	Filing Date	Herewith
	Group Art Unit	Not Yet Assigned
	Examiner Name	Not Yet Assigned

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A System And Method For Scrambling The Phase Of The Carriers In A Multicarrier Communications System

(Title of the Invention)

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) ______ as United States Application Serial Number or PCT International Application Number ______ and was amended on (MM/DD/YYYY) ______ *(if applicable)*.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose to the Patent Office all information known by me to be material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Serial Number(s)	Filing Date (MM/DD/YYYY)	
60/164,134	11/09/1999	☐ Additional provisional application serial numbers are listed on a supplemental priority data sheet attached hereto.

DECLARATION – Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c), of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Serial Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet attached hereto.

As a named inventor, I hereby appoint the following registered practitioners to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label Here*

OR

☒ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
Steven M. Bauer	31,481	Thomas C. Meyers	36,989
John V. Bianco	36,748	Joseph B. Milstein	42,897
Isabelle A.S. Blundell	43,321	David G. Miranda	42,898
Maureen A. Bresnahan	44,559	Ronda P. Moore	44,244
Michael H. Brodowski	41,640	Indranil Mukerji	P-46,944
Jennifer A. Camacho	43,526	Edmund R. Pitcher	27,829
Joseph A. Capraro, Jr.	36,471	Michael A. Rodriguez	41,274
John J. Cotter	38,116	Jamie H. Rose	45,054
John V. Forcier	42,545	R. Stephen Rosenholm	45,283
Steven J. Frank	33,497	Christopher W. Stamos	35,370
Brian M. Gaff	44,691	Joseph P. Sullivan	45,349
Michael J. Giannetta	42,574	Robert J. Tosti	35,393
Duncan A. Greenhalgh	38,678	Thomas A. Turano	35,722
William G. Guerin	41,047	Michael J. Twomey	38,349
Jonathan A. Harris	44,744	Christine C. Vito	39,061
Ira V. Heffan	41,059	Patrick R.H. Waller	41,418
Danielle L. Herritt	43,670	Daniel A. Wilson	45,508
Douglas J. Kline	35,574	Yin P. Zhang	44,372
John D. Lanza	40,060		
Kurt W. Lockwood	40,704		

☐ Additional registered practitioners named on supplemental Registered Practitioner Information sheet attached hereto.

Direct all correspondence to:

Patent Administrator
Testa, Hurwitz & Thibeault, LLP
High Street Tower
125 High Street
Boston, MA 02110
Tel. No.: (617) 248-7000
Fax No.: (617) 248-7100

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:	☐ A petition has been filed for this unsigned inventor								
Given Name (first and middle [if any])					Family Name or Surname				
Marcos C.					**Tzannes**				
Inventor's Signature							Date	Nov 9, 2000	
Residence	City	**Orinda**	State	**CA**	Country	**USA**		Citizenship	**USA**
Post Office Address	**121 LaEspiral**								
P.O. Address (line 2)	City	**Orinda**	State	**CA**	ZIP	**94563**	Country	**USA**	
☐ Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheet(s) attached hereto.									
Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor								
Given Name (first and middle [if any])					Family Name or Surname				
Inventor's Signature							Date		
Residence	City		State		Country			Citizenship	
Post Office Address									
P.O. Address (line 2)	City		State		ZIP		Country		
Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor								
Given Name (first and middle [if any])					Family Name or Surname				
Inventor's Signature							Date		
Residence	City		State		Country			Citizenship	
Post Office Address									
P.O. Address (line 2)	City		State		ZIP		Country		

9/24/07

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

11/860,080

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)		OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))							300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))							500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))							200
TOTAL CLAIMS (37 CFR 1.16(i))	/ minus 20 =		X 25=		OR	X 50=	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	/ minus 3 =		X 100=			X 200=	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			N/A			N/A	
			TOTAL			TOTAL	1000

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

OR

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/860,080	Filing Date 09/24/2007	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/24/2007	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 1	Minus	** 20	= 0	X $ =		OR	X $50=	0
	Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $ =		OR	X $200=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/SONYA HILLIARD/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.