nated to correspond to different locations of the portable cell phone proximate the portable cell phone user. For example, one control signal may represent that the portable cell phone is in the vicinity of the user's head. Another control signal may be used to represent that the portable cell phone is in the vicinity of the user's body. In alternative embodiments, the control signal may represent that the portable cell phone is not within the vicinity of the user's body.

In the illustrated embodiment, if it is determined that the portable cell phone is proximate the user, then the transmit power level is reduced as determined by a value of a proximity transmit power level, in a step **340**. In one embodiment, the transmit power level may be reduced to one network adjusted transmit power level whenever the portable cell phone is within the vicinity of any part of the user's body. In another embodiment, the transmit power level may be reduced to various allowable proximity transmit power levels depending on the vicinity of the portable cell phone to different parts of the user's body.

After adjusting the transmit power level, the portable cell phone then transmits at a reduced level in a step **350**. In one embodiment, the adjusted transmit power level may not exceed the network adjusted transmit power level as determined by the communications path between the portable cell phone and the communications tower. In other embodiments, the adjusted transmit power level may be reduced to the proximity transmit power level. Finally, the transmission of the portable cell phone ends in a step **370**.

Returning now to the first decisional step **330**, if the portable cell phone is not proximate the user, then the method **300** proceeds to a step **360** wherein the portable cell phone transmits at the network adjusted transmit power level. In one embodiment, the network adjusted transmit power level may equal the maximum transmit power level of a portable cell phone. In other embodiments, the network adjusted transmit power level may be a reduction from the maximum transmit power level due to the communications path between the communications tower and the portable cell phone. After transmitting in step **370**, the method **300** ends in the previously mentioned step **360**.

Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

What is claimed is:

1. A portable cell phone, comprising:

a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower; and

a proximity regulation system, including:

a location sensing subsystem that determines a location of said portable cell phone proximate a user; and

a power governing subsystem, coupled to said location sensing subsystem, that determines a proximity transmit power level of said portable cell phone based on said location and determines a transmit power level for said portable cell phone based on said network adjusted transmit power level and said proximity transmit power level.

2. The portable cell phone as recited in claim **1** wherein said location sensing subsystem determines said location with respect to a portion of a body of said user.

3. The portable cell phone as recited in claim **1** wherein said proximity transmit power level is limited to a predetermined maximum level.

4. The portable cell phone as recited in claim **1** wherein said proximity transmit power level is maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode.

5. The portable cell phone as recited in claim **1** wherein said portable cell phone is located on a belt-clip of said user.

6. The portable cell phone as recited in claim **1** wherein said location sensing subsystem or said power governing subsystem is embodied in an integrated circuit.

7. The portable cell phone as recited in claim **1** wherein said proximity transmit power level is reduced to one level when said location is within a vicinity of a user's head and reduced to a second level when said location is within a vicinity of a user's midsection.

8. The portable cell phone as recited in claim **1** wherein said location sensing subsystem determines said location by employing a sensor selected from the group consisting of:

a designated sensor,

a contact sensor,

a belt clip sensor, and

a cradle sensor.

9. The portable cell phone as recited in claim **1** wherein said location sensing subsystem determines said location by ascertaining a mode of operation of said portable cell phone.

* * * * *

EXHIBIT K

7694435

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September 24, 2018

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: ***09/967,140***
FILING DATE: ***September 28, 2001***
PATENT NUMBER: ***7039435***
ISSUE DATE: ***May 02, 2006***

Certified by

Under Secretary of Commerce
for Intellectual Property
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Patent and Trademark Office

PTO/SB/05 (11-00)
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09/28/01 jc978 U.S. PTO 09/967140 09/28/01

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	R.L. MCDOWELL 20-76
First Inventor	Richard L. McDowell
Title	A PROXIMITY REGULATION SYSTEM FOR USE WITH A PORTABLE CELL PHONE AND A METHOD OF OPERATION THEREOF
Express Mail Label No.	EL843410469US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [X] Specification [*Total Pages* 28] *(preferred arrangement set forth below)*
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (*if filed*)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 3]
5. Oath or Declaration [*Total Pages*]
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63 (d)) *(for continuation/divisional with Box 18 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program (*Appendix*)
8. Nucleotide and/or Amino Acid Sequence Submission (*if applicable, all necessary*)
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] paper
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. [ ] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Request and Certification under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. [ ] Other: ....

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ______

Prior application information: *Examiner* ______ *Group Art Unit* ______

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

[X] *Customer Number or Bar Code Label* 27964 *(Insert Customer No. or Attach bar code label here)* or [X] *Correspondence address below*

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Name (Print/Type)	Glenn W. Boisbrun	*Registration No. (Attorney/Agent)*	39,615
Signature	[signature]	*Date*	09/28/2001

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/967,140	09/28/2001	Richard L. McDowell	R.L. MCDOWELL 20-76	4925

27964 7590 08/13/2004

HITT GAINES P.C.
P.O. BOX 832570
RICHARDSON, TX 75083

EXAMINER	
VU, THAI	
ART UNIT	**PAPER NUMBER**
2643	5

DATE MAILED: 08/13/2004

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

Office Action Summary	Application No. 09/967,140	Applicant(s) MCDOWELL ET AL.	
	Examiner Thai Vu	Art Unit 2643	

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *28 September 2001*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-27* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-27* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *4*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claims 1-3, 6-7, 9-12, 15-16 and 18 are rejected under 35 U.S.C. 102(e) as being anticipated by Werling et al. (U.S. Patent #: 6,456,856; hereinafter "Werling").

Regarding claim 1, Werling teaches a system for use with a portable cell phone, a proximity regulation system (FIG. 1), comprising:

a location sensing subsystem configured to determine a location of said portable cell phone proximate a user (i.e. the proximity detector noted in FIG. 1, block 18; column 3, lines 1-14) ; and

a power governing subsystem, coupled to said location sensing subsystem, configured to determine a proximity transmit power level of said portable cell phone based on said location (FIG. 1, block 17; column 3, lines 15-18).

Regarding claim 2, Werling teaches limitations of the claim in column 3, lines 1-14 (i.e. power is reduced when phones used close to human body including head).

Regarding claim 3, Werling teaches limitations of the claim in column 4, lines 36-60 (i.e. P_{MAX}).

Regarding claim 6, Werling further teaches limitations of the claim in FIG.1, block 17 and column 2, lines 54-66 (i.e. Micro controllers which are widely available as integrated circuits).

Regarding claim 7, Werling further teaches limitations of the claim in FIG. 4 and column 4, lines 40-60.

Regarding claim 9, Werling further teaches limitations of the claim in column 3, lines 1-14.

Regarding claim 10, Werling teaches a method of operating a portable cell phone, comprising:

determining a location of said portable cell phone proximate a user (i.e. based on temperature and humidity, the proximity can be determined, column 3, lines 1-14);

providing a control signal based on said location (i.e. control signal provided by a microcontroller in FIG. 1, column 3 lines 15-18) ; and

determining a proximity transmit power level of said portable cell phone based on said control signal (FIG. 1 block 16, column 3, lines 15-18).

Regarding claim 11, Werling teaches limitations of the claim in column 3, lines 1-14 (i.e. power is reduced when phones used close to human body including head).

Regarding claim 12, Werling teaches limitations of the claim in column 4, lines 36-60 (i.e. P_{MAX}).

Regarding claim 15, Werling further teaches limitations of the claim in FIG.1, block 17 and column 2, lines 54-66 (i.e. Micro controllers which are widely available as integrated circuits).

Regarding claim 16, Werling further teaches limitations of the claim in FIG. 4 and column 4, lines 40-60.

Regarding claim 18, Werling further teaches limitations of the claim in column 3, lines 1-14.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if 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. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 4 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Pirhonen et al. (US Patent #: 6,195,562; hereinafter "Pirhonen").

Regarding claims 4 and 13, Werling teaches all subject matter as claimed above except for proximity transmit power level being maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode. However, Pirhonen teaches such limitations in column 2, lines 29-37 for the purpose of achieving high speed data transmission.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of proximity transmit power level being maximum when said portable cell phone is operating in a data transfer operation mode, as taught by Pirhonen, in view of Werling, in order to achieve high speed data transmission.

5. Claims 5 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Merriam (U.S. Patent #: 6,408,187; hereinafter "Merriam").

Regarding claims 5 and 14, Werling teaches all subject matter as claimed above except for portable cell phone being located on a belt-clip of the user. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the inventions was made to incorporate the use of portable cell phone being located on a belt-clip of the user, as taught by Merriam, in view of Werling, in order to determine the behavior of the communications device.

6. Claims 8 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling et al. (U.S. Patent #: 6,456,856) in view of Merriam (U.S. Patent #: 6,408,187) and Mitzlaff (U.S. Patent #: 4,636,741; hereinafter "Mitzlaff").

Regarding claims 8 and 17, Werling teaches all subject matter as claimed above. Werlington further teaches location sensing subsystem determining said location by employing a sensor selected from the group consisting of:

a designated sensor (column 3, lines 1-14),

a contact sensor (i.e. heat/humidity sensor is used to detect a contact with human skin, column 3, lines 1-14)

It should be noticed that Werlington fails to clearly teach a belt clip sensor. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a belt clip sensor, as taught by Merriam, in view of Werlington, in order to determine the behavior of the mobile unit.

It should be further noticed that Werlington and Merriam, in combination, fails to clearly teach a cradle sensor. However, Mitzlaff teaches such limitations in the abstract for the purpose of detecting the presence of the Mobile unit.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a cradle sensor, as taught by Mitzlaff, into view of Werlington and Merriam, in order to adjust the transmission power accordingly.

7. Claim 19-21, 24-25 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Vogel et al. (U.S. Patent #: 6,498,924, hereinafter "Vogel").

Regarding claim 19, Werling teaches a portable cell phone (FIG.2), comprising:

a power circuit (FIG. 1 block 16 column 2 lines 54-66)

a proximity regulation system, including:

a location sensing subsystem that determines a location of said portable cell phone proximate a user (FIG. 1, block 18; column 3, lines 1-14); and

a power governing subsystem, coupled to said location sensing subsystem, that determines a proximity transmit power level of said portable cell phone based on said location (FIG. 1, block 17; column 3, lines 15-18).

It should be noticed that Werling fails to clearly teach the feature of providing a network adjusted transmit power level as a function of a position to a communications tower. However, Vogel teaches such limitations in column 1, lines 26-37 for the purpose of reducing the overall interference level.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of providing a network adjusted transmit power level as a function of a position to a communications tower, as taught by Vogel, in view of Werling, in order to prevent the cell phone from unnecessarily transmitting at highest level at all times.

Regarding claim 20, Werling teaches limitations of the claim in column 3, lines 1-14 (i.e. power is reduced when phones used close to human body including head).

Regarding claim 21, Werling teaches limitations of the claim in column 4, lines 36-60 (i.e. P_{MAX}).

Regarding claim 24, Werling further teaches limitations of the claim in FIG.1, block 17 and column 2, lines 54-66 (i.e. Micro controllers which are widely available as integrated circuits).

Regarding claim 25, Werling further teaches limitations of the claim in FIG. 4 and column 4, lines 40-60.

Regarding claim 27, Werling further teaches limitations of the claim in column 3, lines 1-14.

8. Claim 22 is rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Vogel (U.S. Patent #:6,498,924) as applied to claim 19 above, and in further view of Pirhonen et al. (US Patent #: 6,195,562).

Regarding claim 22, Werlington and Vogel, in combination, teaches all subject matter as claimed above except for proximity transmit power level being maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode. However, Pirhonen teaches such limitations in column 2, lines 29-37 for the purpose of achieving high speed data transmission.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of proximity transmit power level being maximum when said portable cell phone is operating in a data transfer operation mode, as taught by Pirhonen, into view of Werling and Vogel, in order to achieve high speed data transmission.

9. Claim 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Vogel (U.S. Patent #:6,498,924) as applied to claim 19 above, and in further view of Merriam (U.S. Patent #: 6,408,187).

Regarding claim 23, Werling and Vogel, in combination, teaches all subject matter as claimed above except for portable cell phone being located on a belt-clip of the user. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the inventions was made to incorporate the use of portable cell phone being located on a belt-clip of the user, as taught by Merriam, into view of Werling and Vogel, in order to determine the behavior of the communications device.

10. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Werling et al. (U.S. Patent #: 6,456,856) in view of Vogel (U.S. Patent #:6,498,924) as applied to claim 19 above, and in further view of Merriam (U.S. Patent #: 6,408,187) and Mitzlaff (U.S. Patent #: 4,636,741).

Regarding claim 26, Werlington and Vogel, in combination, teaches all subject matter as claimed above. Werlington further teaches location sensing subsystem determining said location by employing a sensor selected from the group consisting of:

a designated sensor (column 3, lines 1-14),

a contact sensor (i.e. heat/humidity sensor is used to detect a contact with human skin, column 3, lines 1-14)

It should be noticed that Werlington and Vogel, in combination, fails to clearly teach a belt clip sensor. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a belt clip sensor, as taught by Merriam, in view of Werlington and Vogel, in order to determine the behavior of the mobile unit.

It should be further noticed that Werlington, Vogel and Merriam, in combination, fails to clearly teach a cradle sensor. However, Mitzlaff teaches such limitations in the abstract for the purpose of detecting the presence of the Mobile unit.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a cradle sensor, as taught by Mitzlaff, into view of Werlington, Vogel and Merriam, in order to adjust the transmission power accordingly.

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thai Vu whose telephone number is 703-305-3417. The examiner can normally be reached on 9:00AM-6:00PM, M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Curtis Kuntz can be reached on 703-305-3900. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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).

Thai Vu
Examiner
Art Unit 2643

BINH TIEU
PRIMARY EXAMINER

41

Cp2643

OIPE JC133 NOV 18 2004 PATENT & TRADEMARK OFFICE

ATTORNEY DOCKET NO. R.L. MCDOWELL 20-76 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Richard L. McDowell, *et al.*

Serial No.: 09/967,140

Filed: September 28, 2001

Title: A PROXIMITY REGULATION SYSTEM FOR USE WITH A PORTABLE CELL PHONE AND A METHOD OF OPERATION THEREOF

Grp./A.U.: 2643

Examiner: Thai Vu

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Debbie Sams
(Signature of the person signing the certificate)

Sir:

AMENDMENT UNDER 37 C.F.R. § 1.111

The Applicants have carefully considered this application in connection with the Examiner's Action mailed August 13, 2004, and respectfully request reconsideration of this application in view of the following amendment and remarks.

IN THE CLAIMS:

1. (Currently Amended) For use with a portable cell phone, a proximity regulation system, comprising:

a location sensing subsystem configured to determine a location of said portable cell phone with respect to a portion of a body of ~~proximate~~ a user; and

a power governing subsystem, coupled to said location sensing subsystem, configured to determine a proximity transmit power level of said portable cell phone based on said location.

2. (Currently Amended) The proximity regulation system as recited in Claim 1 wherein said proximity transmit power level is reduced to one level when said location is within a vicinity of a user's head and reduced to a second level when said location is within a vicinity of a user's midsection.

3. (Original) The proximity regulation system as recited in Claim 1 wherein said proximity transmit power level is limited to a predetermined maximum level.

4. (Original) The proximity regulation system as recited in Claim 1 wherein said proximity transmit power level is maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode.

5. (Original) The proximity regulation system as recited in Claim 1 wherein said portable cell phone is located on a belt-clip of said user.

6. (Original) The proximity regulation system as recited in Claim 1 wherein said location sensing subsystem or said power governing subsystem is embodied in an integrated circuit.

7. (Original) The proximity regulation system as recited in Claim 1 wherein said location sensing subsystem or said power governing subsystem is embodied in a sequence of operating instructions.

8. (Original) The proximity regulation system as recited in Claim 1 wherein said location sensing subsystem determines said location by employing a sensor selected from the group consisting of:

a designated sensor,

a contact sensor,

a belt clip sensor, and

a cradle sensor.

9. (Original) The proximity regulation system as recited in Claim 1 wherein said location sensing subsystem determines said location by ascertaining a mode of operation of said portable cell phone.

10. (Currently Amended) A method of operating a portable cell phone, comprising:

determining a location of said portable cell phone with respect to a portion of a body of ~~proximate~~ a user;

providing a control signal based on said location; and

determining a proximity transmit power level of said portable cell phone based on said control signal.

11. (Currently Amended) The method as recited in Claim 10 wherein said proximity transmit power level is reduced to one level when said location is within a vicinity of a user's head and reduced to a second level when said location is within a vicinity of a user's midsection.

12. (Original) The method as recited in Claim 10 wherein said proximity transmit power level is limited to a predetermined maximum level.

13. (Original) The method as recited in Claim 10 wherein said proximity transmit power level is maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode.

14. (Original) The method as recited in Claim 10 wherein said portable cell phone is located on a belt-clip of said user.

15. (Original) The method as recited in Claim 10 wherein said determining said location is performed by a location sensing subsystem embodied in an integrated circuit.

16. (Original) The method as recited in Claim 10 wherein said determining a proximity transmit power level is performed by a power governing subsystem embodied in a sequence of operating instructions.

17. (Original) The method as recited in Claim 10 wherein said determining a location employs a sensor selected from the group consisting of:

a designated sensor,

a contact sensor,

a belt clip sensor, and

a cradle sensor.

18. (Original) The method as recited in Claim 10 wherein said determining a location is performed by ascertaining a mode of operation of said portable cell phone.

19. (Currently Amended) A portable cell phone, comprising:

a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower; and

a proximity regulation system, including:

a location sensing subsystem that determines a location of said portable cell phone proximate a user; and

a power governing subsystem, coupled to said location sensing subsystem, that determines a proximity transmit power level of said portable cell phone based on said location and determines a transmit power level for said portable cell phone based on said network adjusted transmit power level and said proximity transmit power level.

20. (Currently Amended) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location with respect to a portion of a body of said user ~~proximity transmit power level is reduced when said location is within a vicinity of a user's head~~.

21. (Original) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is limited to a predetermined maximum level.

22. (Original) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode.

23. (Original) The portable cell phone as recited in Claim 19 wherein said portable cell phone is located on a belt-clip of said user.

24. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem or said power governing subsystem is embodied in an integrated circuit.

25. (Currently Amended) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is reduced to one level when said location is within a vicinity of a user's head and reduced to a second level when said location is within a vicinity of a user's midsection ~~location sensing subsystem or said power governing subsystem is embodied in a sequence of operating instructions~~.

26. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location by employing a sensor selected from the group consisting of:

a designated sensor,

a contact sensor,

a belt clip sensor, and

a cradle sensor.

27. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location by ascertaining a mode of operation of said portable cell phone.

REMARKS/ARGUMENTS

The Applicants originally submitted Claims 1-27 in the application. The Applicants have amended Claims 1-2, 10-11, 19-20 and 25. No claims have been canceled or added. Accordingly, Claims 1-27 are currently pending in the application.

I. Rejection of Claims 1-3, 6-7, 9-12, 15-16 and 18 under 35 U.S.C. §102

The Examiner has rejected Claims 1-3, 6-7, 9-12, 15-16 and 18 under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,456,856 to Werling, *et al.* The Applicants respectfully disagree.

Werling is directed to minimizing radio wave exposure to users of radio communication apparatuses. (*See* column 1, line 65 to column 2, line 12.) Werling does not teach, however, a portable cell phone that determines a location of the portable cell phone with respect to a portion of a body of a user as recited in independent Claims 1 and 10. On the contrary, Werling simply determines if a radio communication apparatus is proximate to human tissue. (*See* column 3, lines 1-8.) The Applicants do not find where Werling determines location of the radio communication apparatus with respect to a portion of a user's body. Werling, therefore, does not teach each element of independent Claims 1 and 10.

Since Werling does not disclose each and every element of independent Claims 1 and 10, Werling does not anticipate Claims 1 and 10 and Claims dependent thereon. Accordingly, the Applicants respectfully request the Examiner to withdraw the §102 rejection with respect to Claims 1-3, 6-7, 9-12, 15-16 and 18 and allow issuance thereof.

II. Rejection of Claims 4-5, 8, 13-14 and 17 under 35 U.S.C. §103

The Examiner has rejected Claims 4-5, 8, 13-14 and 17 under 35 U.S.C. §103(a) as being unpatentable over Werling in view of the following U.S. Patents: U.S. Patent No. 6, 195,562 to Pirhonen for Claims 4 and 13; U.S. Patent No. 6,408,187 to Merriam for Claims 5 and 14; and Merriam in further view of U.S. Patent No. 4,636,741 to Mitzlaff for Claims 8 and 17. The Applicants respectfully disagree.

As discussed above, Werling does not teach a portable cell phone that determines a location of the portable cell phone with respect to a portion of a body of a user as recited in independent Claims 1 and 10. Additionally, Werling does not suggest a portable cell phone that determines a location of the portable cell phone with respect to a portion of a body of a user since Werling simply addresses determining proximity of a radio communications device to human tissue. (*See* column 3, lines 1-8.)

Each of the references, Pirhonen, Merriam and Mitzlaff, have been cited to disclose the subject matter of a dependent Claim. The Applicants do not find, however, where any of the references Pirhonen, Merriam and Mitzlaff teach or suggest a portable cell phone that determines a location of the portable cell phone with respect to a portion of a body of a user. The cited references, therefore, do not teach each element of independent Claims 1 and 10 and Claims dependent thereon. Accordingly, the cited references do not provide a *prima facie* case of obviousness for Claims 4-5, 8, 13-14 and 17 which depend on Claims 1 or 10, respectively. Thus, the Applicants respectfully request the Examiner withdraw the §103(a) rejection of Claims 4-5, 8, 13-14 and 17 and allow issuance thereof.

III. Rejection of Claims 19-21, 24-25 and 27 under 35 U.S.C. §103

The Examiner has rejected Claims 19-21, 24-25 and 27 under 35 U.S.C. §103(a) as being unpatentable over Werling in view of U.S. Patent No. 6, 498,924 to Vogel, *et al.*195,562. The Applicants respectfully disagree.

As recognized by the Examiner, Werling does not teach or suggest a portable cell phone including a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower as recited in independent Claim 19. Thus, the Examiner cites Vogel to cure this deficiency of Werling. (*See* Examiner's Action, page 7.)

Vogel provides mobile radio communications systems and an apparatus for measuring the distance or the propagation time between a mobile station and a base station in such a system. (*See* column 2, lines 15-32.) Vogel provides no teaching or suggestion, however, of a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower. Instead, Vogel is directed to improving the accuracy of determining the distance and propagation. (*See* column 2, lines 1-14.) Vogel does teach in the background that the distance and propagation measurements may be used for various purposes. Vogel provides no teaching or suggestion, however, that the purpose may be for providing a power level for transmitting.

Accordingly, neither Werling nor Vogel, individually or in combination, teach or suggest a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower. Thus, neither Werling or Vogel, individually or in combination, teach or suggest a power governing subsystem that determines a transmit power level for a portable cell phone based on a network adjusted transmit power level and a proximity transmit power level as recited in Claim 19. The cited combination of Werling and Vogel, therefore, does not provide a *prima facie* case of obviousness of independent Claim 19 and Claims dependent thereon. Thus, the cited combination of Werling and Vogel does not render unpatentable Claims 19-21, 24-25 and 27. Accordingly, the Applicants respectfully request the Examiner withdraw the §103(a) rejection of Claims 19-21, 24-25 and 27 and allow issuance thereof.

IV. Rejection of Claims 22, 23 and 26 under 35 U.S.C. §103

The Examiner has rejected Claims 22, 23 and 26 under 35 U.S.C. §103(a) as being unpatentable over Werling in view of Vogel and the following U.S. Patents to Pirhonen for Claim 22, to Merriam for Claim 23 and Merriam in further view of Mitzlaff for Claim 26. The Applicants respectfully disagree.

As discussed above, the combination of Werling and Vogel does not teach or suggest each element of independent Claim 19. Each of the references, Pirhonen, Merriam and Mitzlaff, have not been cited to cure the above deficiency of Werling and Vogel but to disclose the subject matter of a dependent claim. The Applicants do not find, however, where any of the references Pirhonen, Merriam and Mitzlaff teach or suggest a portable cell phone including a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower and a proximity regulation system including a power governing subsystem that determines a transmit power level for the portable cell phone based on the network adjusted transmit power level and a proximity transmit power level. The cited references, therefore, do not teach each element of independent Claim 19 and Claims dependent thereon. Accordingly, the cited references do not provide a *prima facie* case of obviousness for Claims 22, 23 and 26 which depend on Claim 19.

Thus, the Applicants respectfully request the Examiner withdraw the §103(a) rejection of Claims 22, 23 and 26 and allow issuance thereof.

V. Conclusion

In view of the foregoing amendment and remarks, the Applicants now see all of the Claims currently pending in this application to be in condition for allowance and therefore earnestly solicit a Notice of Allowance for Claims 1-27.

The Applicants request the Examiner to telephone the undersigned attorney of record at (972) 480-8800 if such would further or expedite the prosecution of the present application.

Respectfully submitted,

HITT GAINES, P.C.

J. Joel Justiss
Registration No. 48,981

Dated: 11/15/04

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/967,140	09/28/2001	Richard L. McDowell	R.L. MCDOWELL 20-76	4925

47396 7590 08/08/2005

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EXAMINER	
VU, THAI	
ART UNIT	**PAPER NUMBER**
2687	

DATE MAILED: 08/08/2005

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

Office Action Summary	Application No. 09/967,140	Applicant(s) MCDOWELL ET AL.
	Examiner Thai N. Vu	Art Unit 2687

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 11/18/2004.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-27 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) 19-27 is/are allowed.

6)☒ Claim(s) 1-18 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 05/24/2005.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Applicant's arguments with respect to claims 1-18 have been considered but are moot in view of the new ground(s) of rejection.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

3. Claims 1-3, 6-7, 9-12, 15-16 and 18 are rejected under 35 U.S.C. 102(e) as being anticipated by Werling et al. (U.S. Patent #: 6,456,856; hereinafter "Werling").

Regarding claim 1, Werling teaches a system for use with a portable cell phone, a proximity regulation system (FIG. 1), comprising:

a location sensing subsystem configured to determine a location of said portable cell phone with respect to a portion of a body of a user (i.e. the proximity detector noted in FIG. 1, block 18; column 3, lines 1-14 – inherently, the detector is capable of distinguishing areas having different heat or humidity signatures, e.g. bare skin areas emits more heat or higher humidity than clothed areas); and a power governing subsystem, coupled to said location sensing subsystem, configured to determine a proximity transmit power level of said portable cell phone based on said location (FIG. 1, block 17; column 3, lines 15-18).

Regarding claim 2, Werling teaches limitations of the claim in column 3, lines 1-19; column 4, lines 16-36 (i.e. with different areas of the user body provides, detector provides different data value resulting in different transmit power values).

Regarding claim 3, Werling teaches limitations of the claim in column 4, lines 36-60 (i.e. P_{MAX}).

Regarding claim 6, Werling further teaches limitations of the claim in FIG.1, block 17 and column 2, lines 54-66 (i.e. Micro controllers which are widely available as integrated circuits).

Regarding claim 7, Werling further teaches limitations of the claim in FIG. 4 and column 4, lines 40-60.

Regarding claim 9, Werling further teaches limitations of the claim in column 3, lines 1-14.

Regarding claim 10, Werling teaches a method of operating a portable cell phone, comprising:

determining a location of said portable cell phone with respect to a portion of a body of a user (i.e. based on temperature and humidity, the proximity can be determined, column 3, lines 1-14 - inherently, the detector is capable of distinguishing areas having different heat or humidity signatures, e.g. bare skin areas emits more heat or higher humidity than clothed areas);

providing a control signal based on said location (i.e. control signal provided by a microcontroller in FIG. 1, column 3 lines 15-18) ; and

determining a proximity transmit power level of said portable cell phone based on said control signal (FIG. 1 block 16, column 3, lines 15-18).

Regarding claim 11, Werling teaches limitations of the claim in column 3, lines 1-14 (i.e. with different areas of the user body provides, detector provides different data value resulting in different transmit power values).

Regarding claim 12, Werling teaches limitations of the claim in column 4, lines 36-60 (i.e. P_{MAX}).

Regarding claim 15, Werling further teaches limitations of the claim in FIG.1, block 17 and column 2, lines 54-66 (i.e. Micro controllers which are widely available as integrated circuits).

Regarding claim 16, Werling further teaches limitations of the claim in FIG. 4 and column 4, lines 40-60.

Regarding claim 18, Werling further teaches limitations of the claim in column 3, lines 1-14.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if 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. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 4 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Pirhonen et al. (US Patent #: 6,195,562; hereinafter "Pirhonen").

Regarding claims 4 and 13, Werling teaches all subject matter as claimed above except for proximity transmit power level being maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode. However, Pirhonen teaches such limitations in column 2, lines 29-37 for the purpose of achieving high speed data transmission.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of proximity transmit power level being maximum when said portable cell phone is operating in a data transfer operation mode, as taught by Pirhonen, in view of Werling, in order to achieve high speed data transmission.

6. Claims 5 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling (U.S. Patent #: 6,456,856) in view of Merriam (U.S. Patent #: 6,408,187; hereinafter "Merriam").

Regarding claims 5 and 14, Werling teaches all subject matter as claimed above except for portable cell phone being located on a belt-clip of the user. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the inventions was made to incorporate the use of portable cell phone being located on a belt-clip of the user, as taught by Merriam, in view of Werling, in order to determine the behavior of the communications device.

7. Claims 8 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Werling et al. (U.S. Patent #: 6,456,856) in view of Merriam (U.S. Patent #: 6,408,187) and Mitzlaff (U.S. Patent #: 4,636,741; hereinafter "Mitzlaff").

Regarding claims 8 and 17, Werling teaches all subject matter as claimed above. Werlington further teaches location sensing subsystem determining said location by employing a sensor selected from the group consisting of:

a designated sensor (column 3, lines 1-14),

a contact sensor (i.e. heat/humidity sensor is used to detect a contact with human skin, column 3, lines 1-14)

It should be noticed that Werlington fails to clearly teach a belt clip sensor. However, Merriam teaches such limitations in column 3, lines 36-49 for the purpose of indicating whether the device within relatively close proximity to a user.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a belt clip sensor, as taught by Merriam, in view of Werlington, in order to determine the behavior of the mobile unit.

It should be further noticed that Werlington and Merriam, in combination, fails to clearly teach a cradle sensor. However, Mitzlaff teaches such limitations in the abstract for the purpose of detecting the presence of the Mobile unit.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of a cradle sensor, as taught by Mitzlaff, into view of Werlington and Merriam, in order to adjust the transmission power accordingly.

Allowable Subject Matter

8. Claims 19-27 are allowed.

9. The following is a statement of reasons for the indication of allowable subject matter: The prior art fails to teach the feature of a portable cell phone, comprising:

a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower; and

a proximity regulation system, including:

a location sensing subsystem that determines a location of said portable cell phone proximate a user; and

a power governing subsystem, coupled to said location sensing subsystem, that *determines a proximity transmit power level of said portable cell phone based on said location and determines a transmit power level for said portable cell phone based on said network adjusted transmit power level and said proximity transmit power level.*

Conclusion

10. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP

§ 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thai N. Vu whose telephone number is 571-272-7928. The examiner can normally be reached on 9:00AM-7:00PM, M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lester Kincaid can be reached on 571-272-7922. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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).

SONNY TRINH
PRIMARY EXAMINER

Thai N. Vu
Examiner
Art Unit 2687

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HITT GAINES, P.C.

Intellectual Property Law & Related Matters

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TO: USPTO
Examiner: Thai Vu - Art Unit: 2643

FAX NO. 571-273-8300

FROM: J. Joel Justiss

RE: Serial No.: 09/967,140
Attorney Docket No.: R.L. MCCOWELL 20-76
Amendment Under 37 C.F.R. § 1.116

DATE: October 6, 2005

PAGES: 6 (including cover page)

If you do not receive the indicated number of pages, please notify the sender at the telephone number shown below. Thank you.

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ATTORNEY DOCKET NO. R.L. MCDOWELL 20-76 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Richard L. McDowell, *et al.*
Serial No.:	09/967,140
Filed:	September 28, 2001
Title:	A PROXIMITY REGULATION SYSTEM FOR USE WITH A PORTABLE CELL PHONE AND A METHOD OF OPERATION THEREOF
Grp./A.U.:	2643
Examiner:	Thai Vu

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

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Sir:

AMENDMENT UNDER 37 C.F.R. § 1.116

The Applicants have carefully considered this application in connection with the Examiner's Final Rejection mailed August 8, 2005, and respectfully request reconsideration of this application in view of the following amendment and remarks.

IN THE CLAIMS:

Claims 1-18 (canceled)

19. (Previously Presented) A portable cell phone, comprising:

a power circuit that provides a network adjusted transmit power level as a function of a position to a communications tower; and

a proximity regulation system, including:

a location sensing subsystem that determines a location of said portable cell phone proximate a user; and

a power governing subsystem, coupled to said location sensing subsystem, that determines a proximity transmit power level of said portable cell phone based on said location and determines a transmit power level for said portable cell phone based on said network adjusted transmit power level and said proximity transmit power level.

20. (Previously Presented) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location with respect to a portion of a body of said user.

21. (Original) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is limited to a predetermined maximum level.

22. (Original) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is maximum when said portable cell phone is operating in a headset operation mode or data transfer operation mode.

23. (Original) The portable cell phone as recited in Claim 19 wherein said portable cell phone is located on a belt-clip of said user.

24. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem or said power governing subsystem is embodied in an integrated circuit.

25. (Previously Presented) The portable cell phone as recited in Claim 19 wherein said proximity transmit power level is reduced to one level when said location is within a vicinity of a user's head and reduced to a second level when said location is within a vicinity of a user's midsection.

26. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location by employing a sensor selected from the group consisting of:

a designated sensor,

a contact sensor,

a belt clip sensor, and

a cradle sensor.

27. (Original) The portable cell phone as recited in Claim 19 wherein said location sensing subsystem determines said location by ascertaining a mode of operation of said portable cell phone.

REMARKS/ARGUMENTS

The Applicants originally submitted Claims 1-27 in the application and amended Claims 1-2, 10-11, 19-20 and 25 in a previous response. In the present Final Rejection, the Examiner has indicated that Claims 19-27 are allowed. In order to expedite issuance, the Applicants have canceled Claims 1-18 without prejudice or disclaimer to place the application in condition for allowance. Accordingly, Claims 19-27 are currently pending in the application.

I. Rejection of Claims 1-3, 6-7, 9-12, 15-16 and 18 under 35 U.S.C. §102

The Examiner has rejected Claims 1-3, 6-7, 9-12, 15-16 and 18 under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,456,856 to Werling, *et al.* The §102(b) rejection, however, is now moot since the Applicants have canceled Claims 1-3, 6-7, 9-12, 15-16 and 18 without prejudice or disclaimer. Accordingly, the Applicants respectfully request the Examiner to withdraw the §102 rejection and allow issuance of the pending claims.

II. Rejection of Claims 4-5, 8, 13-14 and 17 under 35 U.S.C. §103

The Examiner has rejected Claims 4-5, 8, 13-14 and 17 under 35 U.S.C. §103(a) as being unpatentable over Werling in view of the following U.S. Patents: U.S. Patent No. 6, 195,562 to Pirhonen for Claims 4 and 13; U.S. Patent No. 6,408,187 to Merriam for Claims 5 and 14; and Merriam in further view of U.S. Patent No. 4,636,741 to Mitzlaff for Claims 8 and 17. The §103(a) rejection, however, is now moot since the Applicants have canceled Claims 4-5, 8, 13-14 and 17 without prejudice or disclaimer. Accordingly, the Applicants respectfully request the Examiner to withdraw the §103(a) rejection and allow issuance of the pending claims.

III. Conclusion

In view of the foregoing amendment and remarks, the Applicants now see all of the Claims currently pending in this application to be in condition for allowance and therefore earnestly solicit a Notice of Allowance for Claims 19-27.

The Applicants request the Examiner to telephone the undersigned attorney of record at (972) 480-8800 if such would further or expedite the prosecution of the present application. The Commissioner is hereby authorized to charge any fees, credits or overpayments to deposit account 08-2395.

Respectfully submitted,

HITT GAINES, PC

J. Joel Justiss
Registration No. 48,981

Dated: 10/6/05

P.O. Box 832570
Richardson, Texas 75083
(972) 480-8800

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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NOTICE OF ALLOWANCE AND FEE(S) DUE

47396 7590 11/18/2005

HITT GAINES, PC
AGERE SYSTEMS INC.
PO BOX 832570
RICHARDSON, TX 75083

EXAMINER	
TRINH, SONNY	
ART UNIT	PAPER NUMBER
2687	

DATE MAILED: 11/18/2005

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/967,140	09/28/2001	Richard L. McDowell	R.L. MCDOWELL 20-76	4925

TITLE OF INVENTION: PROXIMITY REGULATION SYSTEM FOR USE WITH A PORTABLE CELL PHONE AND A METHOD OF OPERATION THEREOF

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	02/21/2006

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 REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

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 should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. 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.

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)

47396 7590 11/18/2005

HITT GAINES, PC
AGERE SYSTEMS INC.
PO BOX 832570
RICHARDSON, TX 75083

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.
09/967,140	09/28/2001	Richard L. McDowell	R.L. MCDOWELL 20-76	4925

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APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	02/21/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
TRINH, SONNY	2687	455-522000

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 enclosed:

☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), 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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
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.

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EXAMINER	
TRINH, SONNY	
ART UNIT	PAPER NUMBER
2687	

DATE MAILED: 11/18/2005

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 575 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 575 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 (703) 305-8283.

Notice of Allowability	**Application No.** 09/967,140	**Applicant(s)** MCDOWELL ET AL.	
	Examiner Sonny TRINH	**Art Unit** 2687	

-- 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 *10/06/05*.

2. ☒ The allowed claim(s) is/are *19-27*.

3. ☒ The drawings filed on *28 September 2001* are accepted by the Examiner.

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-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

SONNY TRINH
PRIMARY EXAMINER

EXHIBIT L

IN THE UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. COOLPAD TECHNOLOGIES, INC. AND YULONG COMPUTER COMMUNICATIONS, Defendants.	C.A. No. 3:18-cv-1783-CAB-BLM Judge: Hon. Cathy Ann Bencivengo Magistrate Judge: Hon. Barbara L. Major
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. HUAWEI DEVICE (DONGGUAN) CO., LTD, HUAWEI DEVICE (SHENZHEN) CO., LTD., and HUAWEI DEVICE USA, INC., Defendants.	C.A. yoceraNo. 3:18-cv-1784-CAB-BLM
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. KYOCERA CORPORATION and KYOCERA INTERNATIONAL INC., Defendants.	C.A. No. 3:18-cv-1785-CAB-BLM

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. ZTE CORPORATION, ZTE (USA) INC., ZTE (TX) INC., Defendants.	C.A. No. 3:18-cv-1786-CAB-BLM[1]

AMENDED OPENING DECLARATION OF DR. VIJAY K. MADISETTI, PH.D. IN SUPPORT OF PLAINTIFF'S CLAIM CONSTRUCTIONS

[1] This declaration is submitted with respect to the Coolpad, Huawei, and Kyocera Defendants pending the Court's resolution of BNR's Motion for Clarification as to ZTE (*see* Dkt. 75 in Case No. 3:18-cv-1786-CAB-BLM). If the Court determines that Dr. Madisetti is not precluded from opining on consolidated issues with respect to ZTE, this declaration will be deemed submitted in the ZTE matter as well.

Table of Contents

BACKGROUND

A. Qualifications and Experience

1. My qualifications can be found in my Curriculum Vitae, which includes a complete list of my publications, and is attached as **Appendix 1**. Some of my background and experience that qualifies me to offer the opinions offered in this Declaration as an expert in the technical issues in this case follow.

2. I received my Bachelor of Technology (Honors) in Electronics and Electrical Communication Engineering at the Indian Institute of Technology (IIT) in Kharagpur, India, in 1984. I obtained my Ph.D. in Electrical Engineering and Computer Science at the University of California, Berkeley, in 1989. I received the Demetri Angelakos Outstanding Graduate Student Award from the University of California, Berkeley, and the IEEE/ACM Ira M. Kay Memorial Paper Prize in 1989.

3. I now am a tenured Professor in Electrical and Computer Engineering at Georgia Tech and currently serve as its representative to the European Telecommunications Standards Institute ("ETSI"). I am knowledgeable and familiar with wireless communications including the IEEE's 802.11 standards, microprocessor architecture, radio frequency ("RF") communication, cellular networks including ETSI/3GPP/3GPP2 standards, ASIC design, computer engineering, digital signal processing, sensors, wireless terminal power regulation, and software and firmware design for wireless and telecommunications terminals and base stations in general. I also am familiar with standard-setting organizations' protocols and procedures.

4. I have created and taught undergraduate and graduate courses in hardware and software design for signal processing and wireless communication circuits at Georgia Tech for the past twenty years. I also have supervised the Ph.D. dissertations of over twenty engineers in the areas of computer engineering, signal processing, communications, rapid prototyping, and system - level design methodology, of which

five have resulted in thesis prizes or paper awards. I also have graduated more than 20 Ph.D. students that now work as professors or in technical positions around the world.

5. Additionally, I have been active in the areas of wireless communications, digital signal processing, integrated circuit design (analog and digital), software engineering, system‑level design methodologies and tools, and software systems.

6. I have been the principal investigator ("PI") or co‑PI in several active research programs in these areas, including DARPA's Rapid Prototyping of Application Specific Signal Processors, the State of Georgia's Yamacraw Initiative, the United States Army's Federated Sensors Laboratory Program, and the United States Air Force Electronics Parts Obsolescence Initiative. I have received an IBM Faculty Award and NSF's Research Initiation Award.

7. I have designed several specialized computer and communication systems over the past two decades at Georgia Tech for tasks such as wireless audio and video processing and protocol processing for portable platforms, such as cell phones and PDAs. I have worked on designing systems that are efficient from performance, size, weight, area, and thermal considerations.

8. I have developed courses and classes for the industry on these topics, and many of my lectures in advanced computer system design, developed under the sponsorship of the United States Department of Defense in the late 1990s, are available for educational use at http://www.eda.org/rassp and have been used by several U.S. and international universities as part of their course work.

9. I have been working in the area of wireless communications and signal processing, since the early 1980s. Some of my recent publications in the area of design of wireless communications systems and associated protocols are listed in **Appendix 1**.

10. In the 1980s, I designed and prototyped a very low RF frequency (VLF) receiver for submarine communications utilizing MSK (Minimum Shift Key) modulation/demodulation techniques in hardware.

11. In the early 2000 ‑ 2001 timeframe, I designed three GSM multiband mobile phones for a leading telecom equipment manufacturer in Asia.

12. In the 2002-2007 timeframe, I developed wireless baseband and protocol stack software and assembly code for a leading telecommunications handset vendor that focused on the efficient realization of speech codecs and echo ‑ cancellation and for another in the optimization of their 3G software stack. My work in this regard included the creation of software code and analysis and revision of existing software code.

13. I have been an active consultant to industry and various research laboratories (including Massachusetts Institute of Technology Lincoln Labs and Johns Hopkins University Applied Physics Laboratory). My consulting work for MIT Lincoln Labs involved high-resolution imaging for defense applications, where I worked in the area of prototyping complex and specialized computing systems. My consulting work for the Johns Hopkins Applied Physics Lab ("APL") mainly involved localization of objects in image fields, where I worked on identifying targets in video and other sensor fields and identifying computer architectures and circuits for power and space ‑ efficient designs.

14. I have founded three companies in the areas of embedded software, military chipsets involving imaging technology, and wireless communications. The first of the companies I founded, VP Technologies, offers products in the area of semiconductor integrated circuits, including building computing systems for imaging systems for avionics electronics for the United States Air Force and the United States Navy, since 1995. I remain a director of VP Technologies. The second of these companies, Soft Networks, LLC, offers software for multimedia and wireless

computing platforms, including the development of a set‑top box for Intel that decodes MPEG‑2 video streams, wireless protocol stacks, and imaging codecs for multimedia phones. The technology involved with the design, development and implementation of the set‑top box included parsing the bit streams, decoding communications protocols, extracting image and video data, and then processing for subsequent display or storage. The third of these companies, Elastic Video, uses region of interest based video encoding or decoding for capturing high-quality video at very low bit rates, with primary application for wireless video systems.

15. I have authored more than sixty refereed journal publications and around forty peer-reviewed conference publications. I have been active in research in the area of wireless and mobile communications and some of my recent peer‑reviewed publications in this area include: (i) Mustafa Turkboylari & Vijay K. Madisetti, Effect of Handoff Delay on the System Performance of TDMA Cellular Systems, Proceedings of the Fourth IEEE Conference on Mobile and Wireless Communications Network 411‑15 (Sept. 9‑11, 2002); (ii) Loran A. Jatunov & Vijay K. Madisetti, Computationally‑Efficient SNR Estimation for Bandlimited Wideband CDMA Systems, 5 IEEE Transactions on Wireless Communications, no. 12 (2006) at 3480‑91; and (iii) Nimish Radio, Ying Zhang, Mallik Tatipamula & Vijay K. Madisetti, Next Generation Applications on Cellular Networks: Trends, Challenges, and Solutions, 100 Proceedings of the IEEE, no. 4 (April 2012) at 841‑54.

16. I have extensive experience analyzing, designing, and testing systems based on 3GPP Technical Specifications, including specifications describing WCDMA and HSDPA technologies. I have been active in the area of location‑based services and wireless localization techniques since the mid‑1990s, and have authored several papers on location‑based services, including, Vijay K. Madisetti et al., Mobile Fleet Application Using SOAP and System on Devices (SyD) Middleware Technologies, Communications, Internet, and Information Technology (2002) at

426 ‑ 31. I have served as associate editor or on the editorial board for technical journals, including IEEE Transactions on Circuits & Systems II, International Journal in Computer Simulation, and International Journal in VLSI Signal Processing.

17. I have authored or co ‑ authored several books, including VLSI Digital Signal Processors (IEEE Press 1995) and the Digital Signal Processing Handbook (CRC Press, 1998, 2010). I co ‑ authored Quick ‑ Turnaround ASIC Design in VHDL (Kluwer Academic Press 1996) and Platform ‑ Centric Approach to System ‑ on ‑ Chip (SoC) Design (Springer 2004). I am also the editor of several books, including the three ‑ volume DSP Handbook set: Volume 1: Digital Signal Processing Fundamentals, Volume 2: Video, Speech, and Audio Signal Processing and Associated Standards, and Volume 3: Wireless, Networking, Radar, Sensory Array Processing, and Nonlinear Signal Processing, published in 2010 by CRC Press, Boca Raton, Florida. More recently I have authored Cloud Computing (2014, CreateSpace Press), and Internet of Things (2014, CreateSpace), and the book, Cloud Computing, was nominated as a Notable Book of 2014 by the Association of Computing Machinery (ACM) in July 2015.

18. I have been elected a Fellow of the IEEE, for contributions to embedded computing systems. The Fellow is the highest grade of membership of the IEEE, a world professional body consisting of over 300,000 electrical and electronics engineers, with only one ‑ tenth of one percent (0.1%) of the IEEE membership being elected to the Fellow grade each year. Election to Fellow is based upon votes cast by existing Fellows in IEEE. I have also been awarded the 2006 Frederick Emmons Terman Medal by the American Society of Engineering Education for contributions to Electrical Engineering, including authoring a widely used textbook in the design of VLSI digital signal processors. I was awarded VHDL International Best Ph.D. Dissertation Advisor Award in 1997 and the NSF RI Award in 1990. I was Technical Program Chair for both the IEEE MASCOTS in 1994 and the IEEE Workshop on

Parallel and Distributed Simulation in 1990. In 1989 I was recognized with the Ira Kay IEEE/ACM Best Paper Award for Best Paper presented at the IEEE Annual Simulation Symposium.

19. I have submitted approximately 40 invention disclosures and provisional patents over the past ten years. I am listed as the inventor on eight allowed or issued U.S. Patents.

20. I am generally familiar with issues involving patents and with determining the meaning of patent claim terms from the perspective of a "person of ordinary skill in the art" ("POSITA") at the time the purported invention was made.

21. I have completed reports, depositions, and provided testimony regarding communications systems in more than 20 proceedings over the past six years. About half of the proceedings in which I have testified were in the area of 2G/3G/4G/WiFi/WiMax/OFDM/MIMO wireless transceiver design covering both hardware and software features of base stations and/or mobile devices.

22. I have followed, tested compliance requirements, participated in, and contributed to activities of Standards Setting Organizations ("SSOs") such as the IEEE, IETF, ETSI, TIA, and others, as part of my work as a teacher and researcher in advanced telecom, wireless and computer technologies since the 1990s.

23. I have been extensively involved in the activities of one of the premier SSOs in the world, the IEEE, since the 1980s, and I have participated in the development of standards for hardware design and description languages, such as VHDL, used in the design of computer chips – IEEE 1076.6. This standard is now used worldwide in the design of advanced computer chips and associated design automation tools for VLSI. I have also taught courses and authored papers and books on how to comply with these standards in terms of writing code for design of chipsets.

24. The Internet Engineering Task Force (IETF) (https://www.ietf.org/how/wgs/) is the premier SSO in the area of computer networks

and associated technologies, and creates a number of working groups (WG) that focus on specific deliverables (guidelines, standards specifications, etc.) and focus on creating and improving existing network protocols. I have contributed draft proposals for such improvement to standardized protocols over the past several years that include contributions to mobile wireless, stream controlled transport protocols, networking, encryption and voice/video transmission. These proposals include:

- IETF Internet Draft (Nov 2002): Enhancements to ECRTP with Applications to Robust Header Compression for Wireless. URL https://tools.ietf.org/html/draft-madisetti-rao-suresh-rohc-00
- IETF Internet Draft (May 2002): Voice & Video over Mobile IP Networks. URL https://tools.ietf.org/html/draft-madisetti-argyriou-voice-video-mip-00
- IETF Internet Draft (July 2002): A Transport Layer Technology for Improving QoS of Networked Multimedia Applications. URL https://tools.ietf.org/html/draft-madisetti-argyriou-voice-video-mip-00

25. I have developed speech and video codecs that comply with 3GPP standards, such as a Wideband AMR and the AMR. These tasks involved developing software to implement the associated 3GPP standards and also tests to verify compliance with these standards. The families of these 3GPP standards include TS 26.071 – TS 26.204, covering over a hundred standard specification documents. The software that I developed that complies with these standards is now available commercially on millions of 3G and 4G handsets worldwide. My codecs were tested on live 3G and 4G networks in Europe and the USA since the early 2004 – 2006 timeframe.

26. I have also developed several speech and VOIP codecs that conform with the ITU (International Telecommunications Union) standards G.723.1, G.729 and

Echo Cancellers conforming with the ITU G.168 standards (See https://www.itu.int/rec/T-REC-G.723/en)

27. The software and code I have developed and tested based on technologies essential to the ITU standards are now used by one of the leading suppliers of VOIP/Internet telephones in the world. This software is also part of commercially released soft switches for internet telephony used extensively in Asia. See for example URL https://www.thehindubusinessline.com/bline/2002/04/09/stories/2002040900660700.htm

B. Compensation

28. I am being paid for my work on this matter on an hourly basis at $500/hour. My compensation is not contingent on reaching any particular findings or conclusions, or on any particular outcome in this matter. I have no financial interest in the outcome of this matter.

C. Scope of this Declaration

29. I submit this declaration at the request of Bell Northern Research LLC ("BNR"). BNR has asked me to review certain claim terms in BNR's patents and to offer my opinions as to how a person of ordinary skill in the art would understand those terms.

D. Materials Considered

30. For this declaration, I have reviewed the specification, claims and file histories for U.S. Patent Nos. 7,957,450; 6,941,156; 8,416,862; 7,990,842; 7,319,889; and 8,204,554 along with the associated file histories. Further, I have reviewed the extrinsic evidence submitted by both BNR and Defendants in connection with the Local Patent Rule disclosures.

31. In addition, in forming my opinions contained herein, I drew on my background and experience to consider the knowledge and viewpoint of a person of ordinary skill in the art at the time of the invention.

LEGAL STANDARDS

32. I have applied the following principles in formulating the opinions contained herein.

A. Claim Construction

33. I have been informed and understand from counsel that to determine the meaning of the claims, one must start by considering the intrinsic evidence, which includes the claims themselves, the specification, and the prosecution history. Each claim term is construed according to its ordinary and accustomed meaning as understood by one of ordinary skill in the art at the time of the invention in the context of the patent.

34. I understand claims must be read in view of the specification, of which they are a part, and that the specification is always highly relevant to the claim construction analysis. However, I also understand that particular embodiments and examples appearing in the specification will not generally be read into the claims.

35. I further understand that a term's context in the asserted claim can be instructive. Also, other asserted or unasserted claims can also aid in determining the claim's meaning, because claim terms are typically used consistently throughout the patent. Differences among the claim terms can also assist in understanding a term's meaning. For example, when a dependent claim adds a limitation to an independent claim, it is presumed that the independent claim does not include the limitation.

Means-Plus-Function (§ 112(6))

36. I have been informed and understand from counsel that a claim limitation is subject to Section 112(6) if an element in a claim is expressed as a means or step for performing a specified function without the recital of structure, material, or acts in

support thereof. In such a case, the claim limitation must be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

37. I further understand that a claim limitation that does not use the phrase "means for" or "step for" will trigger a rebuttable presumption that § 112(6) does not apply.

38. Furthermore, a claim limitation is not means-plus-function if persons of ordinary skill in the art reading the specification understand a term used in the limitation identifies the structure that performs the function. In other words, it is sufficient if the claim term is used in common parlance or by persons of skill in the pertinent art to designate structure, even if the term covers a broad class of structures and even if the term identifies the structures by their function. In this regard, the term is not required to denote any specific structure or a precise physical structure in order to avoid means plus function treatment.

B. Definiteness

39. I have been informed and understand from counsel that a claim term is not indefinite if, when viewed in light of the specification and prosecution history, it informs those skilled in the art of the scope of the invention with reasonable certainty. I further understand that whether a claim is indefinite is determined from the viewpoint of a person skilled in the art at the time the patent was filed.

C. Person of Ordinary Skill in the Art

40. I understand that the level of ordinary skill may be reflected by the prior art of record and that a person of ordinary skill in the art ("POSITA") to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

41. I understand there are multiple factors that may be used when determining the level of ordinary skill in the pertinent art, including (1) the educational level of the

inventor; (2) the types of problems encountered in the art; (3) the prior art solutions to those problems; (4) the rapidity with which innovations are made; (5) the sophistication of the technology; and (6) the educational level of active workers in the field.

OPINIONS

U.S. PATENT NOS. 7,319,889 AND 8,204,554

A. Person of Ordinary Skill in the Art

42. I have been informed by counsel that the earliest possible priority date for the ’889 and ’554 Patents is June 17, 2003 (“priority date”). It is my opinion that a POSITA for the ’889 and ’554 patents would have a bachelor’s degree in electrical engineering, computer engineering, computer science or similar field, and two to three years of experience in digital communications systems, such as wireless communications systems and networks, or equivalent. Moreover, I recognize that someone with more technical education but less experience could have also met this standard. I believe that I possessed and exceeded such experience and knowledge before and at the priority date.

B. “substantially concurrently”[2]

43. It is my opinion that the term “substantially concurrently,” as used in the ’889 Patent and the ’554 Patent informs a POSITA of the scope of the claim with reasonable certainty.

44. I understand that Defendants’ expert may opine that this term is indefinite. I will respond to Defendants’ expert’s opinions in my rebuttal declaration.

U.S. PATENT NO. 6,941,156

A. Person of Ordinary Skill in the Art

[2] A copy of Appendix B to the Parties’ Joint Claim Construction submission to the Court is attached to this Declaration as **Appendix 3**.

45. I have been informed by counsel that the earliest possible priority date for the '156 Patent is August 1, 2000 ("priority date"). It is my opinion that a POSITA for the '156 patent would have a bachelor's degree in electrical engineering, computer engineering, computer science or similar field, and two to three years of experience in digital communications systems, such as wireless communications systems and networks, or equivalent. Moreover, I recognize that someone with more technical education but less experience could have also met this standard. I believe that I possessed and exceeded such experience and knowledge before and at the priority date.

B. "simultaneous communication paths from said multimode cell phone"

46. It is my understanding that each side's respective claim construction of the above term from the '156 Patent is as follows:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "two or more active links at the same time from said multimode cellphone"	"at least two established distinct and different communication links from said multimode cell phone to a far-end communication device, at the same time"

47. The term "simultaneous communication paths from said multimode cell phone" appears in Claim 1 of the '156 Patent:

> 1. A multimode cell phone, comprising:
> a cell phone functionality; and
> an RF communication functionality separate from said cell phone functionality;
> a module to establish ***simultaneous communication paths from said multimode cell phone*** using both said cell phone functionality and said RF communication functionality; and
> an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone

> functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality.

48. It is my opinion that a person of ordinary skill in the art at the time of the invention would understand the term "simultaneous communication paths from said multimode cell phone" and that no construction would be necessary. To the extent that the Court believes construction would be necessary or helpful, a person of skill in the art would understand that "simultaneous communication paths from said multimode cell phone" means "two or more active links at the same time from said multimode cellphone."

49. As shown in Figure 1, two simultaneous communication paths (labeled 1st and 2nd) are represented as active from the multimode cell phone 100. They both communicate via RF communication, and connect either to the cellular network or to a base unit, both of which connect to a core telephone provider's network. *See* Fig. 1; Col. 4:12–17.

50. I understand that Defendants have proposed that the term be construed to mean "at least two established distinct and different communication links from said multimode cell phone to a far-end communication device, at the same time." While I have not seen specific arguments from Defendants or their expert(s) supporting their construction, I believe this construction is flawed because it implies that the communication links for each mode must be established at both the near end device and the far end device.

51. Figure 1 shows clearly that the two active links that are active from the same time from the multimode cellphone are two links only to the core network of the provider for the far end device 150. *See* Figure 1. That is, the simultaneous links are active from the multimode cell phone but there does not need to be two simultaneous links which are active at the far end device. *See* Figure 1. This is also confirmed by the specification, which states that the far end device "can be any telephonic device,

multi-mode or single mode." *See* Col. 4:12–17. Should the far end device be single mode, it would not be possible for two links to simultaneously exist at the point of the far end device. Thus, the specification is clear that it is only the multimode cell phone near-end device that must have simultaneous active links.

52. Thus, Defendants' construction conflicts with the specification and figures which show that there may be a single connection at the far end device.

53. I understand that Defendants' expert may offer an opinion in support of Defendants' claim construction. I will respond to Defendants' expert's opinions in my rebuttal declaration.

C. "a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality"

54. It is my understanding that the following parties have the following positions on the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element – In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: Function: establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality Structure:	This is a 112 ¶ 6 claim element. Function: "establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" Structure: Indefinite for lack of corresponding structure in the patent specification.	This is a 112 ¶ 6 claim element. Function: "establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" Structure: Fig. 1 (element 101); Fig. 2 steps 202-208; Fig. 4 steps 402-408; 4:50-67; 7:1-16.

Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 1, 3, Col. 3:48–4:49; 4:54–5:62; 6:3–55; 6:60–8:5		

55. The term "a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" appears in Claim 1 of the '156 Patent:

> 1. A multimode cell phone, comprising:
> a cell phone functionality; and
> an RF communication functionality separate from said cell phone functionality;
> ***a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality***; and
> an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality.

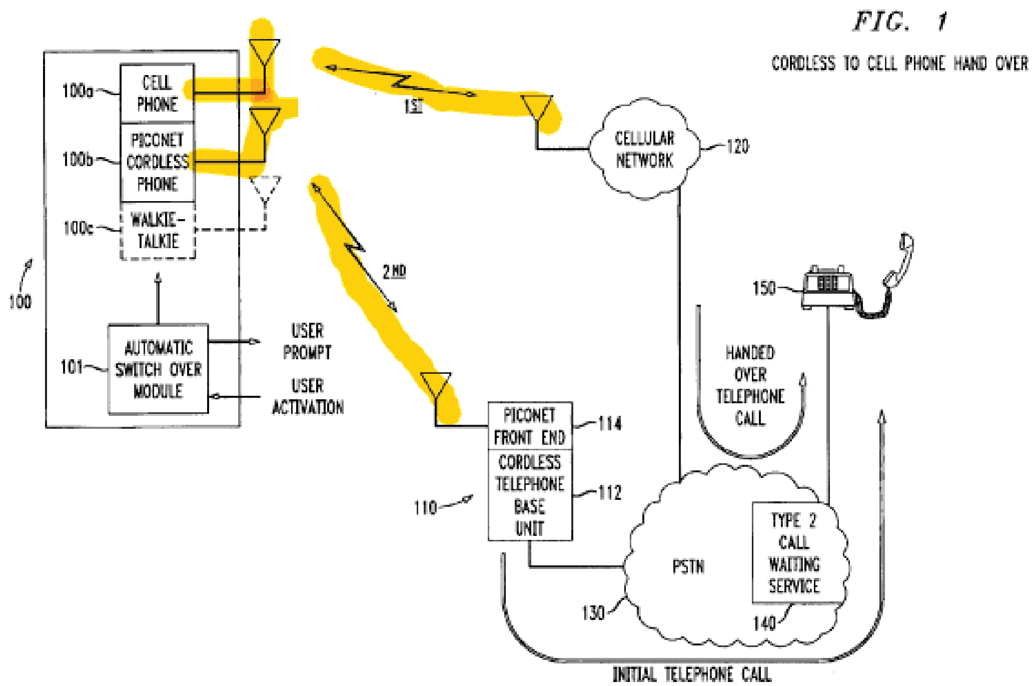
56. It is my opinion that the term is not mean-plus-function because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures within multimode cell phones that negotiate and control each of the modes of communication, namely cellular, RF communication (other than cellular) including piconet, walkie-talkie, and such genus of RF communications

57. I understand that Defendants intend to argue that the term "a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" is a means-plus-function term, and that it lacks structure in the specification. First, as noted above and further described below, I disagree that this term is a means-plus-function term. Second, even if it were a means-plus-function term, I disagree that the term would lack sufficient structure.

This Term is Not Means-Plus-Function

58. This term is not a means-plus-function because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures within multimode cell phones that negotiate and control each of the modes of communication, namely cellular, RF communication (other than cellular) including piconet, walkie-talkie, and such genus of RF communications.

59. A person of ordinary skill in the art at the time of the invention was familiar with well-known modes of communication that are described in the specification itself. For example, cellular, wireless, cordless and related piconet technologies are all mentioned in the specification. *See* '156 Patent, Col. 3:48-55, 4:28-37. As would be understood by a person of ordinary skill in the art, on review of at least Fig. 1, that these modes are related to the transceivers for each mode, which may be integrated or separate as was known in the art at the time of the invention. The highlighted Fig. 1 below shows the common notation for radio components in RF communication:



See '156 Patent, Fig. 1.

60. Each of these modes is enabled and controlled by hardware and software within a multimode cell phone, and the interaction between each was understood in the art to be through integrated circuitry (including hardware and software) interacting with the transceivers. Thus, a person of ordinary skill in the art would understand that the "module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" denotes a class of structures in multimode cell phones that negotiate and control each of the modes of communication, namely cellular, RF communication (other than cellular) including piconet, walkie-talkie, and such genus of RF communications in the known art of cellular telephone technology at the time of the invention.

Even if this Term were Means-Plus-Function, There is Sufficient Structure

61. Should the Court decide that the term "module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" be governed by § 112, ¶ 6, it is my opinion that the term is not indefinite for lack of sufficient structure because sufficient structure is disclosed in the specification. It is also my understanding that at least two defendants, Huawei and Coolpad, also believe that there is sufficient structure disclosed in the specification.

62. With regard to function, it is my understanding that all parties agree that if the Court determined that 112 ¶ 6 applied to this term, the <u>function</u> would be the following: "establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality."

63. My opinion, therefore is that the related structure is disclosed as the multimode cellular phone 100 in Figure 1, including the transceivers and related hardware and software components of 100a and 100b of multimode cellular phone 100 which also connects to one skilled in the art that there is a structure that is circuitry (including hardware and software) that controls, based on described inputs, produces certain outputs based on certain types of calculations, and also describes where the information travels next. *See* '156 Patent, Figure 1, Col. 3:52–55. This is confirmed by noting that Figure 1 shows an embodiment of a multimode cell phone in which the simultaneous communication paths are signified by the "1st" and "2nd" arrows labeled in the figure. A person of ordinary skill in the art would understand how a multimode cell phone would transmit and receive for each of these modes, and the particular hardware and software components are well known in the art of cellular telephone technology.

64. Second, the specification further describes that "more than one mode of the multimode cell phone 100 may operate simultaneously, allowing the establishment

of a secondary communication path in the background, allowing easy and quick switch over as desired or required." '156 Patent, Col. 3:64-4:1. This disclosure confirms that the module to establish simultaneous communication is also the module in a multimode cellular telephone that controls each of the transceivers, such as an integrated circuit, the existence of such integrated circuits are well known in the art (though the invention's modification to these circuits and modules that allows for simultaneous communication paths and switchover processes as described below were not in the prior art but instead novel inventive modifications).

65. The specification further describes Figure 1 and that the components within the multimode cell phones capable of establishing communication paths: "For explanation purposes, Fig. 1 depicts an established telephone call between the multimode cell phone 150….Once the multimode cell phone 100 extends beyond its acceptable range…the telephone call between the multimode cell phone 100 and the far end telephone 150 is automatically re-established using the cellular network…" Col. 4:12-23.

66. Further confirming the proposed structure and equivalents thereof, the specification also describes techniques and associated software and hardware available to one of skill in the art to establish the simultaneous communication paths. For example, it states that "numbers for the far end party may be recalled from a last number dialed functionality of the multimode cell phone." '156 Patent, Col. 5:27-32. In addition, the specification describes that the communication paths may be tracked by a lookup table including entries relating to alternate numbers associated with the same party, and that a communication path can be checked against and matched with entries in such a table. *See* '156 Patent, Col. 6:3-8, 6:33-40. A person of ordinary skill in the art would understand that the "lookup table" is a commonly used tracking mechanism implemented in software in the multimode cell phone. In this context, it would be used to identify which communication paths to switch between.

67. The specification and additional figures provide additional examples of the types of communication paths that may be used in conjunction with the multimode phone. *See* ’156 Patent, Fig. 3, Col. 6:60-8:5.

68. Thus, it is my opinion that should the Court construe the term to be governed by § 112 ¶ 6, that there is sufficient disclosed structure such that the term is not indefinite for lack of sufficient structure.

69. I also note that while Kyocera has claimed that the term lacks sufficient structure, Defendant has not provided any explanation, basis, or reasoning as to why it believes it lacks sufficient structure. Therefore, I reserve the right to rely on any additional intrinsic or extrinsic evidence as may be necessary to refute its argument upon it being disclosed for the first time in its opening claim construction brief and related expert declarations.

70. I further note that Huawei and Coolpad first identified its proposed structure for this term hours before the deadline to submit the Joint Claim Construction Submission to the Court. As a result, I am still reviewing these Defendants’ positions and reserve the right to offer additional opinions and rely on any additional intrinsic or extrinsic evidence as may be necessary to refute their argument upon it being first sufficiently disclosed (and discussed) for the first time in their opening claim construction brief and related expert declarations.

71. I understand, further, that Huawei and Coolpad have proposed the following structure for the identified function: Fig. 1 (element 101); Fig. 2 steps 202-208, Fig. 4 steps 402-408, 4:50-67; 7:1-16. I believe that Huawei and Coolpad have narrowed the structure too far and attempts to read different “exemplary process[es]”, *see* 4:50–67 (“Fig. 2 shows an exemplary process of handing over a telephone call from the cordless mode of a multimode cell phone to a cellular mode of the multimode cell phone . . . .”); 7:1–16 (“Fig. 4 shows an exemplary process for handing over the walkie-talkie conversation to the cellular telephone call handled by

the cellular mode of the multimode cell phones.") into a required limitation and further precludes structure that I have identified above

72. I understand that Defendants' expert may offer an opinion in support of Defendants' claim construction and identification of function and structure. I will respond to Defendants' expert's opinions in my rebuttal declaration.

D. "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality"

73. It is my understanding that the following parties have the following positions regarding the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: <u>Function:</u> in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of	This is a 112 ¶ 6 claim element. <u>Function</u>: "in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF	This is a 112 ¶ 6 claim element. <u>Function</u>: "automatic switch over of a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" <u>Structure</u>: Fig. 1 (element 101); Fig. 2 steps 210-212; Fig. 4 steps 410-412; 5:1-7; 7:17-26, claim 1 ("an automatic switch over

said cell phone functionality and said RF communication functionality Structure: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 1, 3, Col. 3:48–4:49; 4:54–5:62; 6:3–55; 6:60–8:5	communication functionality" Structure: Indefinite for lack of corresponding structure in the patent specification.	module, in communication with both said cell phone functionality and said RF communication functionality").

74. The term "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" appears in Claim 1 of the '156 Patent:

> 1. A multimode cell phone, comprising:
> a cell phone functionality; and
> an RF communication functionality separate from said cell phone functionality;
> a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality; and
> ***an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality***.

75. I understand that Defendants intend to argue that the term "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" is a means-plus-

function term. I understand that Kyocera also contends that it lacks structure in the specification, but that two other Defendants (Huawei and Coolpad) have identified structure for the alleged function. First, I disagree that this term is a means-plus-function term. Second, even if it were a means-plus-function term, I disagree that the term would lack sufficient structure.

This Term is Not Means-Plus-Function

76. As described above, in paragraphs 58–60, a person of ordinary skill in the art is aware of the components of a multimode cellular phone and how each mode is enabled and controlled by hardware and software within a multimode cell phone, and the interaction between each was understood in the art to be through integrated circuitry interacting with the transceivers. Thus, a person of ordinary skill in the art would understand that the "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" denotes a class of structures that control the radios in the known art of cellular telephone technology at the time of the invention, including integrated circuits and the like, and that the term here represents an inventive modification to those known structures.

Even if this Term were Means-Plus-Function, There is Sufficient Structure

77. Should the Court decide that the term "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and

said RF communication functionality" be governed by § 112, ¶ 6, it is my opinion that the term is not indefinite for lack of sufficient structure because sufficient structure is disclosed in the specification. It is also my understanding that at least two defendants, Huawei and Coolpad, also believe that there is sufficient structure disclosed in the specification.

78. With regard to function, it is my understanding that all the Defendants have identified separate proposed functions. Specifically, I understand that the proposed functions are as in the table below:

BNR's Proposed Function	Kyocera's Proposed Function	Huawei and Coolpad's Proposed Construction
in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality	in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality	automatic switch over of a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality

79. My opinion is that the related structure to BNR's proposed function is disclosed as the multimode cellular phone 100 in Figure 1, including the transceivers and related hardware and software components of 100a and 100b of multimode cellular phone 100 and the automatic switchover module 101 that is shown implemented within the hardware and software of the multimode cell phone. *See* Figure 1; Col. 3:52–55. This is confirmed by noting that Figure 1 shows an

embodiment of a multimode cell phone in which the simultaneous communication paths are signified by the "1st" and "2nd" arrows labeled in the figure and further noting that the specification makes clear that the automatic switchover module 101 "is in communication with each communication path functionality" and that the "desired mode of the multimode cell phone 100 may be controlled through suitable communications with each communication path functionality." *See* '156 Patent, Fig. 1; Col. 3:56–63. A person of ordinary skill in the art would understand how a multimode cell phone would transmit and receive for each of these modes and which components would incorporate the inventive additional functionalities embodied in this claim, and the particular hardware and software components are well known in the art of cellular telephone technology.

80. I also note that while Kyocera has claimed that the term lacks sufficient structure, Defendant has not provided any explanation, basis, or reasoning as to why it believe it lacks sufficient structure. Therefore, I reserve the right to rely on any additional intrinsic or extrinsic evidence as may be necessary to refute its argument upon it being disclosed for the first time in its opening claim construction brief and related expert declarations.

81. I further note that Huawei and Coolpad first identified its proposed structure and differing function for this term hours before the deadline to submit the Joint Claim Construction Submission to the Court. As a result, I am still reviewing these Defendants' positions and reserve the right to offer additional opinions and rely on any additional intrinsic or extrinsic evidence as may be necessary to refute their argument upon it being first sufficiently disclosed (and discussed) for the first time in their opening claim construction brief and related expert declarations.

82. I understand, further, that Huawei and Coolpad have proposed the following structure for the its identified function: Fig. 1 (element 101); Fig. 2 steps 210-212; Fig. 4 steps 410-412; 5:1-7; 7:17-26, claim 1 ("an automatic switch over

module, in communication with both said cell phone functionality and said RF communication functionality"). I believe that Huawei and Coolpad have narrowed the structure too far and attempts to read an "exemplary process" into a required limitation and further precludes structure that I have identified above, including 100, and 100a and 100b.

83. I understand that Defendants' expert may offer an opinion in support of Defendants' claim construction and identification of function and structure. I will respond to Defendants' expert's opinions in my rebuttal declaration.

E. "cell phone functionality"

84. It is my opinion that the term "cell phone functionality" informs a POSITA of the scope of the claim with reasonable certainty.

85. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

F. "RF communication functionality"

86. It is my opinion that the term "RF communication functionality" informs a POSITA of the scope of the claim with reasonable certainty.

87. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

U.S. PATENT NO. 8,416,862

A. Person of Ordinary Skill in the Art

88. I have been informed by counsel that the earliest possible priority date for the '862 Patent is April 21, 2005 ("priority date"). It is my opinion that a POSITA for the '862 patent would have a bachelor's degree in electrical engineering, computer engineering, computer science or similar field, and two to three years of experience in digital communications systems, such as wireless communications systems and networks, or equivalent. Moreover, I recognize that someone with more technical education but less experience could have also met this standard. I believe that I

possessed and exceeded such experience and knowledge before and at the priority date.

B. "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information"

89. It is my understanding that each side's respective claim construction of the above term from the '862 patent is as follows:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients"	"factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles"

90. The term "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information" appears in Claim 9 of the '862 patent:

> 9. A wireless communication device comprising:
> a plurality of Radio Frequency (RF) components operable to receive an RF signal and to convert the RF signal to a baseband signal; and
> a baseband processing module operable to:
> receive a preamble sequence carried by the baseband signal;
> estimate a channel response based upon the preamble sequence;
> determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
> ***decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information***; and
> form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device.

91. It is my opinion that a POSITA would understand the term "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information" would be understood by a person of ordinary skill in the art at the time of the invention, and that no construction would be necessary. To the extent that the Court believes construction would be necessary or helpful, a person of skill in the art would understand that "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information" means "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients."

92. In the context of this term, it is important to understand that the goal of the claimed approaches is to, as described in the specification, "reduces the size of the feedback information" including over the use of Cartesian coordinates. *See* '862 patent, Col. 12:60-64.

93. Thus, as the patent explains, the "coefficients of Givens Rotation and the phase matrix coefficients serve as the transmitter beamforming information that is sent from the receiving wireless communication device to the transmitting wireless communication device." *See* '862 patent, Col. 15:34-39. The Givens rotation operates to reduce the set of coefficients of the estimated transmitter beamforming matrix (V). *See* '862 patent, Col. 14:48-15:8. Such reduction permits transmitting fewer coefficients back.

94. The invention discloses further reduction through quantization of the coefficients. *See* '862 patent, Col. 15:9-17. As used in the patent and as understood by a person of skill in the art, quantization is reducing a larger set of possible values to a smaller set. Here, for example, the patent discloses that a "quantized angle is either [pi/4, 3pi/4] to cover [0, pi] angle resolution of pi/2." *See* '860 patent, Col. 13:14-15. Thus, the invention clearly indicates that the angles in the estimated transmitter beamforming unitary matrix (V) are mapped (or quantized) to a finite set

of representative angles or values based upon the angle resolution as would be applied.

95. I have reviewed Defendants' proposed construction, which is "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles" and believe that this construction is incorrect. Specifically, it is incorrect that the transmitter beamforming information is a reduced set of angles. Instead, as the patent clearly states, and my opinion above describes, the transmitter beamforming information is further quantized as described in the invention. Additionally, a person of ordinary skill in the art knows that such transmitter beamforming information may be otherwise converted to a form for transmission that may represent bits or other representations of certain angles, and would not send angles via plain text or other readable manner.

96. I understand that Defendants' expert may offer an opinion in support of Defendants' claim construction. I will respond to Defendants' expert's opinions in my rebuttal declaration.

C. "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device"

97. It is my understanding that each side has the following positions on the above term from the '862 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction

Not a 112 ¶ 6 claim element In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: <u>Function</u>: "receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" <u>Structure</u>: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 2-5, Col. 5:49–6:12, 6:37–7:20; 7:51–9:30; 9:31–13:35; 13:54–15:67.	This is a 112 ¶ 6 claim element. <u>Function</u>: "receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification.

98. The term "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" appears in Claim 9 of the '862 patent:

9. A wireless communication device comprising:
a plurality of Radio Frequency (RF) components operable to receive an RF signal and to convert the RF signal to a baseband signal; and
a baseband processing module operable to:
receive a preamble sequence carried by the baseband signal;
estimate a channel response based upon the preamble sequence;
determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device.

99. It is my opinion that this term is not a means-plus-function claim because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware and software.

100. I understand that Defendants intend to argue that the term "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" is a means-plus-function term, and that it lacks structure in the specification. First, as stated above and described below, I disagree that this term is a means-plus-function term. Second, even if it were a means-plus-function term, I disagree that the term would lack sufficient structure.

This Term is Not Means-Plus-Function

101. This term is not a means-plus-function because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware and software. This is first confirmed within the specification itself, which states

> The baseband processing modules 100 may be implemented using one or more processing devices. Such a processing device may be a microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on operational instructions. The memory 65 may be a single memory device or a plurality of memory devices. Such a memory device may be a read-only memory, random access memory, volatile memory, non-volatile memory, static memory, dynamic memory, flash memory, and/or any device that stores digital information. Note that when the processing module 100 implements one or more of its functions via a state machine, analog circuitry, digital circuitry, and/or logic circuitry, the memory storing the corresponding operational instructions is embedded with the circuitry comprising the state machine, analog circuitry, digital circuitry, and/or logic circuitry.

See '862 Patent, Col. 8:1-20.

102. Further, the specification confirms how the wireless communication may be implemented using one or more integrated circuits for the respective structures of the wireless communication device:

> As one of average skill in the art will appreciate, the wireless communication device of FIG. 3 may be implemented using one or more integrated circuits. For example, the host device may be implemented on one integrated circuit, the baseband processing module **100** and memory **65** may be implemented on a second integrated circuit, and the remaining components of the radio **60**, less

> the antennas **81-85**, may be implemented on a third integrated circuit. As an alternate example, the radio **60** may be implemented on a single integrated circuit. As yet another example, the processing module **50** of the host device and the baseband processing module **100** may be a common processing device implemented on a single integrated circuit. Further, the memory **52** and memory **65** may be implemented on a single integrated circuit and/or on the same integrated circuit as the common processing modules of processing module **50** and the baseband processing module **100**.

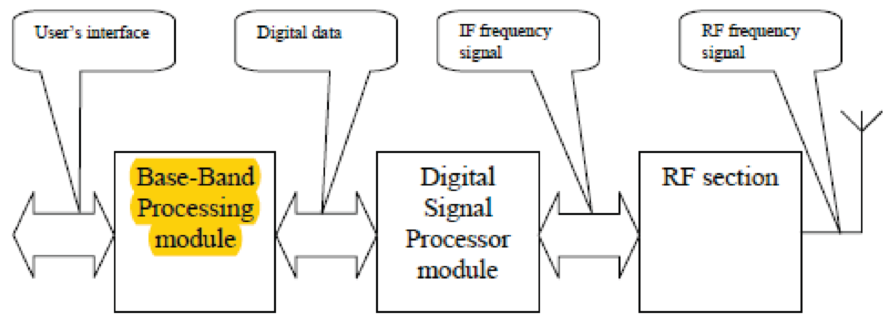
See ’862 Patent, Col. 9:13-30.

103. Likewise, the ’862 patent discusses the baseband processing module in the context of specific structure or processing modules that are aspects of a physical wireless device. For example, the ’862 patent states that “Most of the operations 700 of Fig. 7 are typically performed by a baseband processing module, e.g. 100 of Fig. 3 of a receiving wireless device.” *See* ’862 Patent, Col. 13:31–35. This usage also confirms to a person of ordinary skill in the art that the baseband processing module is a specific component (hardware and/or software) of a wireless device.

104. Thus, the specification of the ’862 patent confirms that, to a person of ordinary skill in the art, this term is itself a class of structures that would be known and readily understood by a person of skill in the art, namely baseband processors, in their various implementations.

105. Additionally, reviewing extrinsic evidence available around the time of the filing of the patent also indicates that those of skill in the art use the term baseband processing module to refer to the baseband processor in RF communication devices, and that such terms refer more broadly to the implementation of baseband operations in ASIC, FGPA, logic circuits, or other like implementations.

106. For example, the paper *Wireless vs. Wired. How Software Define Radio technology addresses issues related to the use of wireless networks when compared to a wired solution*, written in May 2005, includes the following description of a baseband processing module:

> A simplified structure of a SDR is shown in Figure 1 below. It consists of three main blocks: Base-Band Processing module, Digital Signal Processor module, and the RF section.
>
> 
>
>
> Figure 1. SDR structure.
>
> The Base-Band Processing module provides user interface support and retains the software, which defines the protocol to be used in the RF channel (RF packets structure, algorithms of interaction between the nodes in the network, etc.).

See BNR-SDCA00037995 at 37999. This usage of baseband processing module comports with my understanding of how a person of skill in the art would understand that the term denoted a specific class of structures at the time of the invention.

107. As another example, the academic paper *Evolution of Mobile Base Station Architectures*, written by Igor S. Simic in June 2007, uses the term baseband module to denote a class of structures with specific responsibilities in the transmission and receiving of RF signals, and states "[t]he baseband module processes the encoded signal before transmitting/receiving it from/to the core network through the transmission module." Though this paper was written shortly after the time of the invention, it comports with how a person of skill in the art would have used the term at the time of the invention. *See* BNR-SDCA-00037973 at 37976.

108. Another example, the industry document *A Simple Baseband Processor for RF Transceivers*, explains the role and implementation of a baseband processor as follows:

> Today, wireless systems are ubiquitous, and the number of wireless devices and services are continuing to grow. The design of a complete RF system is a multidisciplinary design challenge, with the analog RF front end being the most critical part of it. However, the availability of integrated RF transceivers such as AD9361 greatly reduces the RF challenges on such designs. These transceivers provide a digital interface for the analog RF signal chain and allow easy integration to an ASIC or FPGA for the baseband processing. The baseband processor (BBP) allows user data to be processed in the digital domain between an end application and the transceiver device. The baseband processor design is also easily designed using system modeling tools such as Simulink.

See BNR-SDCA-00037967. This usage in the industry also comports with how a person of skill in the art used this term to describe a particular class of structures or components used in RF transmission at the time of the invention.

109. Thus, it is my opinion that a person of skill in art at the time of the invention would have understood that viewing the term in light of the specification, it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware.

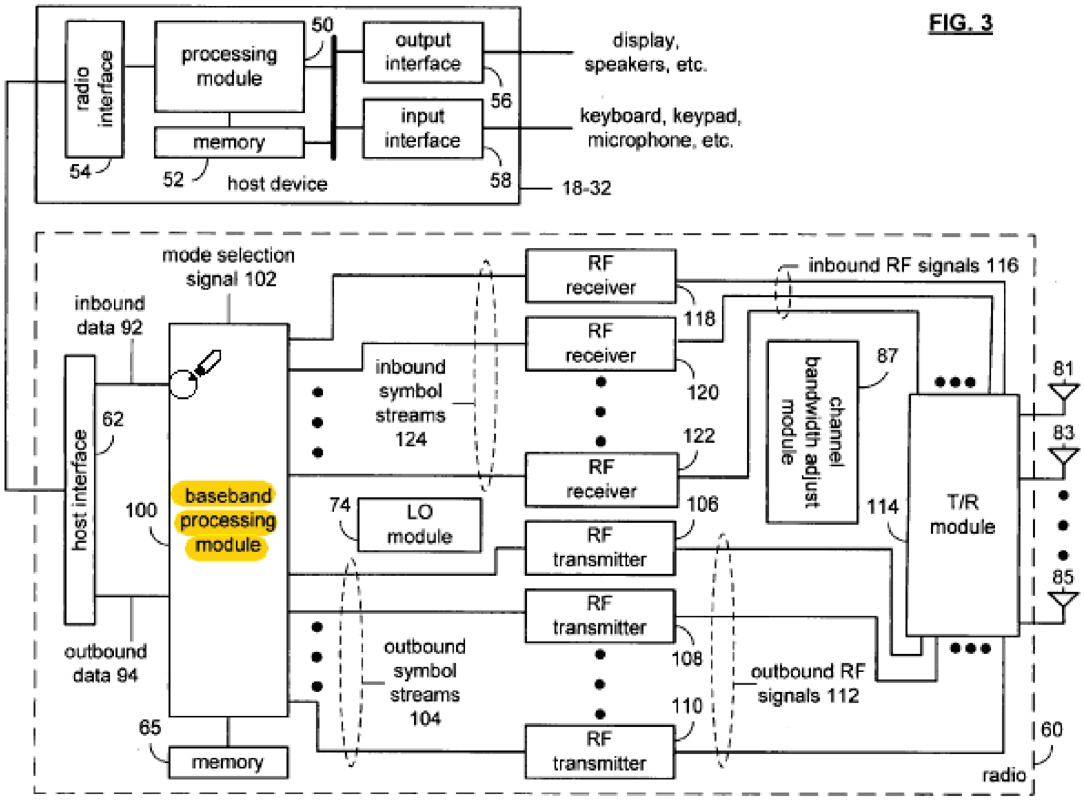
Even if this Term were Means-Plus-Function, There is Sufficient Structure

110. Should the Court decide that the term "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" be

governed by § 112, ¶ 6, it is my opinion that the term is not indefinite for lack of sufficient structure because sufficient structure is disclosed in the specification.

111. With regard to function, it is my understanding that both parties agree that if the Court determined that 112 ¶ 6 applied to this term, the <u>function</u> would be the following: "receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device."

112. The corresponding structure for the alleged function for the term exists and is first shown in Figure 3 of the '862 Patent and connotes to one skilled in the art that there is a structure that is circuitry (including hardware and software) that controls, based on described inputs, produces certain outputs based on certain types of calculations, and also describes where the information travels next (and its equivalents thereof):



113. Further within the figures, Figure 4 shows the baseband receive processing 100-RX, which is within the baseband processing module 100 and connotes to one skilled in the art that there is a structure that is circuitry (including hardware and software) that controls, based on described inputs, produces certain outputs based on certain types of calculations, and also describes where the information travels next:

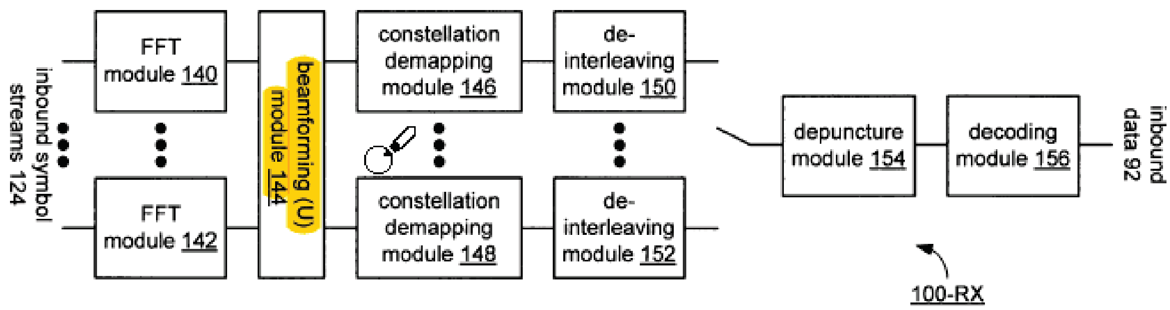


FIG. 5

See '862 Patent, Fig. 5.

114. As discussed in the specification, the beamforming module 144 multiplies a beamforming unitary matrix (U) with baseband signals and is "functional to produce feedback information for the transmitter as further described with reference to Figure 6." *See* '862 Patent, Col. 12:34–46; Fig. 6.

115. The specification then confirms that the structure of the baseband processing module performs most of the operations of the flow chart 700 of Figure 7 which also connotes to one skilled in the art that there is a structure that is circuitry (including hardware and software) that controls, based on described inputs, produces certain outputs based on certain types of calculations, and also describes where the information travels next:

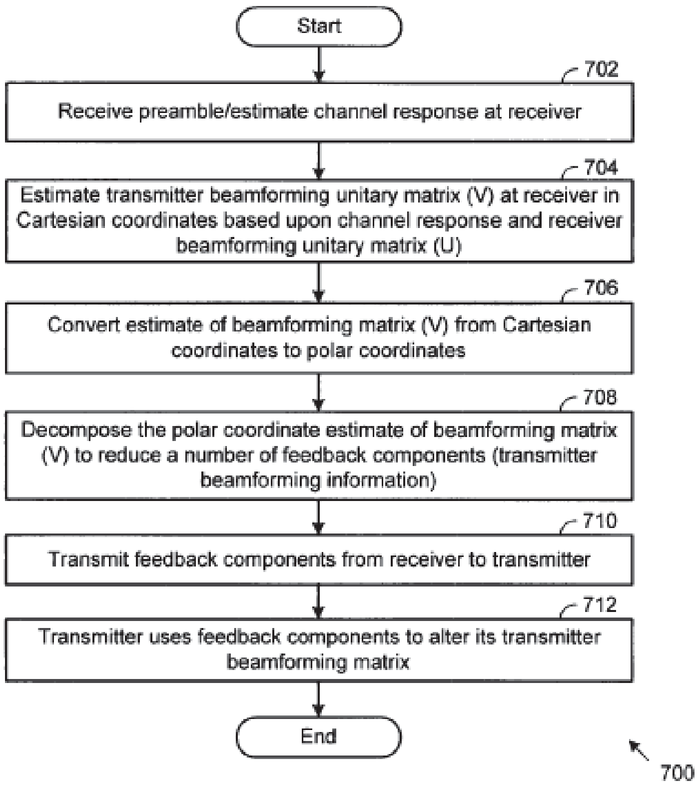


FIG. 7

See '862 Patent, Fig. 7; Col. 13:31–35 ("Most of the operations 700 of Fig. 7 are typically performed by a baseband processing module, e.g. 100 of Fig. 3 of a receiving wireless device.").

116. Thus, it is my opinion that should the Court construe the term to be governed by § 112 ¶ 6, that there is sufficient disclosed structure such that the term is not indefinite for lack of sufficient structure.

117. I also note that while Defendants have claimed that the term lacks sufficient structure, Defendants have not provided any explanation, basis, or reasoning as to why they believe it lacks sufficient structure. Therefore, I reserve the right to rely on any additional intrinsic or extrinsic evidence as may be necessary to refute their argument upon it being disclosed for the first time in their opening claim construction brief and related expert declarations.

D. "the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates"

118. It is my understanding that each side has the following positions on the above term from the '862 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Not a 112 ¶ 6 claim element –. In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: Function: "a baseband processing module operable to . . . produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" Structure: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 2-5, Col. 5:49–6:12, 6:37–7:20; 7:51–9:30; 9:31–13:35; 13:54–15:67.	This is a 112 ¶ 6 claim element. Function: "a baseband processing module operable to . . . produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" Structure: Indefinite for lack of corresponding structure in the patent specification.

119. The term "the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" appears in Claim 10 of the '862 patent:

> 10. The wireless communication device of claim 9, wherein in determining an estimated transmitter beamforming unitary matrix

> (V) based upon the channel response and a receiver beamforming unitary matrix (U), **the baseband processing module is operable to:**
>
> **produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and**
>
> **convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates.**

120. It is my opinion that the term is not a means-plus-function term because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware or software.

121. I understand that Defendants intend to argue that the term "the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" is a means-plus-function term, and that it lacks structure in the specification. First, I disagree that this term is a means-plus-function term. Second, even if it were a means-plus-function term, I disagree that the term would lack sufficient structure.

122. This term is not a means-plus-function because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware or software. This is true for the same reasons I detail in paragraphs 101–1099, above.

123. Should the Court decide that the term "the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" be governed by § 112, ¶ 6, it is my opinion that the term is not indefinite for lack of sufficient structure because sufficient structure is disclosed in the specification.

124. With regard to function, it is my understanding that both parties agree that if the Court determined that 112 ¶ 6 applied to this term, the function would be the following: "a baseband processing module operable to . . . produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates."

125. First, as this Claim 10 is dependent on Claim 9, and relates to the same baseband processing module which Defendants have claimed is means-plus-function, my opinion, as discussed in paragraphs 110–116 regarding the prior term of the independent Claim 9 applies with full force here and that the structure is the baseband processing module 100 of Figure 3 and equivalents thereof.

126. Specifically, the specification discloses that the baseband processing module, e.g. 100 of Fig. 3 of a receiving wireless device performs the operations of 700 of Fig. 7, which includes producing the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates and converting the estimated transmitter beamforming unitary matrix (V) to polar coordinates as per step 706. *See* '862 Patent, Col. 13:25–35, 54–62; Fig. 7. This connotes to one skilled in the art that there is a structure that is circuitry (including hardware and software) that controls, based on described inputs, produces certain outputs based on certain types of calculations, and also describes where the information travels next.

127. Thus, it is my opinion that should the Court construe the term to be governed by § 112 ¶ 6, that there is sufficient disclosed structure such that the term is not indefinite for lack of sufficient structure.

128. I also note that while Defendants have claimed that the term lacks sufficient structure, Defendants have not provided any explanation, basis, or reasoning as to why they believe it lacks sufficient structure. Therefore, I reserve the right to rely on any additional intrinsic or extrinsic evidence as may be necessary to refute

their argument upon it being disclosed for the first time in their opening claim construction brief and related expert declarations.

U.S. PATENT NO. 7,957,450

A. Person of Ordinary Skill in the Art

129. I have been informed by counsel that the earliest possible priority date for the ’450 Patent is December 14, 2004 (“priority date”). It is my opinion that a POSITA for the ’450 patent would have a bachelor’s degree in electrical engineering, computer engineering, computer science or similar field, and two to three years of experience in digital communications systems, such as wireless communications systems and networks, or equivalent. Moreover, I recognize that someone with more technical education but less experience could have also met this standard. I believe that I possessed and exceeded such experience and knowledge before and at the priority date.

B. “channel estimate matrices” / “matrix based on the plurality of channel estimates”

130. It is my understanding that each side has the following claim construction positions regarding the above term from the ’450 patent:

Plaintiff’s Proposed Construction	Defendants’ Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: “one or more matrices that is based on an SVD decomposition of the estimates of the values of H(t)”	“matrix H_{est} for tones of different frequencies, where H_{est} contains estimates of the true values of H(t)”

131. The term in question is highlighted below in Claim 1 of the ’450 Patent:

> 1. A method for communication, the method comprising:
> computing a plurality of **channel estimate matrices** based on signals received by a mobile terminal from a base station, via one or more downlink RF channels, wherein said plurality of **channel estimate matrices** comprise

coefficients derived from performing a singular value matrix decomposition (SVD) on said received signals; and
transmitting said coefficients as feedback information to said base station, via one or more uplink RF channels.

132. The term in question is also highlighted below in Claim 11 of the ’450 Patent:

11. A system for communication, the system comprising:
one or more circuits of a mobile terminal that are operable to compute a plurality of **channel estimate matrices** based on signals received by said mobile terminal from a base station, via one or more downlink RF channels, wherein said plurality of **channel estimate matrices** comprise coefficients derived from performing a singular value matrix decomposition (SVD) on said received signals; and
said one or more circuits are operable to transmit said coefficients as feedback information to said base station, via one or more uplink RF channels.

133. The term in question is further highlighted below in Claim 21 of the ’450 Patent:

21. A method for communication, the method comprising:
computing a plurality of channel estimates based on signals received by a mobile terminal from a base station, via one or more downlink RF channels;
deriving a **matrix based on the plurality of channel estimates**, wherein the matrix comprises coefficients from performing a singular value matrix decomposition (SVD) on said plurality of channel estimates; and
transmitting the coefficients as feedback information to said base station, via one or more uplink RF channels.

134. The term in question is also highlighted below in Claim 22 of the ’450 Patent:

22. A system for communication, the system comprising:
one or more circuits of a mobile terminal that are operable to compute a plurality of channel estimates based on signals received by said mobile terminal from a base station, via one or more downlink RF channels;
said one or more circuits are operable to derive a **matrix based on said plurality of channel estimates**, wherein said matrix comprises coefficients derived from performing a singular value matrix decomposition (SVD) on said plurality of channel estimates;
and said one or more circuits are operable to transmit said coefficients as feedback information to said base station, via one or more uplink RF channels.

135. The specification provides:

> A communications medium, such as a radio frequency (RF) channel between a transmitting mobile terminal and a receiving mobile terminal, may be represented by a transfer system function, H. The relationship between a time varying transmitted signal, X(t), a time varying received signal, y(t), and the systems function may be represented as shown in equation [1]:
>
> y(t)=Hxx(t)+n(t),
>
> where equation 1 n(t) represents noise which may be introduced as the signal travels through the communications medium and the receiver itself. In MIMO systems, the elements in equation 1 may be represented as vectors and matrices. If a transmitting mobile terminal comprises M transmitting antenna, and a receiving mobile terminal comprises N receiving antenna, then y(t) may be represented by a vector of dimensions Nx1, x(t) may be represented by a vector of dimensions Mx1, n(t) by a vector of dimensions Nx1, and H may be represented by a matrix of dimensions NxM. In the case of fast fading, the transfer function, H, may itself become time varying and may thus also become a function of time, H(t). Therefore, individual coefficients, hij(t), in the transfer function H(t) may become time varying in nature.

See '450 Patent, Col. 3:53-4:9.

136. The specification also explains:

> In MIMO systems which communicate according to specifications in IEEE resolution 802.11, the receiving mobile terminal may compute H(t) each time a frame of information is received from a transmitting mobile terminal based upon the contents of a preamble field in each frame. **The computations which are performed at the receiving mobile terminal may constitute an estimate of the "true' values of H(t) and may be known as "channel estimates'.** For a frequency selective channel there may be a set of H(t) coefficients for each one that is transmitted via the RF channel. To the extent that **H(t), which may be referred to as the "channel estimate matrix"**, changes with time and to the extent that the transmitting mobile terminal fails to adapt to those changes, information loss between the transmitting mobile terminal and the receiving mobile terminal may result.

See '450 Patent, Col. 4:10-24.

137. In other words, the RF communication signals transmitted between a base station and a wireless device can be represented mathematically as matrices. In addition, the specification mentions 802.11 in explaining the background of the invention. *See* '450 Patent, Col. 1:26-29. A POSITA would understand that the invention involves mathematical matrix manipulations and that versions of 802.11 standard used similar types of mathematical operators described in the '450 patent.

138. Singular Value Decomposition ("SVD") is a well-known mathematical concept from linear algebra. SVD is a matrix decomposition method for reducing a matrix to its constituent parts to make certain subsequent matrix calculations easier.

139. Turning to the claim language, the method requires computing one or more channel estimate matrices, H(t) from signals received by a wireless communication device from a base station. The claim language goes on to explain that a plurality of channel estimate matrices are comprised of coefficients derived from performing SVD on the RF signals received by the wireless communication device from the base station. These SVD coefficients of H(T) are then transmitted back to the base station. By doing so, the wireless communication device can feedback channel information in a compressed format that the base station can use to adjust or attenuate signal strength as necessary to improve performance, for example by reducing noise.

140. Therefore, it is my opinion that a POSITA would understand the term "channel estimate matrices/matrices based on the plurality of channel estimates" to mean "one or more matrices that is based on an SVD decomposition of the estimates of the values of H(t)."

141. I understand that Defendants' construction of this term is "matrix H_{est} for tones of different frequencies, where H_{est} contains estimates of the true values of H(t)." While I have not seen specific arguments from Defendants or their expert(s) supporting their construction, I believe Defendants' proposed construction is wrong.

H_{est} or any other similar terms (for example, H_{up} or H_{down}) are never sent back. Only the results of a decomposition are transmitted back.

142. Furthermore, H_{est} is not the only matrix that can be decomposed, other possible examples of the decomposed matrix include H_{up} or $H_{down.}$ Thus, Defendants' reliance solely (while also incorrect in the light of the claim language) on H_{est} is misplaced.

143. I understand that Defendants' expert may opine that this term has a different meaning or provide support for Defendants' proposed construction. I will respond to Defendants' expert's opinions in my rebuttal declaration.

C. "coefficients derived from performing a singular value matrix decomposition (SVD)"

144. It is my understanding that each side has the following claim construction positions regarding the above term from the '450 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "values derived from a singular value decomposition"	"values in the matrices U, S, or V^H, where $H_{est}=USV^H$"

145. The term in question is highlighted below in Claim 1 of the '450 Patent:

> 1. A method for communication, the method comprising:
> computing a plurality of channel estimate matrices based on signals received by a mobile terminal from a base station, via one or more downlink RF channels, wherein said plurality of channel estimate matrices comprise **coefficients derived from performing a singular value matrix decomposition (SVD)** on said received signals; and
> transmitting said coefficients as feedback information to said base station, via one or more uplink RF channels.

146. The term in question is also highlighted below in Claim 11 of the ’450 Patent:

> 11. A system for communication, the system comprising:
> one or more circuits of a mobile terminal that are operable to compute a plurality of channel estimate matrices based on signals received by said mobile terminal from a base station, via one or more downlink RF channels,
> wherein said plurality of channel estimate matrices comprise **coefficients derived from performing a singular value matrix decomposition (SVD)** on said received signals; and
> said one or more circuits are operable to transmit said coefficients as feedback information to said base station, via one or more uplink RF channels.

147. The term in question is further highlighted below in Claim 21 of the ’450 Patent:

> 21. A method for communication, the method comprising:
> computing a plurality of channel estimates based on signals received by a mobile terminal from a base station, via one or more downlink RF channels;
> deriving a matrix based on the plurality of channel estimates, wherein the matrix comprises **coefficients from performing a singular value matrix decomposition (SVD)** on said plurality of channel estimates; and
> transmitting the coefficients as feedback information to said base station, via one or more uplink RF channels.

148. The term in question is also highlighted below in Claim 22 of the ’450 Patent:

> 22. A system for communication, the system comprising:
> one or more circuits of a mobile terminal that are operable to compute a plurality of channel estimates based on signals received by said mobile terminal from a base station, via one or more downlink RF channels;
> said one or more circuits are operable to derive a matrix based on said plurality of channel estimates, wherein said matrix comprises **coefficients derived from performing a singular value matrix decomposition (SVD)** on said plurality of channel estimates;
> and said one or more circuits are operable to transmit said coefficients as feedback information to said base station, via one or more uplink RF channels.

149. I hereby incorporate my explanation from above concerning the “channel estimate matrices” term.

150. As explained above, the structure of the claim dictates that SVD must be performed on the wireless signals received by a wireless device from a base station. The SVD will result in a decomposition of the estimates of the values of H(t). The coefficients derived from the SVD operation will then be transmitted back to the base station.

151. Therefore, it is my opinion that a POSITA would understand the term "coefficients derived from performing a singular value matrix decomposition (SVD)" to mean "values derived from a singular value decomposition."

152. I understand that Defendants' proposed construction for this term is values in the matrices U, S, or V^H, where $H_{est}=USV^H$". While I have not seen specific arguments from Defendants or their expert(s) supporting their construction, I believe Defendants' proposed construction is wrong at least because it is limited to the H_{est} matrix, which is incorrect for at least the reasons I stated above. Defendants' construction of the present term appears to flow from their incorrect construction of the "channel estimate matrices" term above.

153. I understand that Defendants' expert may opine that this term has a different meaning or provide support for Defendants' proposed construction. I will respond to Defendants' expert's opinions in my rebuttal declaration.

U.S. PATENT NO. 7,990,842

A. Person of Ordinary Skill in the Art

154. I have been informed by counsel that the earliest possible priority date for the '842 Patent is January 1, 2002 ("priority date"). It is my opinion that a POSITA for the '842 patent would have a bachelor's degree in electrical engineering, computer engineering, computer science or similar field, and two to three years of experience in digital communications systems, such as wireless communications systems and networks, or equivalent. Moreover, I recognize that someone with more technical education but less experience could have also met this standard. I believe that I

possessed and exceeded such experience and knowledge before and at the priority date.

B. "standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme"

155. It is my understanding that each side has the following positions regarding the above term from the '842 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: "a standard issued by a Standard Setting Organization (for, example, IEEE or 3GPP) utilizing an Orthogonal Frequency Division Multiplexing scheme."	Indefinite

156. I understand that one or more of the Defendants in this matter contend that this term is indefinite. I disagree.

157. The term in question is highlighted below in Claim 1 of the '842 Patent:

> 1. A wireless communications device, comprising:
> a signal generator that generates an extended long training sequence; and
> an Inverse Fourier Transformer operatively coupled to the signal generator,
> wherein the Inverse Fourier Transformer processes the extended long training sequence from the signal generator and provides an optimal extended long training sequence with a minimal peak-to-average ratio, and
> wherein at least the optimal extended long training sequence is carried by a greater number of subcarriers than a **standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme**.

158. The '842 Patent explains the invention in reference to the well-known 802.11 standard:

> **Devices implementing both the 802.11a and 802.11g standards use an orthogonal frequency division multiplexing (OFDM) encoding scheme. OFDM is a frequency division multiplexing modulation technique for transmitting large amounts of digital data over a radio wave**. OFDM works by spreading a single data stream over a band of sub-carriers, each of which is transmitted in parallel. In 802.11a and 802.11g compliant devices, only 52 of the 64 active sub-carriers are used. Four of the active sub-carriers are pilot sub-carriers that the system uses as a reference to disregard frequency or phase shifts of the signal during transmission. The remaining 48 sub-carriers provide separate wireless pathways for sending information in a parallel fashion. The 52 sub-carriers are modulated using binary or quadrature phase shift keying (BPSK/QPSK), 16 Quadrature Amplitude Modulation (QAM), or 64 QAM. Therefore, 802.11a and 802.11g compliant devices use sub-carriers -26 to +26, with the 0-index sub-carrier set to 0 and 0-index sub-carrier being the carrier frequency. As such, only part of the 20 Mhz bandwidth supported by 802.11a and 802.11g is use.

See '842 Patent, Col. 2:8-29.

159. However, the specification also provides that the invention is not restricted to the 802.11 scheme:

> It should be appreciated by one skilled in art, **that the present invention may be utilized in any device that implements the OFDM encoding scheme**. The foregoing description has been directed to specific embodiments of this invention. It will be apparent, however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages. Therefore, it is the object of the appended claims to cover all such variations and modifications as come within the true spirit and scope of the invention.

See '842 Patent, Col. 5:26-35.

160. The specification also specifically states that wireless communication devices may be compliant with different standards:

> **Different wireless devices in a wireless communication system may be compliant with different standards or different variations of the same standard**. For example, 802.11a an extension of the 802.11 standard, provides up to 54 Mbps in the 5 GHz band. 802.11b, another extension of the 802.11 standard, provides 11 Mbps transmission (with a fallback to 5.5, 2 and 1 Mbps) in the 2.4 GHz band. 802.11g, another extension of the 802.11 standard, provides 20+ Mbps in the 2.4 GHz band. 802.11n, a new extension of 802.11, is being developed to address, among other thins [sic], higher throughput and compatibility issues. An 802.11a compliant communications device may reside in the same WLAN as a device that is compliant with another 802.11 standard. **When devices that are compliant with multiple versions of the 802.11 standard are in the same WLAN, the devices that are compliant with older versions are considered to be legacy devices**. To ensure backward compatibility with legacy devices, specific mechanisms must be employed to insure that the legacy devices know when a device that is compliant with a newer version of the standard is using a wireless channel to avoid a collision. **New implementations of wireless communication protocol enable higher speed throughput, while also enabling legacy devices which might be only compliant with 802.11a or 802.11g to communicate in systems which are operating at higher speeds**.

See '842 Patent, Col. 1:50-2:8.

161. It is clear to one skilled in the art that the patent is directed to OFDM communication protocols such as 802.11, which is a communication protocol promulgated by IEEE, a standard setting organization ("SSO"). The 802.11 standard is a set of rules used for communication between devices operating in compliance with those rules. However, OFDM is not limited exclusively to the 802.11 standard. OFDM is also utilized in LTE communication protocols promulgated by 3GPP, another SSO.

162. Therefore, based on the teachings in the specification and the claim language, it is my opinion that a POSITA would understand the term "standard wireless networking configuration for an Orthogonal Frequency Division

Multiplexing scheme" to mean "a standard issued by a Standard Setting Organization (for, example, IEEE or 3GPP) utilizing an Orthogonal Frequency Division Multiplexing scheme." Therefore, it is also my opinion that the term "standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme" informs a POSITA of the scope of the claim with reasonable certainty.

163. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

C. "extended long training sequence"

164. It is my understanding that each side has the following positions regarding the above term from the '842 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: "a training sequence that uses more active subcarriers than an earlier version of the same standard."	Indefinite

165. I understand that one or more of the Defendants in this matter contend that this term is indefinite. I disagree.

166. The term in question is highlighted below in Claim 1 of the '842 Patent:

> 1. A wireless communications device, comprising:
> a signal generator that generates an **extended long training sequence**; and
> an Inverse Fourier Transformer operatively coupled to the signal generator,
> wherein the Inverse Fourier Transformer processes the **extended long training sequence** from the signal generator and provides an optimal **extended long training sequence** with a minimal peak-to-average ratio, and
> wherein at least the optimal **extended long training sequence** is carried by a greater number of subcarriers

> than a standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme.

167. The ’842 Abstract explains:

> A network device for generating an expanded long training sequence with a minimal peak-to-average ratio. The network device includes a signal generating circuit for generating the expanded long training sequence. The network device also includes an Inverse Fourier Transform for processing the expanded long training sequence from the signal generating circuit and producing an optimal expanded long training sequence with a minimal peak-to-average ratio. **The expanded long training sequence and the optimal expanded long training sequence are stored on more than 52 sub-carriers.**

168. The specification teaches the invention, which is based on OFDM, against the background of the 802.11 standard. The specification states:

> OFDM works by spreading a single data stream over a band of sub-carriers, each of which is transmitted in parallel. **In 802.11a and 802.11g compliant devices, only 52 of the 64 active sub-carriers are used.** Four of the active sub-carriers are pilot sub-carriers that the system uses as a reference to disregard frequency or phase shifts of the signal during transmission. **The remaining 48 sub-carriers provide separate wireless pathways for sending information in a parallel fashion. The 52 sub-carriers are modulated** using binary or quadrature phase shift keying (BPSK/QPSK), 16 Quadrature Amplitude Modulation (QAM), or 64 QAM. Therefore, 802.11a and 802.11g compliant devices use sub-carriers -26 to +26, with the 0-index sub-carrier set to 0 and 0-index sub-carrier being the carrier frequency. As such, only part of the 20 Mhz bandwidth supported by 802.11a and 802.11g is use.
>
> In 802.11a/802.11g, each data packet starts with a preamble which includes a short training sequence followed by a long training sequence. The short and long training sequences are used for synchronization between the sender and the receiver. **The long training sequence of 802.11a and 802.11g is defined such that each of sub-carriers -26 to +26** has one BPSK constellation point, either +1 or -1.
>
> There exists a need to create **a long training sequence** of minimum peak-to-average ratio **that uses more sub-carriers**

> **without** interfering with adjacent channels. The inventive long trains sequence with a minimum peak-to-average power ratio should be usable by legacy devices in order to estimate channel impulse response and to estimate carrier frequency offset between a transmitter and a receiver.

See '842 Patent, Col. 2:11-43.

169. In other words, the specification explains that earlier versions of the 802.11 standard utilized training sequences over 52 sub-carriers, which are used for device synchronization. The patentees recognized a need to move to training sequences that utilize more subcarriers than the existing 52 subcarriers.

170. The '842 specification goes on to teach two examples of longer training sequences utilizing 56 and 63 sub-carriers, which are longer (extended) compared to the 52 sub-carriers used in the 802.11a and 802.11g standards:

> In a first embodiment of the invention, **the expanded long training sequence is implemented in 56 active sub-carriers including sub-carriers -28 to +28**. In another embodiment, **an expanded long training sequence is implemented using 63 active sub-carriers**, i.e., all of the active sub-carriers (-32 to +31) except the 0-index sub-carrier which is set to 0.

See '842 Patent, Col. 4:19-24.

171. Further, still, the '842 specification teaches:

> Signal generating circuit 205 **generates the expanded long training sequence** and if 56 active sub-carriers are being used, signal generating circuit generates the expanded long training sequence and **stores the expanded long training sequence in sub-carriers -28 to +28**. If 63 active sub-carriers are being used, signal generating circuit generates the **expanded long training sequence and stores the expanded long training sequence in sub-carriers -32 to +32** i.e., all of the active sub-carriers (-32 to +31) except the 0-index sub-carrier which is set to 0.

See '842 Patent, Col. 4:41-50.

172. Therefore, based on the teachings in the specification and the claim language, it is my opinion that a POSITA would understand the term "extended long

training sequence" to mean "a training sequence that uses more active subcarriers than an earlier version of the same standard." Therefore, it is also my opinion that the term "extended long training sequence" informs a POSITA of the scope of the claim with reasonable certainty.

173. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

D. "a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard"

174. It is my understanding that each side has the following positions regarding the above term from the '842 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: "a training sequence that uses more active subcarriers than an earlier version of the same standard."	Indefinite

175. I understand that one or more of the Defendants in this matter contend that this term is indefinite. I disagree.

176. The term in question is highlighted below in Claim 14 of the '842 Patent:

> 14. The wireless communications device according to claim 1, wherein the optimal extended long training sequence is longer than a long training sequence used by a **legacy wireless local area network device in accordance with a legacy wireless networking protocol standard**.

177. The '842 Patent explains in the "Background of the Invention" section that "[t]he present invention relates generally to wireless communication systems and

more particularly to long training sequences of minimum peak-to-average power ratio **which may be used by legacy systems**." '842 Patent, Col. 1:20-23.

178. The invention is explained in the context of the 802.11 standard:

> **Different wireless devices in a wireless communication system may be compliant with different standards or different variations of the same standard**. For example, 802.11a an extension of the 802.11 standard, provides up to 54 Mbps in the 5 GHz band. 802.11b, another extension of the 802.11 standard, provides 11 Mbps transmission (with a fallback to 5.5, 2 and 1 Mbps) in the 2.4 GHz band. 802.11g, another extension of the 802.11 standard, provides 20+ Mbps in the 2.4 GHz band. 802.11n, a new extension of 802.11, is being developed to address, among other thins [sic], higher throughput and compatibility issues. An 802.11a compliant communications device may reside in the same WLAN as a device that is compliant with another 802.11 standard. **When devices that are compliant with multiple versions of the 802.11 standard are in the same WLAN, the devices that are compliant with older versions are considered to be legacy devices**. To ensure backward compatibility with legacy devices, specific mechanisms must be employed to insure that the legacy devices know when a device that is compliant with a newer version of the standard is using a wireless channel to avoid a collision. **New implementations of wireless communication protocol enable higher speed throughput, while also enabling legacy devices which might be only compliant with 802.11a or 802.11g to communicate in systems which are operating at higher speeds**.

See '842 Patent, Col. 1:50-2:7.

179. Therefore, a legacy device in the specification is one that operates under a prior version of an OFDM standard. For example, the 802.11a standard is a prior version of the 802.11n standard. Standards like 802.11 are promulgated by IEEE, an SSO. However, the specification warns that the invention is not restricted to the 802.11:

> It should be appreciated by one skilled in art, that the present invention may be utilized in any device that implements the OFDM encoding scheme. The foregoing description has been directed to

> specific embodiments of this invention. It will be apparent, however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages. Therefore, it is the object of the appended claims to cover all such variations and modifications as come within the true spirit and scope of the invention.

See '842 Patent, Col. 5:26-35.

180. Therefore, based on the teachings in the specification and the claim language, it is my opinion that a POSITA would understand the term "a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard" to mean "a wireless local area network device using an earlier version of a standard issued by a Standard Setting Organization (SSO) (for, example, IEEE or 3GPP)." Therefore, it is also my opinion that the term "a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard" informs a POSITA of the scope of the claim with reasonable certainty.

181. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

E. "optimal extended long training sequence"

182. It is my opinion that the phrase "optimal extended long training sequence," as used in the '842 Patent informs a POSITA of the scope of the claim with reasonable certainty.

183. I understand that Defendants' expert may opine that this term is indefinite. I will respond to Defendants' expert's opinions in my rebuttal declaration.

F. "Inverse Fourier transformer"

184. It is my understanding that each side proposes the following construction for the above term from the '842 patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning.	

In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "circuit and/or software that at least performs an inverse Fourier transform."	"a circuit and/or software that performs a defined mathematical function that transforms a series of values from the frequency domain into the time domain"

185. The term in question is highlighted below in Claim 1 of the '842 Patent:

> 1. A wireless communications device, comprising:
> a signal generator that generates an extended long training sequence; and
> an **Inverse Fourier Transformer** operatively coupled to the signal generator,
> wherein the **Inverse Fourier Transformer** processes the extended long training sequence from the signal generator and provides an optimal extended long training sequence with a minimal peak-to-average ratio, and
> wherein at least the optimal extended long training sequence is carried by a greater number of subcarriers than a standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme.

186. Practically speaking, every student of math or engineering has been exposed to the concept of a Fourier transform at some point in a college-level math course. It is a well-understood concept.

187. A Fourier transform operates in one-dimension or in multiple-dimensions to map functions between one domain and another domain. These domains can include, but are not limited to, space, time, frequency, or another variable. An inverse Fourier transform is the reverse of a Fourier transform. Below is a generic mathematical representation of two definitions of a Fourier transform, where one of them is the inverse or reverse of the other (i.e., f() is inverse of F(), and vice versa):

$$F(s) = \int_{-\infty}^{\infty} f(x)e^{-i2\pi xs}\,dx$$

$$f(x) = \int_{-\infty}^{\infty} F(s)e^{i2\pi xs}\,ds.$$

See **Appendix 2** (Ronald N. Bracewell, *The Fourier Transform and its Applications* (3rd ed., 2000)).

188. The mathematical operations of a Fourier transform and inverse Fourier transform can be implemented in a logic chip (for example, an ASIC chip) or via traditional software running on one or more microprocessors.

189. The '842 specification teaches:

> Signal generating circuit 205 generates the expanded long training sequence and if 56 active sub-carriers are being used, signal generating circuit generates the expanded long training sequence and stores the expanded long training sequence in sub-carriers -28 to +28. If 63 active sub-carriers are being used, signal generating circuit generates the expanded long training sequence and stores the expanded long training sequence in sub-carriers -32 to +32 i.e., all of the active sub-carriers (-32 to +31) except the 0-index sub-carrier which is set to 0. **The inventive long training sequence is inputted into an Inverse Fourier Transform 206**. The invention uses the same +1 or -1 BPSK encoding for each new sub-carrier. Inverse Fourier Transform 206 may be an inverse Fast Fourier Transform (IFFT) or Inverse Discrete Fourier Transform (IFDT). **Inverse Fourier Transform 206 processes the long training sequence from signal generating circuit 205 and thereafter produces an optimal expanded long training sequence with a minimal peak-to-average power ratio.** The optimal expanded long training sequence may be used in either 56 active sub-carriers or 63 active subscribers. Serial to parallel module 208 converts the serial time domain signals into parallel time domain signals that are subsequently filtered and converted to analog signals via the D/A.

See '842 Patent, Col. 4:41-64.

190. It is my opinion that a POSITA would understand the term "inverse Fourier transformer" to mean "circuit and/or software that at least performs an inverse Fourier transform."

191. I understand that Defendants' proposed construction of this term is "a circuit and/or software that performs a defined mathematical function that transforms a series of values from the frequency domain into the time domain." Both sides appear to agree that a circuit or software can perform the function.

192. While I have not seen specific arguments from Defendants or their expert(s) supporting their construction, I believe Defendants' proposed construction is wrong. First, as noted above, Fourier and inverse Fourier transforms map one domain to another, it a generally mathematical concept with broad applicability. Defendants' proposed construction erroneously restricts the inverse Fourier transform to time and frequency domains, which is not required by the claim language. Second, there is no specific direction for the transform required by the claims. So there is no basis to restrict the inverse Fourier operation to transforming signals from the frequency domain into the time domain. In essence, Defendant's proposed construction is overly restrictive in light of the claim language and the generally understood meaning of inverse Fourier transform.

193. I understand that Defendants' expert may opine that this term has a different meaning or provide support for Defendants' proposed construction. I will respond to Defendants' expert's opinions in my rebuttal declaration.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 2nd day of May, 2019, in Atlanta, Georgia.

Vijay K Madisetti

Dr. Vijay K. Madisetti, Ph.D.

EXHIBIT M

IN THE UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. COOLPAD TECHNOLOGIES, INC. AND YULONG COMPUTER COMMUNICATIONS, Defendants.	C.A. No. 3:18-cv-1783-CAB-BLM Judge: Hon. Cathy Ann Bencivengo Magistrate Judge: Hon. Barbara L. Major
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. HUAWEI DEVICE (DONGGUAN) CO., LTD, HUAWEI DEVICE (SHENZHEN) CO., LTD., and HUAWEI DEVICE USA, INC., Defendants.	C.A. No. 3:18-cv-1784-CAB-BLM
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. KYOCERA CORPORATION and KYOCERA INTERNATIONAL INC., Defendants.	C.A. No. 3:18-cv-1785-CAB-BLM

REBUTTAL DECLARATION OF DR. VIJAY K. MADISETTI, PH.D. IN SUPPORT OF PLAINTIFF'S CLAIM CONSTRUCTIONS

TABLE OF CONTENTS

INTRODUCTION

1. On May 2, 2019, I submitted an Opening Declaration on Claim Construction. I hereby incorporate by reference the contents of that declaration in its entirety, including the appendices attached thereto.

2. I have reviewed the declaration of Paul Min, Ph.D., Regarding Claim Construction dated May 1, 2019, concerning United States Patent Nos. 6,941,156 (the ’156 Patent); 7,957450 (the ’450 Patent); and 8,416,862 (the ’862 Patent) (“Min Declaration” or “Min Decl.”). Below I provide responses to certain arguments raised by Dr. Min in his declaration.

3. I have reviewed the declaration of Jonathan Wells, Ph.D. dated May 1, 2019, concerning United States Patent Nos. 6,941,156 (the ’156 Patent) and 7,990,842 (the ’842 Patent) (“Wells Declaration” or “Wells Decl.”). Below I provide responses to certain arguments raised by Dr. Wells in his declaration.

U.S. PATENT NO. 6,941,156

4. I understand that Dr. Min’s opinions regarding the ’156 Patent are at ¶¶ 10–12 and 66–132. Further, I understand that ¶¶ 10–12 are a summary of Dr. Min’s opinions, which are further addressed in ¶¶ 66–132. Thus, I disagree with the summary of Dr. Min’s opinions in accordance with my disagreements with the specifics of Dr. Min’s opinions as discussed further below.

5. I understand that Dr. Wells’s opinions regarding the ’156 Patent are at ¶¶ 77–108. For the reasons discussed below, I disagree with Dr. Wells’s opinions regarding the ’156 Patent.

A. Opinions Regarding the Min Declaration

6. In ¶¶ 66–69, Dr. Min quotes portions of the specification of the ’156 Patent. I do not dispute that these paragraphs accurately quote the specification.

7. In ¶¶ 70–73, Dr. Min provides his opinion for the definition of a POSITA, which he defines as having a Bachelor’s degree in Electrical Engineering, Computer Engineering, Computer Science, or a related field, and at least 2 years of experience in

the field of wireless communication, or a person with equivalent education, work, or experience in this field. I note that my definition of a POSITA includes two to three years of experience in digital communications systems, such as wireless communications systems and networks or the equivalent. Thus, while I disagree with Dr. Min's more narrowed field of experience, however, my opinions also remain the same when I apply Dr. Min's definition of the POSITA as well.

B. Opinions Regarding the Wells Declaration

8. In ¶¶ 77–79, Dr. Wells quotes portions of the specification of the '156 Patent. I do not dispute that these paragraphs accurately quote the specification.

9. In ¶ 80, Dr. Wells provides his opinion for the definition of a POSITA, which he defines as having a bachelor's degree in electrical engineering or a related field, and at least 1–2 years of experience in the field of wireless communication devices, or the equivalent education in the field of wireless communication devices. I note that my definition of a POSITA includes two to three years of experience in digital communications systems, such as wireless communications systems and networks or the equivalent. Thus, while I disagree with Dr. Well's more narrowed field of experience and years of experience, however, my opinions also remain the same when I apply Dr. Wells's definition of a POSITA as well.

C. "simultaneous communication paths from said multimode cell phone"

10. It is my understanding that each side's respective claim construction of the above term from the '156 Patent is as follows:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "two or more active links at the same time from said multimode cellphone"	"at least two established distinct and different communication links from said multimode cell phone to a far-end communication device, at the same time"

11. For the reasons set forth below, I disagree with Dr. Min's opinion that the term "simultaneous communication paths from said multimode cell phone" should be construed as "at least two established distinct and different communication links from said multimode cell phone to a far-end communication device, at the same time" because it is confusing, imports improper limitations, and has no basis in the specification or intrinsic record.

12. First, I understand that Dr. Min has criticized Plaintiff's proposed construction because the term "active links" is "confusing" and "BNR does not explain the meaning of the term 'active.'" *See* Min Decl. ¶ 86. While Dr. Min considers these two possible conditions to be confusing, they are not—they actually capture the possibilities for an active state of a connection. A connection that is active by maintaining the connected state is no less active when transmission and reception of data begins on that connection. Thus, I disagree that the term "active link" is confusing to a POSITA. On the other hand, I believe that Defendants' use of "established distinct and different" is confusing, as Defendants fail to define what each of those terms mean and has no reference to the specification, intrinsic record, or extrinsic evidence. For example, Dr. Min offers no explanation for why Defendants use the terms "distinct" and "different", seeming synonyms, or whether they are supposed to connote different things and if so, what.

13. I also disagree with Dr. Min's opinions in ¶¶ 88–91 regarding the prosecution history and specifically the arguments made by Applicants in response to a rejection by the Patent Office related to U.S. Patent No. 5,842,122 (Schellinger). Specifically, Dr. Min misreads Applicant's distinguishing of Schellinger regarding the "module to establish simultaneous communication paths from said multimode cell phone" by improperly focusing on the language "a three way call through the cellular telephone system." Dr. Min fails to capture the entire sentence which states that Schellinger operates where "a call in process is handed off by producing a THREE WAY CALL <u>through the cellular telephone system</u> (i.e., NOT through the cell phone

itself)" and in doing so, fails to connect the first sentence which states that in Schellinger "automatic forwarding systems of a central office are implemented to allow handoff of a call." Read together, Schellinger describes a multimode cellular phone that requires a cellular telephone system or central office to establish the second communication link on the multimode cellular phone. The Applicant contrasted Schellinger with the invention by noting that the multimode cellular phone of the invention is able to establish the second communication link without having a second call forwarded to it (i.e. relying on an external source to establish the second link with the multimode cellular phone). Dr. Min improperly applies this requirement to the far end device, though the specification only spoke with regard to the multimode cellphone that represents the near-end device. Thus, Dr. Min misinterprets the prosecution history, which in fact supports BNR's claim construction position.

14. I disagree with Dr. Min's opinions, in ¶¶ 79–85, related to the specification of the '156 Patent. Specifically, I disagree with Dr. Min's incorrect interpretation of Figure 1, where he improperly labels the "initial telephone call" and the "handed over telephone call" as the "distinct and different communication links" to a "far end communication device." *See* Min Decl. ¶ 80. This interpretation is plainly inconsistent with the specification, for at least two reasons. First, the portions of Figure 1 that Dr. Min identifies as the relevant communication paths ("initial telephone call" and "handed over telephone call") do not even extend from the multimode cellular telephone, but instead only begin at elements 120 and 110. This interpretation is inconsistent with the claim language itself, which requires the multimode cellular phone to establish both links. Second, Figure 1 plainly identifies each link as "1st" and "2nd" and shows an RF connection from the multimode cellular phone to 120 and another connection to the piconet base station 110. Then, each of cellular network 120 and base unit 110 have a clear connection to the PSTN 130. Within PSTN 130, one embodiment of the handover, a Type 2 Call Waiting Service

140, is identified. And finally, there is a single link from the PSTN 130 to the far-end communication device 150.

15. Thus, it is my opinion that Defendants' construction is incorrect because it improperly requires two links to be active at the far-end communication device, despite clear evidence to the contrary from the specification. Further, Defendants' use of ambiguous terms like "distinct and different" have no definition or reference in the specification. Finally, Dr. Min incorrectly interprets the prosecution history, which actually supports BNR's construction and contradicts Defendants' proposed construction.

D. "cell phone functionality"

16. It is my understanding that the following parties have the following positions on the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element – "cell phone functionality" is not a nonce word. Instead, cell phone functionality is itself sufficient structure. A POSA would know that this is a cellular RF communication functionality well known in the art.	This is a 112 ¶ 6 claim element. <u>Function</u>: "cell phone" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification.	This is a 112 ¶ 6 claim element. <u>Function</u>: "cell phone" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification. Alternatively, to the extent that the Court requires an identification of structure, the cell phone 100a and corresponding antenna depicted in Fig. 1 are insufficient structure to perform the claimed function.

17. For the reasons set forth below, I disagree with Dr. Min's opinion that the term "cell phone functionality" should be governed by 112 ¶ 6 because a POSITA

would know that this is a cellular RF communication functionality that is well known in the art.

18. First, I disagree with Dr. Min's interpretation of "cell phone functionality" to be related to the multimode cell phone 100, instead of the cell phone functionality 100a that is described by the '156 Patent, in Figure 1 and the specification, which identifies "the cell phone functionality 100a." *See* '156 Patent at Col. 3:55–58. Dr. Min incorrectly interprets cell phone functionality to include "the ability and convenience of storing all phone book data, calling history, and user preference," which actually relates to the multimode cell phone 100 and not the cell phone functionality 100a.

19. Second, Dr. Min admits that a POSITA would understand that cell phone functionality requires "radio communication equipment (e.g. amplifier, transmitter, receiver, etc.) operating in conjunction with [a processor] . . . to perform wireless communications, typically in compliance with telecommunication industry standards (e.g., 3GPP/ETSI, etc.). *See* Min Decl. ¶ 100. Thus, Dr. Min appears to acknowledge that a POSITA would understand that cell phone functionality is a cellular RF communication functionality and that a POSITA would understand that cell phone functionality by itself refers to sufficient structure.

20. Dr. Min primarily appears to disagree with BNR's construction because "the claimed 'multimode cell phone' cannot be limited to 'cellular RF communication functionality' because it includes functionality to operate as a cordless telephone or walkie-talkie, and because it includes functionality to store phone book data, calling history, and user preferences." *See* Min Decl. ¶ 101. Dr. Min is improperly construing "multimode cell phone" and not the term "cell phone functionality" which is a part of (but not the entirety of) the claimed multimode cell phone, as discussed above. Indeed, the specification makes clear that Dr. Min's claimed functions are separate (e.g. 100b for RF functionality, 100c for walkie-talkie functionality) from the cell phone functionality.

21. Finally, Dr. Min states that BNR's proposed construction fails to recognize that a POSITA would understand that the claimed multimode cell phone includes a general purpose computer programmed to perform wireless communications. It is my opinion that this is incorrect because (1) Dr. Min again improperly focuses on the multimode cell phone instead of the cell phone functionality and (2) Dr. Min admits in his declaration that a POSITA would understand that cell phone functionality requires radio communication equipment and a specific processor programmed in accordance with industry standards.

22. Therefore it is my opinion that the term "cell phone functionality" is not governed by 112 ¶ 6, but that a POSITA would know that this is a cellular RF communication functionality that is well known in the art.

E. "RF functionality"

23. It is my understanding that the following parties have the following positions on the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element – "RF communication functionality" RF communication functionality is itself sufficient structure. A POSA would know that this is a structure for RF communications through a genus of RF communication types well known in the art.	This is a 112 ¶ 6 claim element. <u>Function</u>: "RF communication" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification.	This is a 112 ¶ 6 claim element. <u>Function</u>: "RF communication" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification. Alternatively, to the extent that the Court requires an identification of structure, any of the cordless phone 100b with its corresponding antenna and the walkie-talkie 100c with its corresponding antenna, are

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
		insufficient structure to perform the claimed function.

24. For the reasons set forth below, I disagree with Dr. Min's opinion that the term "RF communication functionality" should be governed by 112 ¶ 6 because a POSITA would know that RF communication functionality is itself structure and further that a POSITA would know that RF communication functionality is a structure for RF communications through a genus of RF communication types well known in the art.

25. Dr. Min's opinion is based on his belief that the "RF communication functionality" is used solely in the context of the claimed multimode cell phone and therefore must include a general purpose computer. *See* Min Decl. ¶¶ 106–109. I disagree. First, I disagree that it is proper to incorporate RF communication into the claimed multimode cell phone in the manner in which Dr. Min is doing. The RF functionality is a separate element of the claimed device and has its own structure (*see, e.g.*, elements 100a, 100b, each of which have their own antennas and are described distinctly in the specification of the '156 Patent, *see*, *e.g.*, Col. 3:64–4:6).

26. I also disagree that the RF communication functionality would include a general purpose computer. Instead, a POSITA would understand that an RF communication functionality would utilize hardware and software specifically programed and implemented for the relevant RF type and that such hardware and software was, at the time of the invention, routinely purchased or implemented as distinct, specialized hardware and software from a manufacturer and installed into a cell phone. The RF communication types encompassed by this structure are well known in the art and governed by relevant industry standards.

27. Thus, I disagree with Dr. Min's opinion that this term should be construed as means-plus-function. It should not.

F. "a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality"

28. It is my understanding that the following parties have the following positions on the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element – In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: Function: establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality Structure: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 1, 3, Col. 3:48–4:49; 4:54–5:62; 6:3–55; 6:60–8:5	This is a 112 ¶ 6 claim element. Function: "establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" Structure: Indefinite for lack of corresponding structure in the patent specification.	This is a 112 ¶ 6 claim element. Function: "establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality" Structure: Fig. 1 (element 101); Fig. 2 steps 202-208; Fig. 4 steps 402-408; 4:50-67; 7:1-16.

29. I note that the Defendants are unable to agree on whether (and what) structure is disclosed in the patent with respect to this claim term, and, accordingly, have proffered a declaration from two different experts on this claim term. However, I disagree with both Dr. Wells and Dr. Min.

30. For the reasons set forth below, I disagree with Dr. Wells's opinion that this term is subject to Section 112(6) and/or that it "does not have a well-known structural meaning in the field." *See* Wells Decl. ¶ 83. Likewise, I disagree with Dr. Min's opinion that the term is subject to § 112(6) and that a POSITA would understand the structure includes a general purpose computer. *See* Min Decl. ¶¶ 112–116.

31. I disagree with Dr. Wells's and Dr. Min's opinions that the written description and the prosecution history fails to impart any structural significance to this term. As stated in my opening report, it is my opinion that a POSITA, viewing the term in light of the specification, would understand that it refers to a known class of structures within multimode cell phones that negotiate and control each of the modes of communication. *See* Madisetti Opening Decl. ¶¶ 56-60.

32. Further, as stated in my opening declaration, I disagree with Dr. Min that if the term is subject to § 112(6), that there is insufficient structure. I also note that Dr. Wells disagrees with Dr. Min's opinion that the specification lacks sufficient structure. *See* Wells Decl. ¶¶ 88–96. That said, it is my opinion that Dr. Wells does not identify the correct structure. The parties agree that, should the Court determine the term to be governed by § 112(6), that the relevant function is "to establish simultaneous communication paths." Dr. Wells begins his analysis with the flawed assumption that a "POSITA would recognize that the function…is implemented by a computer/processor" and that therefore an algorithm must be identified. But a POSITA, well-versed in the field of wireless communication technology, would understand that each mode of communication (e.g., cell phone, wireless, etc.) is controlled by hardware and software components in a multimode cell phone interacting with transceivers. This would have been basic knowledge at the time of the invention, and it goes beyond mere computer processing technology.

33. Dr. Min opines that Steps 202, 204, 206, and 208 fail to recite an algorithm to a POSITA. *See* Min Decl. ¶¶ 118–121. I note that these steps are the

exact steps that Dr. Wells identifies as the corresponding structure that is sufficient to a POSITA, and therefore that Dr. Wells was able to determine that a POSITA would understand the algorithm that Dr. Min was unable to identify. *See* Wells Decl. ¶¶ 92–96.

34. For the reasons stated in my opening declaration, however, I disagree with Dr. Wells's conclusion that the corresponding structures for this term "are the algorithm provided by steps 202-208 in FIG. 2 and the algorithm provided by steps 402-408 in FIG. 4…" First, FIG. 2 and 4 merely present two embodiments of the claimed invention that vary by *communication mode*. In other words, neither of those figures have any bearing on the functionality and structure disclosed for this term in the specification, because they represent examples of types of *communication paths* – not the module to establish them.

35. Second, Dr. Wells fails to address FIG. 1 and the portions of the specification that describe the structures with which "more than one mode of the multimode cell phone 100 may operate simultaneously…" '156 Patent at Col. 3:64–4:1. As I explained in my opening declaration, the specification, in conjunction with FIG. 1, discloses to one of skill in the art the various components and tools relevant to establishing the communication paths. *See* Madisetti Opening Decl. ¶¶ 61-68.

G. "an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality"

36. It is my understanding that the following parties have the following positions on the above term from the '156 Patent:

Plaintiff's Proposed Construction	Kyocera's Proposed Construction	Huawei & Coolpad's Proposed Construction
Not a 112 ¶ 6 claim element In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: Function: in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality Structure: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 1, 3, Col. 3:48–4:49; 4:54–5:62; 6:3–55; 6:60–8:5	This is a 112 ¶ 6 claim element. Function: "in communication with both said cell phone functionality and said RF communication functionality, operable to switch a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" Structure: Indefinite for lack of corresponding structure in the patent specification.	This is a 112 ¶ 6 claim element. Function: "automatic switch over of a communication path established on one of said cell phone functionality and said RF communication functionality, with another communication path later established on the other of said cell phone functionality and said RF communication functionality" Structure: Fig. 1 (element 101); Fig. 2 steps 210-212; Fig. 4 steps 410-412; 5:1-7; 7:17-26, claim 1 ("an automatic switch over module, in communication with both said cell phone functionality and said RF communication functionality").

37. I note that the Defendants have proffered a declaration from two different experts on this claim term. However, I must disagree with both Dr. Wells and Dr. Min.

38. For the reasons set forth below, I disagree with Dr. Wells's opinion that this term is subject to Section 112(6) and/or that it "does not have a well-understood structural meaning in the field." *See* Wells Decl. ¶ 98. Likewise, I disagree with Dr. Min's opinion that the term is subject to § 112(6) and that a POSITA would

understand the structure includes a general purpose computer. *See* Min Decl. ¶¶ 124–128.

39. I further disagree with Dr. Wells's and Dr. Min's opinions that the written description and the prosecution history fails to impart any structural significance to this term. As stated in my opening report, it is my opinion that a POSITA, viewing the term in light of the specification, would understand that it refers to a known class of structures within multimode cell phones responsible for controlling radio communication, including integrated circuits (hardware and software components). *See* Madisetti Opening Decl. ¶ 76.

40. Further, as stated in my opening declaration, I disagree with Dr. Min that if the term is subject to § 112(6), that there is insufficient structure. I also note that Dr. Wells disagrees with Dr. Min's opinion that the specification lacks sufficient structure. *See* Wells Decl. ¶¶ 102–108. That said, it is my opinion that Dr. Wells does not identify the correct function or structure. First, Dr. Wells's formulation of the function reorders the claim terms in a way that introduces an extra requirement not found in the claim as written. By moving "automatic switch over" from the portion that refers to the module to the claim language that actually describes what the module does, Dr. Wells implies that the "automatic switch over" by itself adds a functional requirement. But Dr. Wells does not address the fact that if such a reordering occurred, it would render superfluous the portion of the claim that describes the module as "operable to switch a communication path…with another communication path later established…" Therefore, my identification of the function— with which Dr. Min agrees—is the correct one in view of the claim language itself.

41. Next, Dr. Wells begins his analysis with the flawed assumption that a "POSITA would recognize that the function…is implemented by a computer/processor" and that therefore an algorithm must be identified. *See* Wells Decl. Para. 103. But a POSITA, well-versed in the field of wireless communication

technology, would understand that the use and operation of each mode of communication (e.g., cell phone, wireless, etc.) is controlled by hardware and software components in a multimode cell interacting with transceivers. This would have been basic knowledge at the time of the invention, and it goes beyond mere computer processing technology.

42. Dr. Min opines that Steps 210 and 212 fail to recite an algorithm to a POSITA. *See* Min Decl. ¶¶ 130–131. I note that these steps are the exact steps that Dr. Wells identifies as the corresponding structure that is sufficient to a POSITA, and therefore that Dr. Wells was able to determine that a POSITA would understand the algorithm that Dr. Min was unable to identify. *See* Wells Decl. ¶¶ 104–108.

43. For the reasons stated in my opening declaration, however, I disagree with Dr. Wells's conclusion that the corresponding structures for this term "are the algorithm provided by steps 210-212 in FIG. 2 and the algorithm provided by steps 410-412 in FIG. 4…" First, FIG. 2 and 4 merely present two embodiments of the claimed invention that vary by *communication mode*. In other words, neither of those figures have any bearing on the functionality and structure disclosed for this term in the specification, because they represent examples of types of *communication paths* – not the module to switch from one to another.

44. Second, Dr. Wells fails to address FIG. 1 and the portions of the specification that describe the structures with which "the desired mode of the multimode cell phone 100 may be controlled through suitable communications with each communication path functionality…" '156 Patent at Col. 3:56–63. As I explained in my opening declaration, the specification, in conjunction with FIG. 1, discloses to one of skill in the art the various components and mechanisms for switching the communication paths. *See* Madisetti Opening Decl. ¶¶ 79–82.

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45. I understand that Dr. Paul Min, Ph.D. submitted a declaration for the Defendants (the "Min Declaration" or "Min Decl.") and provided his opinions regarding terms related to the '862 Patent. I understand that Dr. Min's opinions are at ¶¶ 16–18 and 163–221. Further, I understand that ¶¶ 16–18 are a summary of Dr. Min's opinions, which are further addressed in ¶¶ 163–221. Thus, I disagree with the summary of Dr. Min's opinions in accordance with my disagreements with the specifics of Dr. Min's opinions as discussed further below.

A. Opinions Regarding the Min Declaration

46. In ¶¶ 163–166, Dr. Min quotes portions of the specification of the '862 Patent. I do not dispute that these paragraphs accurately quote the specification.

47. I also note that Dr. Min provides a technology background for the Patents-in-Suit in ¶¶32–54. I do not see where Dr. Min incorporates this background for the purposes of any of his opinions regarding claim construction and therefore I do not provide opinions about Dr. Min's recitation of the technology background but reserve the right to do so later if called upon or should it otherwise be required.

48. In ¶¶ 167–169, Dr. Min provides his opinion for the definition of a POSITA, which he defines as having a Bachelor's degree in Electrical Engineering, Computer Engineering, Computer Science, or a related field, and at least 2 to 4 years of experience in the field of wireless communication, or a person with equivalent education, work, or experience in this field. I note that my definition of a POSITA includes two to three years of experience in digital communications systems, such as wireless communications systems and networks or the equivalent. Thus, while I disagree with Dr. Min's more narrowed field of experience, my opinions remain the same even under Dr. Min's definition of a POSITA.

B. "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information"

49. It is my understanding that each side's respective claim construction of the above term from the '862 Patent is as follows:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients"	"factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles"

50. For the reasons set forth below, I disagree with Dr. Min's opinion that the "decompose . . ." term should be construed to mean "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles." First, I note that Dr. Min and I both agree with the first part of the decompose term, specifically "factor the estimated beamforming unitary matrix (V)." *See* Min Decl. ¶ 174.

51. I disagree with Dr. Min that the "decompose . . ." limitation produces a reduced set of angles, and I believe that Dr. Min's opinion ignores the specification, the claim language, and the knowledge of a POSITA.

52. I do not dispute Dr. Min's recitation of the specification in ¶¶ 175–178, but I believe Dr. Min's review of the specification stops short of the remaining relevant portions that also include a disclosure of "coefficients". For example, Dr. Min ignores Col. 15:34–39 of the specification, which states that the "coefficients of the Givens Rotation and the phase matrix coefficients serve as the transmitter beamforming information that is sent from the receiving wireless communication device to the transmitting wireless communication device." '862 Patent at Col. 15:34–38.

53. Further, Dr. Min ignores that the transmitter feedback information must actually be fed back to the transmitter. *See* Claim 9. A POSITA would understand

that "angles" are not fed back as angles to the transmitter for the same reason that the patent disparages sending back of Cartesian coordinates—the data would be too large. Instead, the patent clearly contemplates the transmission of coefficients, and specifically quantized coefficients related to the reduced set of angles, to the transmitter as discussed in the specification at Col. 15:9–67.

54. Thus, I disagree with Dr. Min that the transmitter beamforming information produced by factoring V would only restrictively exist as "angles."

C. "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device"

55. It is my understanding that each side has the following positions on the above term from the '862 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Not a 112 ¶ 6 claim element In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: <u>Function</u>: "receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence;	This is a 112 ¶ 6 claim element. <u>Function</u>: "receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to

Plaintiff's Proposed Construction	Defendants' Proposed Construction
determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" Structure: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 2-5, Col. 5:49–6:12, 6:37–7:20; 7:51–9:30; 9:31–13:35; 13:54–15:67.	produce the transmitter beamforming information; and form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device" Structure: Indefinite for lack of corresponding structure in the patent specification.

56. For the reasons set forth below, I disagree with Dr. Min's opinion that the "baseband processing module" term is governed by 112 ¶ 6 and, even if it were a means-plus-function claim, I disagree that there is a lack of sufficient corresponding structure in the specification.

57. I disagree with Dr. Min's opinion that the "baseband processing module" term is governed by 112 ¶ 6 because a POSITA, viewing the term in light of the specification, would understand that it refers to a class of structures of baseband processors that may be implemented in whole or in part in ASIC, FGPA, logic circuits, or similar implementation methods in RF communication hardware and software. Dr. Min's opinion is based on the belief that the claim limitation includes a general purpose computer. In doing so, Dr. Min ignores the knowledge of a POSITA and the prior art, which identify that the term has come to be understood to identify a specific type of processor in RF communications.

58. I notice that Dr. Min, while noting that he reviewed the extrinsic evidence submitted by BNR, did not address it. Had Dr. Min addressed the extrinsic evidence,

he should have been able to determine that the baseband processing module is, itself, a known structure in the art at the time of the invention.

59. Should the Court determine that the "baseband processing module" term is governed by 112 ¶ 6, I also disagree with Dr. Min's opinion that the term lacks sufficient structure for the alleged function. I note that both Dr. Min and myself agree on the alleged, proposed function should the "baseband processing module" term be governed by 112 ¶ 6, as noted in the chart above and in ¶ 186 of Dr. Min's declaration.

60. First, I note that Dr. Min separates portions of the disputed term into the following distinct sub-terms: (1) receive a preamble sequence carried by the baseband signal, (2) estimate a channel response based upon the preamble signal, (3) determine the estimated transmitter beamforming unitary matrix . . ., (4) decompose the estimated transmitter beamforming unitary matrix . . ., and (5) form a baseband signal employed . . . . I understand that Dr. Min believes sufficient structure exists for the determine and decompose sub-terms, but contends that the receive, estimate, and form a baseband signal sub-terms lack sufficient structure.[1] Thus, I will only address why I believe Dr. Min is incorrect that the receive, estimate, and form a baseband signal sub-terms lack sufficient structure.

61. It is my opinion that sufficient structure exists for "receive a preamble sequence carried by the baseband signal" sub-term. First, I note that Dr. Min identifies, from Figure 3, the baseband processing module 100, which he further states that "Baseband processing module 100 is further illustrated in Figures 4 and 5." *See* Min Decl. ¶ 187. Particularly, Dr. Min correctly identifies that "Figure 5 is a schematic block diagram of a baseband receive processing 100-RX . . . ." *See* Min

[1] I also understand from counsel that BNR requested that Defendants separately disclose whether each sub-term lacked sufficient structure and if not, what Defendants claimed the structure to be but that Defendants did not do so until and through Dr. Min's declaration. To the extent Dr. Min's identified structure differs from the structure I identify in my Opening Declaration, I disagree with Dr Min.

Decl. ¶ 187 (citing 11:60–67). Dr. Min does not, however, continue his cited portion of the specification which identifies each of the sub elements of 100-RX or that "one of ordinary skill in the art will further appreciate that" each of these sub elements "may be function[sic] in accordance with one or more wireless communication standards including, but not limited to, IEEE 802.11a, b, g, n." *See* '862 Patent at Col. 11:68—12:10.

62. Likewise, Dr. Min points to steps 702 and 802 of Figures 7 and 8 respectively but does not also identify that "most of the operations 700 of Fig. 7 are typically performed by a baseband processing module, e.g. 100 of Fig. 3 of a receiving wireless device" and the "operations 800 of Fig. 8 are similar to the operations 700 of Fig. 7 and would typically be performed by a baseband processing module, e.g. 100 of Fig. 3 of a receiving wireless device." *See* '862 Patent at Col. 13:31–35; 14:16–20.

63. Further, the specification states that "the FFT modules 140, 142 function in accordance with one of the IEEE 802.11x standards to provide an OFDM (Orthogonal Frequency Domain Multiplexing) frequency domain baseband signals that includes a plurality of tones, or subcarriers, for carrying data." *See* '862 Patent at Col. 12:34–44. A person of ordinary skill in the art would understand that functioning in accordance with one of the IEEE 802.11x standards requires sending (or for the receiving device, receiving) a preamble sequence, which is carried by the baseband signal. Thus, a person of ordinary skill in the art would find sufficient structure in the specification for the "receive a preamble sequence carried by the baseband signal" sub-term.

64. It is my opinion that sufficient structure exists for "estimate a channel response based upon the preamble signal" sub-term. Dr. Min acknowledges that the specification states that "[e]stimating the channel response includes comparing received training symbols of the preamble to corresponding expected training symbols using any number of techniques that are known in the art." *See* Min Decl. ¶ 196

(citing ’862 Patent at Col. 13:40–44). It is my opinion that Dr. Min fails to credit the cited portion of the specification as the necessary algorithm. By disclosing that the estimating a channel response involves comparing received training symbols with the expected training symbols, a POSITA would have sufficient knowledge of the techniques known in the art to perform this algorithm. This is especially so in the context of the specification, which identifies the utilization of an OFDM scheme and therefore implies the various, well known in the art implementations of channel response estimation through comparison of preamble-based received training symbols to expected training symbols.

65. It is my opinion that sufficient structure exists for “form a baseband signal employed . . .” sub-term. Dr. Min incorrectly narrows his analysis to only steps 710 and 808 of Figures 7 and 8. In doing so, Dr. Min ignores the specification’s disclosure of the 100-TX described in Figure 4, the accompanying specification portions, and the knowledge of a POSITA. Specifically, Dr. Min does not note that the baseband processing module 100 executes digital transmitter functions, which includes, at least, inverse fast Fourier transform and digital baseband to IF conversion. *See* ’862 Patent at Col. 7:56–8:1. The specification then goes on in column 8 to describe that the baseband processing module produces one or more outbound symbol streams based on a mode of operation that is compliant with various IEEE 802.11 standards, which are based on OFDM. Thus it is my opinion that the ’862 Patent discloses sufficient structure for the “form a baseband signal employed” sub-term.

D. “the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates”

66. It is my understanding that each side has the following positions on the above term from the ’862 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Not a 112 ¶ 6 claim element –. In the alternative, to the extent the Court determines that this claim is governed by 112 ¶ 6, BNR proposes the following Function and Structure, and disagrees that the term is indefinite for lack of corresponding structure: <u>Function</u>: "a baseband processing module operable to . . . produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" <u>Structure</u>: Corresponding structure for the alleged function exists in at least the following portions of the patent specification, or their equivalents: Figs. 2-5, Col. 5:49–6:12, 6:37–7:20; 7:51–9:30; 9:31–13:35; 13:54–15:67.	This is a 112 ¶ 6 claim element. <u>Function</u>: "a baseband processing module operable to . . . produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" <u>Structure</u>: Indefinite for lack of corresponding structure in the patent specification.

67. I understand that Dr. Min believes this term is governed by 112 ¶ 6 for the same reasons that he concluded the "baseband processing module" term above is governed by 112 ¶ 6. I disagree with Dr. Min for the reasons I state above in response and for the reasons set forth in my Opening Declaration. I also disagree with Dr. Min's opinion that this term, even if governed by 112 ¶ 6, would lack sufficient structure.

68. I note that Dr. Min separates portions of the disputed term into the following distinct sub-terms: (1) produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates and (2) convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates. For the sub-term "produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates," I

understand that Dr. Min believes there is sufficient structure disclosed[2]. Thus, I understand that the only aspect in which Dr. Min believes there is not a disclosure of sufficient structure is for the "convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" sub-term.

69. I disagree with Dr. Min that the "convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates" lacks sufficient structure. Cartesian to polar conversion is a rudimentary mathematical principle taught even in high school trigonometry classes. Further, application of this basic mathematical concept to OFDM communications, as implied by the specification (*see* 13:25–36), states that the method 700 of Fig. 7 relates to MIMO wireless communication systems, among others. A POSITA would then know to employ any of the known Cartesian to polar coordinate techniques well known in the field of MIMO wireless communication and OFDM. Thus, it is my opinion that the specification discloses sufficient structure to a POSITA.

U.S. PATENT NO. 7,957,450

70. I have reviewed the declaration submitted by Dr. Min concerning the disputed terms of the '450 Patent.

71. In ¶ 138, Dr. Min provides his opinion for the definition of a POSITA, which he defines as having a Bachelor's degree in Electrical Engineering, Computer Engineering, Computer Science, or a related field, and at least 2–4 years of experience in the field of wireless communications, or a person with equivalent education, work, or experience in this field. I note that my definition of a POSITA includes two to three years of experience in digital communications systems, such as wireless communications systems and networks or the equivalent. Thus, while I disagree with

[2] I disagree with Dr. Min's opinions in ¶¶198–201 and 218, where he improperly limits the "determine an estimated transmitter beamforming unitary matrix" sub-term to only Cartesian coordinates. The specification makes clear that for Fig. 8 and Step 804, V is produced in polar coordinates. The specification further details this in at least column 12, lines 46 to 64.

Dr. Min's more narrowed field of experience, my opinions remain the same when using Dr. Min's definition of a POSITA as well.

A. "channel estimate matrices" / "matrix based on the plurality of channel estimates"

72. It is my understanding that each side has the following claim construction positions regarding the above term from the '450 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "one or more matrices that is based on an SVD decomposition of the estimates of the values of H(t)"	"matrix H_{est} for tones of different frequencies, where H_{est} contains estimates of the true values of H(t)"

73. As set forth in my opening declaration, which is incorporated by reference, it is my opinion that a POSITA would understand this term to mean "one or more matrices that is based on an SVD decomposition of the estimates of the values of H(t)."

74. I note that the specification describes several different channel estimate embodiments:

> In MIMO systems which communicate according to specifications in IEEE resolution 802.11, the receiving mobile terminal may compute H(t) each time a frame of information is received from a transmitting mobile terminal based upon the contents of a preamble field in each frame. **The computations which are performed at the receiving mobile terminal may constitute an estimate of the "true" values of H(t) and may be known as "channel estimates"**. For a frequency selective channel there may be a set of H(t) coefficients for each tone that is transmitted via the RF channel. To the extent that **H(t), which may be referred to as the "channel estimate matrix"**, changes with time and to the extent that the transmitting mobile terminal fails to adapt to those changes, information loss between the transmitting mobile terminal and the receiving mobile terminal may result.

’450 Patent at Col. 4:10–24.

> **In one embodiment of the invention**, a receiving mobile terminal may periodically transmit feedback information, comprising a **channel estimate matrix, $\mathbf{H_{up}}$**, to a transmitting mobile terminal. In another embodiment of the invention, a receiving mobile terminal may perform a singular value decomposition (SVD) on the channel estimate matrix, and subsequently transmit SVD-derived feedback information to the transmitting mobile terminal.

’450 Patent at Col. 7:64–8:5.

> **Yet another embodiment of the invention** may expand upon the method utilizing sounding frames to incorporate calibration. In this aspect of the invention, a receiving mobile terminal, after transmitting a sounding frame, may subsequently receive a **channel estimate matrix, $\mathbf{H_{down}}$**, from the transmitting mobile terminal. The receiving mobile terminal may then transmit feedback information which is based upon the difference $H._{up}$-H_{down}, to the transmitting mobile terminal.

’450 Patent at Col. 8:10–18.

> **In one embodiment of the invention**, **a full channel estimate matrix** which is computed by a receiving mobile terminal, **$\mathbf{H_{est}}$,** may be represented by its SVD: $H_{est}=USV^H$, where equation[2] H_{est} may be a complex matrix of dimensions N_{rx} xN_{tx}, where N_{rx} may be equal to the number of receive antenna at the receiving mobile terminal, and N_{tx} may be equal to the number of transmit antenna at the transmitting mobile terminal, U may be an orthonormal complex matrix of dimensions N_{rx} N_{rx}, S may be a diagonal real matrix of dimensions N_{rx} x N_{tx}, and V may be an orthonormal complex matrix of dimensions N_{tx} x N_{tx} with V^H being the Hermitian transform of the matrix V.

’450 Patent at Col. 8:52–65.

75. Dr. Min acknowledges that “the ’450 Patent consistently refers to “channel estimate matrix” as a matrix H….Similarly, the claim term ‘matrix based on the/said plurality of channel estimates’ must also refer to a matrix H.” *See* Min Decl. at ¶148.

76. However, Dr. Min goes on to state that the specification discloses “the patent uses the notation ‘H*est*’ to indicate that the matrix H is ‘an estimate’ of the channel.” *See* Min Decl. at ¶149. However, as shown by the specification excepts above, the patent also used H_{up} and H_{down} to describe a “channel estimate matrix.” I understand that it is improper to import a specific embodiment into the construction of

claim term, which appears to be a flaw in Dr. Min's and Defendants' construction. In fact, Dr. Min acknowledges that the use of H_{est} is disclosed as "an embodiment of the invention utilizing singular value decomposition…" *See* Min Decl. at ¶146.

77. I also note that claim 2 of the '450 Patent adds the limitation "computing each of said plurality of channel estimate matrices for a corresponding **one of a plurality of tones**, wherein each of said plurality of tones corresponds to **one or more distinct frequencies**." Thus, Defendants' "for tones of different frequencies" limitation should not be incorporated into claim 1 since it is claimed in a dependent claim.

78. Dr. Min criticizes BNR's proposed construction because it "incorporates into the terms to be construed an SVD limitation that is separately claimed in the independent claims into the terms to be construed…" *See* Min Decl. at ¶154. The Specification discloses:

> If a complete channel response is not to be sent, in step 814, the receiving mobile terminal 222 may compute a complete channel estimate matrix based on the preamble field in the preceding MIMO channel request frame. In step 816, the receiving mobile terminal 222 may compute the matrix decomposition on the complete channel estimate matrix. In step 816, matrix decomposition on the complete channel estimate matrix may be performed by **a plurality of methods comprising SVD, QR decomposition, lower diagonal, diagonal, upper diagonal (LDU) decomposition, and Cholesky decomposition**.

'450 Patent at Col. 17:52–62.

79. While the specification recognizes that there are several decomposition methods, the claim language expressly restricts the decomposition method to singular value decomposition. *See*, for example, '450 Patent at Col. 19:16–19 ("wherein said plurality of channel estimate matrices comprise coefficients derived from performing a **singular value** matrix **decomposition (SVD)** on said received signals"), 19:61–63 ("wherein said plurality of channel estimate matrices comprise coefficients derived from performing a **singular value** matrix **decomposition (SVD)** on said received

signals"), 20:47–49 ("wherein the matrix comprises coefficients from performing a **singular value** matrix **decomposition (SVD)** on said plurality of channel estimates"), and 20:57–60 ("wherein said matrix comprises coefficients derived from performing a **singular value** matrix **decomposition (SVD)** on said plurality of channel estimates"). However, in the alternative, a POSITA would also understand the construction of this term to be the estimate matrices based on a decomposition of the channel matrix estimates by one or more of the methods listed in Col. 17:52–62, and the claim itself restricts it to SVD.

80. Dr. Min also criticizes BNR's construction because it "requires a channel estimate matrix (or matrices) to be "based on an SVD decomposition of the estimates of the values of H(t)." *See* Min Decl. at ¶153. However, as discussed above, the independent claims are specifically limited to SVD by the claim language, and their including a decomposition by other methods, such as QR in addition to SVD in the proposed construction, will not provide a meaningful difference.

B. "coefficients derived from performing a singular value matrix decomposition (SVD)"

81. It is my understanding that each side has the following claim construction positions regarding the above term from the '450 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "values derived from a singular value decomposition"	"values in the matrices U, S, or V^H, where $H_{est}=USV^H$"

82. As set forth in my opening declaration, which is incorporated by reference, it is my opinion that a POSITA would understand this phrase to mean "values derived from a singular value decomposition."

83. Dr. Min's and Defendants' proposed construction of this phrase flows from the flawed construction of the "channel estimate matrices" term above, which I incorporate herein by reference. I explained in the section above why it is improper to limit the claim to the H_{est}, which is one embodiment disclosed in the specification.

U.S. PATENT NO. 7,990,842

84. I have reviewed the declaration submitted by Dr. Wells concerning the disputed terms of the '842 Patent.

85. In ¶ 36, Dr. Wells provides his opinion for the definition of a POSITA, which he defines as having a bachelor's degree in electrical engineering or some similar technical field, along with two to three years of experience with wireless networks, such as experience with wireless local area or mobile networks. I note that my definition of a POSITA includes a bachelor's degree in electrical engineering, computer engineering, computer science or similar field and two to three years of experience in digital communications systems, such as wireless communications systems and networks or the equivalent. Thus, I disagree with Dr. Wells's more narrowed field of experience.

A. "standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme"

86. It is my understanding that each side has the following positions regarding the above term from the '842 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: "a standard issued by a Standard Setting Organization (for, example, IEEE or 3GPP) utilizing an	Indefinite

Orthogonal Frequency Division Multiplexing scheme."	

87. As set forth in my opening declaration, which is incorporated by reference, it is my opinion that this term is not indefinite and that a POSITA at the time of the invention would understand this term to mean "a standard issued by a Standard Setting Organization (for, example, IEEE or 3GPP) utilizing an Orthogonal Frequency Division Multiplexing scheme."

88. Dr. Wells admits that a POSITA would, at a minimum, "interpret the word 'standard' as related to IEEE 802.11 standards." *See* Wells Opening Decl. at ¶42. Further, Dr. Wells acknowledges that a POSITA could "interpret [this] term to be limited to IEEE 802.11 standards that have wireless networking configurations for OFDM." *See* Wells Opening Decl. at ¶43.

89. Dr. Wells goes on to argue that certain 802.11 known at the time are configured for OFDM. *See* Wells Opening Decl. at ¶44.

90. Despite these admissions, Dr. Wells opines that the scope of the claims is not precise because different standards use different wireless networking configurations. *See* Wells Opening Decl. at ¶45.

91. I disagree with Dr. Wells. First, it is important to look at the entire claim limitation to understand the disputed phrase in context: "wherein at least the optimal extended long training sequence is carried by a greater number of subcarriers than a standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme." This language makes clear that the wireless networking configuration must use sub-carriers, which places limits on the standards covered. In addition, the claim language specifically requires that the configuration be one "for an Orthogonal Frequency Division Multiplexing scheme." Again, this is a significant limitation that places bounds on the reach of the claims and provides reasonable certainty to a POSITA.

92. I further note that Dr. Wells only focuses on claim 1 of the '842 Patent. However, the dependent claims provide further clarity to a POSITA. For example, claim 2 requires the optimal extended long training sequence be carried by at least 56 active subcarriers. Therefore, for example, when analyzing the scope of claim 2, the requirement to use 56 sub-carriers provides additional clarity as seen when that requirement is incorporated into the pertinent claim limitation: *wherein at least the optimal extended long training sequence is* ***[carried by at least 56 active subcarriers]*** *than a standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme*. This simple substitution shows that OFDM wireless networking configurations not utilizing 56 active subcarriers would be excluded. Adding the narrowing revisions from dependent claims 3, further narrows the scope.

93. Dr. Wells also argues that the claim is indefinite because he is unclear as to "how many subcarriers is considered 'a greater number of subcarriers' compared to a 'standard' configuration." *See* Wells Opening Decl. at ¶45. I disagree with this argument. A greater number of subcarriers simply means that there must be more subcarriers than are utilized in a prior version of the relevant standard. Furthermore, as the substitution example shows, the dependent claims provide significant information to a POSITA, such that reasonable certainty as to the scope of the claims is provided. I also note that, as Dr. Wells acknowledges in his declaration, absolute precision is not required in a definiteness analysis. *See* Wells Opening Decl. at ¶45.

94. As far as ¶48 in Dr. Wells's Declaration, I disagree that BNR's proposed construction does not provide clarity. First, the proposed construction's identification of IEEE or 3GPP greatly reduces the universe of standards. Second, limiting the technology to standardized versions of OFDM, as required by the claim, places limits on the scope and would be recognized and understood by a POSITA as being applicable to any OFDM-based standard to enhance it over its earlier versions.

95. I conclude that the phrase "standard wireless networking configuration for an Orthogonal Frequency Division Multiplexing scheme" as used in the '842 Patent provides reasonable certainty to a POSITA.

B. "a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard"

96. It is my understanding that each side has the following positions regarding the above term from the '842 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: "a training sequence that uses more active subcarriers than an earlier version of the same standard."	Indefinite

97. As set forth in my opening declaration, which is incorporated by reference, it is my opinion that this term is not indefinite and that a POSITA at the time of the invention would understand this term to mean "a training sequence that uses more active subcarriers than an earlier version of the same standard."

98. A legacy standard is a past version of the standard to the current time. This concept is not unusual and is even found in the literature of the time. *See* **Appendix 4** (S. Mangold, et. al., *Analysis of IEEE 802.11e for QoS Support in Wireless LANs* (IEEE Wireless Communications, Dec. 2003)) ("We analyze the enhancements in 802.11e and compare its performance to the legacy 802.11 standard."…..).

99. Dr. Wells admits that a POSITA would "understand that the term 'legacy' is relative" and that the specification describes that invention in terms of improving upon older versions of the 802.11 standard with a newer version. *See* Wells Opening

Decl. at ¶¶54-55. More importantly, Dr. Wells recognizes that older versions of a standard are "legacy" when compared to a newer version of the same standard. *See* Wells Opening Decl. at ¶55 ("For example, when devices compatible with 802.11a and 802.11g are in the same WLAN, the 802.11a compatible devices would be considered "legacy" because 802.11a is an "older version" of the 802.11 standard *relative to* 802.11g. In contrast, where devices compatible with 802.11a, 802.11g and 802.11n are in the same WLAN, both the 802.11a and 802.11g devices would be considered "legacy" because they are both "older versions" of the 802.11 standard *relative to* 802.11n."). Thus, Dr. Wells admits that a POSITA would recognize that the claim language applies to a standard that evolves over time, which provides clarity to a POSITA.

100. Dr. Wells opines that "A version of a standard can only be an "earlier version" *relative to* another newer version of the standard. Thus, the term [allegedly] remains indefinite because a POSITA cannot ascertain which versions of a standard are "earlier versions" without knowing the full set of standards being considered." *See* Wells Opening Decl. at ¶57. I find this argument perplexing because Dr. Well implies that POSITA would not know if a standard has an older version, which is a perplexing position. Furthermore, Dr. Wells argues for a level of precision (identification of an exact standard in the claims) which contradicts the legal requirements set forth in his declaration that absolute precision is not required. *See* Wells Opening Decl. at ¶30.

101. In ¶ 58, Dr. Wells asserts that "a POSITA would still not be able to ascertain the scope of the relative term 'legacy' without also knowing the specific versions of IEEE 802.11 that are in consideration." I disagree with this assertion for the reasons set forth in my opening declaration. Furthermore, it is important to look at the disputed phrase in context: "wherein the optimal extended long training sequence is longer than a long training sequence used by a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard." ('842

claim 14.) Thus, another factor adding reasonable certainty to the claims is that the claimed extended training sequence must be longer than the training sequence used by a prior version of the standard.

102. I conclude that the phrase “a legacy wireless local area network device in accordance with a legacy wireless networking protocol standard” as used in the ’842 Patent provides reasonable certainty to a POSITA.

C. “extended long training sequence”

103. It is my understanding that each side has the following positions regarding the above term from the ’842 Patent:

Plaintiff’s Proposed Construction	Defendants’ Proposed Construction
BNR contends that this term is not indefinite. However, to the extent the Court determines that a specific construction is warranted, BNR proposes the following alternative construction: “a training sequence that uses more active subcarriers than an earlier version of the same standard.”	Indefinite

104. As set forth in my opening declaration, which is incorporated by reference, it is my opinion that this term is not indefinite and that a POSITA at the time of the invention would understand this term to mean “a training sequence that uses more active subcarriers than an earlier version of the same standard.”

105. The specification identifies that in the existing 802.11a and 802.11g standards, “each data packet starts with a preamble which includes a short training sequence followed by a long training sequence. The short and long training sequences are used for synchronization between the sender and the receiver. The long training sequence of 802.11a and 802.11g is defined such that each of sub-carriers -26 to +26 has one BPSK consellation point, either +1 or -1.” A POSITA would understand this

to mean that the 802.11a and 802.11g training sequences are carried on 52 sub-carriers (i.e., from -26 to +26).

106. The specification describes embodiments that use 56 active sub-carriers and 63-subcarriers. *See* '842 Patent Col. 5:14–25; Figs 4-5. The use of 56 and 63 sub-carriers is more than the 52 sub-carriers used by the 802.11a and 802.11g standard, as set forth in the specification. Thus, I disagree with Dr. Wells's statement that the "specification and claim fail to clearly define how many subcarriers must be used for a training sequence to fall within the scope of the claimed "extended long training sequence." *See* Wells Opening Decl. at ¶66.

107. I also note that Dr. Well does not attempt to analyze the dependent claims, which provide additional information. For example, claim 2 of the '842 Patent specifically states that "the optimal extended long training sequence is carried by at least 56 active sub-carriers." Likewise, claim 5 provides that "the optimal extended long training sequence is carried by at least 63 active sub-carriers." Thus, these claims directly address Dr. Wells's contention that there is no indication of "how many subcarriers must be used for a training sequence to fall within the scope of the claimed 'extended long training sequence.'" *See* Wells Opening Decl. at ¶66.

108. I also disagree with Dr. Wells's general assertion that "a POSITA would not be able to determine whether the use of more active subcarriers of an 'earlier version' of the 802.11 standard or the IEEE 802.16 standard falls within the scope of this term. Dr. Wells cites to prior argument earlier in his declaration and I incorporate my rebuttals to those same arguments.

109. I conclude that the term "extended long training sequence" as used in the '842 Patent provides reasonable certainty to a POSITA.

D. "optimal extended long training sequence"

E. It is my understanding that each side has the following positions regarding the above term from the '842 Patent:

Plaintiff's Proposed Construction	Defendants' Proposed Construction
Not indefinite	Indefinite

110. The specification explains:

> The present invention provides an expanded long training sequence **of minimum peak-to-average power ratio** and thereby decreases power back-off. The inventive expanded long training sequence may be used by 802.11a or 802.11g devices for estimating the channel impulse response and by a receiver for estimating the carrier frequency offset between the transmitter clock and receiver clock. The inventive expanded long training sequence is usable by 802.11a or 802.11g systems only if the values at sub-carriers -26 to +26 are identical to those of the current long training sequence used in 802.11a and 802.11g systems. As such, the invention utilized the same +1 or -1 binary phase shift key (BPSK) encoding for each new sub-carrier and the long training sequence of 802.11a or 802.11g systems is maintained in the present invention.

'842 Patent at Col. 4:4–18.

111. In describing Figure 4, the specification teaches:

> FIG. 4 illustrates the long training sequence **with a minimum peak-to-average power ratio** that is used in 56 active sub-carriers**. Out of the 16 possibilities for the four new sub-carrier positions**, the sequence illustrated in FIG. 4 **has the minimum peak-to-average power ratio, i.e., a peak-to-average power ratio of 3.6 dB**.

'842 Patent at Col. 5:14–19.

112. Likewise, in describing Figure 5, the specification teaches:

> FIG. 5 illustrates the long training sequence with a **minimum peak-to-average power ratio** that is used in 63 active sub-carriers. **Out of the 2048 possibilities for the eleven new sub-carrier positions**, the sequence illustrated in FIG. 5 has **the minimum peak-to-average power ratio, i.e., a peak-to-average power ratio of 3.6 dB**.

'842 Patent at Col. 5:20–25.

113. Thus, the specification explains that as additional sub-carriers are added (from the 52 sub-carriers used by the 802.11a and 802.11g standards), the possible combinations of +1 and -1 BPSK coding combinations increase. However, the goal is to identify the combination the extended sequence with a minimum peak-to-average ratio. This is a key aspect of the invention.

114. Furthermore, it is important to read the disputed phrase in context: "wherein the Inverse Fourier Transformer processes the extended long training sequence from the signal generator and provides an optimal extended long training sequence **with a minimal peak-to-average ratio**." ('842 Patent at Col. 5:46–49.) Thus, the word "optimal" refers to the training sequence with a minimal peak to average ratio. Thus, the claim language, especially in light of the teachings of the specification, provide a POSITA to reasonable clarity as to the scope of the claim.

115. Dr. Wells renews the same arguments made in connection with the disputed "extended long training sequence" phrase. *See* Wells Opening Decl. at ¶74. I have addressed those arguments above and re-incorporate them herein by reference.

116. Dr. Wells argues that "optimal" and "minimal" are relative terms lacking clarity. *See* Wells Opening Decl. at ¶74. I disagree. As noted above, "optimal" refers to the combination of new subcarriers (beyond the 52-subcarriers used in the 802.11a and 802.11g standards) that provides a minimal peak-to-average ratio. The specification teaches that the minimum peak-to-power ration is 3.6 dB. *See* '842 Patent at Col. 5:14–19 (for 56 sub-carriers) and Col. 5:20–25 (for 63 sub-carriers). I further note, that dependent claims 4 and 7, specifically claim the 3.6 dB limitation undermining Dr. Wells's opinions. Finally, in ¶ 30 of his declaration, Dr. Wells acknowledges that absolute precision is not required for a claim to satisfy the definiteness standard.

117. I conclude that the term "optimal extended long training sequence" as used in the '842 Patent provides reasonable certainty to a POSITA.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 8th day of May, 2019, in Atlanta, Georgia.

Vijay K Madisetti

Dr. Vijay K. Madisetti, Ph.D.

5/8/19

EXHIBIT N

IN THE UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. COOLPAD TECHNOLOGIES, INC. AND YULONG COMPUTER COMMUNICATIONS, Defendants.	C.A. No. 3:18-cv-1783-CAB-BLM Judge: Hon. Cathy Ann Bencivengo Magistrate Judge: Hon. Barbara L. Major
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. HUAWEI DEVICE (DONGGUAN) CO., LTD, HUAWEI DEVICE (SHENZHEN) CO., LTD., and HUAWEI DEVICE USA, INC., Defendants.	C.A. No. 3:18-cv-1784-CAB-BLM
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. KYOCERA CORPORATION and KYOCERA INTERNATIONAL INC., Defendants.	C.A. No. 3:18-cv-1785-CAB-BLM

SURREBUTTAL DECLARATION OF DR. VIJAY K. MADISETTI, PH.D. IN SUPPORT OF PLAINTIFF'S CLAIM CONSTRUCTION

INTRODUCTION

1. On May 2, 2019, I submitted an Opening Declaration on Claim Construction, and on May 8, 2019, I submitted a Rebuttal Declaration on Claim Construction. I hereby incorporate by reference the contents of both of those declarations in their entirety, including a description of my qualifications and compensation, and also the appendices attached thereto.

2. I have reviewed the declaration of Jonathan Wells, Ph.D. dated May 1, 2019, concerning United States Patent Nos. 6,941,156 (the ’156 Patent) and 7,990,842 (the ’842 Patent) (“Wells Opening Declaration”). I have also reviewed Dr. Wells’ Declaration dated May 8, 2019, concerning the ’842 Patent (“Wells Rebuttal Declaration”). Below I respond to certain new arguments raised in the Wells Rebuttal Declaration.

OPINIONS

3. I understand that, in the Wells Rebuttal Declaration, Dr. Wells addresses a term that Defendants have proposed for construction from the ’842 Patent, “Inverse Fourier Transformer.” For the reasons discussed in my Opening Declaration and below, I disagree with his opinions regarding this term.

4. As an initial matter, I note that Dr. Wells agrees with me that “the Fourier transform could map one domain to another in a broad mathematical sense.” Wells Rebuttal Declaration at ¶ 8.

5. Dr. Wells then states that “[i]n wireless communications, which is the field of art for the ’842 patent, the Fourier transform operates specifically to map between the time domain and frequency domain.” But this opinion is incorrect for at least three reasons.

6. First, the term that Defendants have proposed for construction is “Inverse Fourier Transformer,” which references a term of art with the broader meaning that I ascribed in my Opening Declaration: “circuit and/or software that at least performs an inverse Fourier transform.” An inverse Fourier transform, in turn, is a mathematical

concept that has broad applicability and connotes transforming from one domain to another. *See* Opening Declaration at ¶¶ 190, 192. Defendants have not proposed construing "Inverse Fourier Transformer in wireless communications" (and such a term does not appear in the '842 Patent).

7. Second, it is incorrect from a technical point to state that, in wireless communications, the inverse Fourier transform can *only* (and must only!) map between the time domain and frequency domain as a matter of fact. Indeed, as shown below, this broad statement by Dr. Wells is readily disproved.

8. For instance, **Appendix 5** to this Declaration, a peer-reviewed and published academic paper entitled "Discrete Fourier Transform based Multimedia Colour Image Authentication for **Wireless Communication** (DFTMCIAWC)," (emphasis added) shows the exemplary use of an inverse Fourier transform to "transform [an] embedded image from **frequency** domain to **spatial** domain" (emphasis added). Equation 1 of this reference further shows exemplary forward mapping between frequency and spatial domains in the wireless communications area between two 2-dimensional domains, (x, y) and (u, v) respectively:

$$F(u,v) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

9. Similarly, **Appendix 6** to this declaration, a peer-reviewed and published academic paper entitled "Spatial Channel and System Characterization" discussing multi-antenna (wireless) communications systems, shows that an example of an "inverse Fourier transform converts a signal from **wave vector** domain to **space** domain" (emphasis added). Equations 2 and 3 of this reference show exemplary mapping between the wave vector and spatial domains in a Fourier transform and corresponding inverse Fourier transform in the context of wireless communications:

$$G(\vec{k}) = \int g(\vec{r}) e^{j\vec{r}\cdot\vec{k}} d^3 r$$
$$g(\vec{r}) = \frac{1}{(2\pi)^3} \int G(\vec{k}) e^{-j\vec{k}\cdot\vec{r}} d^3 k$$

These are simply two examples of references that support my opinion that the plain and ordinary, mathematical meaning of an inverse Fourier transform still applies in wireless communications and a definition that must use time to frequency mapping or vice versa is just an example of its use, and not a correct definition or construction even when restricted to wireless communications. Further, based on my experience in this field, I would expect numerous similar references to exist, including from the 2000-2004 time period. *See, e.g.*, **Appendix 7** ("Spread-Space Holographic CDMA Technique: Basic Analysis and Applications").

10. Therefore, firstly, even in the context of wireless communications, inverse Fourier transforms are not limited to conversions between time and frequency domains, and secondly, would not limit it to a single variable in these or other domains (time, frequency, space, symbol, wave-vectors, …) and must not be, in my technical opinion as supported by factual evidence herein.

11. Thirdly, a person of ordinary skill in the art, when reading the term "Inverse Fourier Transformer" in light of the specification, would not limit it in the manner that Dr. Wells specifies, because there is nothing in the patent or file history that indicates that the Applicants intended to limit it as such. Just because a term is used in a particular context in an embodiment in the patent specification does not necessarily limit it to mean that it can only be applied to the described practical application. Indeed, a POSITA would understand it as exemplary usage.

12. In ¶ 11, Dr. Wells quotes portions of the specification of the '842 Patent. I do not dispute that these paragraphs accurately quote the specification. However, the portion of the patent that Dr. Wells quotes, an explanation of Fig. 3, describes only one embodiment of the claimed invention. As stated in my Opening Declaration, I

understand that it is improper to limit a claim term to a single embodiment. Aside from this one paragraph, Dr. Wells does not cite any other intrinsic evidence to support Defendants' construction.

13. Dr. Wells also cites Appendix 2 (Wells Rebuttal Exhibit F) to my Opening Declaration, the Bracewell reference, as an *example* of transforming between time and frequency domains. It is unclear what Dr. Wells intends to point out by that example. There is no dispute that an inverse Fourier transform *could* be performed between time and frequency domains. But it is *not* limited to those domains, from the point of view of a POSITA at the time of the invention, according to the plain and ordinary meaning of the term in the art.

14. Also, aside from the Bracewell reference, which specifically shows a generic mathematical representation of two definitions of a Fourier transform, where one of them is the inverse or reverse of the other and neither of which is limited to mapping between time and frequency (*see* Opening Declaration at ¶ 187), Dr. Wells does not cite any other extrinsic evidence to support Defendants' construction.

15. Therefore, I disagree with Dr. Wells's unsupported technical opinions regarding "Inverse Fourier Transformer."

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 16th day of May, 2019, in Atlanta, Georgia.

Dr. Vijay K. Madisetti, Ph.D.
5/16/19

EXHIBIT O

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. COOLPAD TECHNOLOGIES, INC. AND YULONG COMPUTER COMMUNICATIONS, Defendants.	Case No. 3:18-cv-01783-CAB-BLM [LEAD CASE]
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. HUAWEI DEVICE (DONGGUAN) CO., LTD., HUAWEI DEVICE (SHENZHEN) CO., LTD., and HUAWEI DEVICE USA, INC., Defendants.	Case No. 3:18-cv-01784-CAB-BLM

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. KYOCERA CORPORATION and KYOCERA INTERNATIONAL INC., Defendants.	Case No. 3:18-cv-01785-CAB-BLM
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. ZTE CORPORATION, ZTE (USA) INC., ZTE (TX) INC., Defendants.	Case No. 3:18-cv-01786-CAB-BLM

DECLARATION OF PAUL MIN, PH.D. REGARDING CLAIM CONSTRUCTION

I certify under penalty of perjury that the following is true and correct.

Date: May 1, 2019 By: ______________________________
Paul Min, Ph.D.

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I. Introduction

1. My name is Paul Min, Ph.D. I am a Senior Professor of Electrical and Systems Engineering at Washington University in St. Louis, Missouri. I am over the age of twenty-one, competent to make this declaration, and have personal knowledge of the matters stated herein.

2. I have been retained on behalf of Defendants Kyocera Corporation and Kyocera International Inc. ("Kyocera Defendants) to opine on and provide expert testimony related to: (i) U.S. Patent No. 6,941,156 ("the '156 Patent") (attached as Exhibit C), and (ii) U.S. Patent No. 7,957,450 ("the '450 Patent") (attached as Exhibit D), and (iii) U.S. Patent No. 8,416,862 ("the '862 Patent") (attached as Exhibit E). I understand that my opinions and expert testimony are also relevant to proceedings involving one or more of these three patents with respect to Defendants Coolpad Technologies, Inc. and Yulong Computer Communications ("Coolpad Defendants"); Huawei Device (Dongguan) Co., Ltd., Huawei Device (Shenzhen) Co., Ltd., Huawei Device USA, Inc., ("Huawei Defendants"); and ZTE Corporation, ZTE (USA) Inc., and ZTE (TX) Inc. ("ZTE Defendants"), whose cases have been consolidated with the Kyocera Defendants for claim construction purposes. For purposes of this statement, the term "Defendants" is used to generally refer to the Kyocera Defendants, Coolpad Defendants, Huawei Defendants, and ZTE Defendants.

3. In this declaration, I opine on the scope and meaning of certain terms that appear in the '156 Patent, '450 Patent, and '862 Patent, which I collectively refer to as the "Patents-in-Suit."

4. In this declaration, I also opine on the level of ordinary skill in the art for the Patents-in-Suit, which is relevant to understanding how a person of ordinary

for the ’156 Patent’s disclosure that the claimed invention is directed to handovers between different modes of a multimode cell phone. Defendants’ proposed construction recognizes this by construing the term to mean “distinct and different communication links.” Moreover, BNR’s proposal is confusing, because BNR does not explain the meaning of the term “active.” To a POSITA, an active link could mean a link maintaining transmission and reception of data or an active link also could mean a link simply maintaining the connected state without transmitting and receiving data. A POSITA would have known that a multimode cell phone could be connected to another device without exchanging data for a certain period of time before it is timed out.

87. Second, BNR’s proposed construction provides no basis to ascertain both end points of the “simultaneous communication path.” A POSITA would understand that a communication path must have two end-points, one at the multimode cell phone and another at a far-end communication device. As explained above, the specification discloses that the communication path is from “said multimode cell phone to a far-end communication device,” consistent with Defendants’ proposed construction.

88. Third, BNR’s proposed construction is in conflict with arguments and amendments made by the applicant for the ’156 Patent during prosecution in response to an Office Action rejecting all 19 original claims as anticipated by U.S. Patent No. 5,842,122 to Schellinger, et al. (“Schellinger”). U.S. Patent Appl. No. 09/888,493, Dec. 8, 2004 Office Action (BNR-SDCA00000059–64). Schellinger discloses “automatic handoff operation” when portable cellular cordless (PCC) radiotelephone 101 “moves out of range of the cordless telephone system and is in the coverage area of the cellular telephone system” (Schellinger, 6:61–7:6):

> In accordance with the preferred embodiment of the present invention, a call in process between the PCC 101 operating in a cellular telephone system 103 and a calling party is handed off from the cellular telephone system 103 to the cordless telephone system by producing a three way call through the cellular telephone system 103, at block 716, between the PCC 101, the other party and the landline phone number of the cordless base station 115.
>
> In FIG. 6-2 the cordless base station 115 receives the handoff from cellular to cordless request at block 617 and answers the landline leg of the three way call at block 619 to open communication between the other party and the cordless base station 115. The PCC 101 is now in a cordless phone call with the calling party at block 621. In FIG. 7A the PCC 101 operating in the cellular telephone system 103 ends the cellular leg of the three way call at block 718 to terminate cellular system communication between the PCC 101 and the other party. Thus, a call in process is handed off from the cellular telephone system 103 to the cordless telephone system when the PCC 101 relocates from the cellular telephone system 103 to the cordless telephone system.

Schellinger, 7:50–8:3.

89. In response to the Patent Office's rejection, the patent applicant amended the claims. For example, claim 1 was amended to further include the limitation "a module to establish simultaneous communication paths from said multimode cell phone using both said cell phone functionality and said RF communication functionality." U.S. Patent Appl. No. 09/888,493, Jan. 6, 2005 Response to Office Action (BNR-SDCA00000073).

90. In addition, the applicant distinguished the amended claims over the Schellinger reference by arguing that Schellinger disclosed a radiotelephone that switched between modes, but that radiotelephone did not operate in "both [modes] simultaneously." The applicant also argued that the handoff was produced using a "three way call through the cellular telephone system." A POSITA would

100. A POSITA would understand that multimode cell phone 100 described by the '156 Patent must include radio communication equipment (e.g., antenna, amplifier, transmitter, receiver, etc.) operating in conjunction with a general purpose computer (e.g., microprocessor) that is specially programmed to perform wireless communications, typically in compliance with telecommunication industry standards (e.g., 3GPP/ETSI, etc.). According to the specification, the multimode cell phone further includes "the ability and convenience of storing all phone book data, calling history and user preferences" (*id*. at 1:13–22), which a POSITA would also understand to be implemented by a general purpose computer (e.g., microprocessor) that is specially programmed to perform such functionality. The specification further supports this understanding by stating that multimode cell phone 100 operates under the control of a "processor."[2] *Id*. at 7:9–13, 7:53–57.

101. I disagree with BNR's statement that "[a] POSA would know this is a cellular RF communication functionality well known in the art." The '156 Patent, including the language of claim 1, makes clear that the claimed "multimode **cell phone**" cannot be limited to "cellular RF communication functionality" because it includes functionality to operate as a cordless telephone or walkie-talkie, and because it includes functionality to store phone book data, calling history and user preferences. *Id*. at 1:13–22 (bold emphasis added). BNR's proposed construction

[2] The '862 Patent further supports this understanding by disclosing a "wireless communication device," such as a "cellular telephone" ('862 Patent, 7:21–27, Fig. 3), that includes a "baseband processing module" which executes "operational instructions" (*id.* at 7:51—8:1). The '862 Patent discloses that the "baseband processing module 100 may be implemented using one or more processing devices," such as a "microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on operational instructions." *Id*. at 8:1–20.

has not identified extrinsic support to establish the meaning of these terms, aside from the possible (but not yet disclosed) testimony of its expert.

a. *"channel estimate matrices"; "matrix based on the/said plurality of channel estimates"*

'450 Patent Claim Term	BNR's Proposed Construction	Defendants' Proposed Construction
"channel estimate matrices"; "matrix based on the/said plurality of channel estimates"	Plain and ordinary meaning. In the alternative, to the extent the Court determines that a specific construction is warranted, BNR proposes: "one or more matrices that is based on an SVD decomposition of the estimates of the values of H(t)"	"matrix H_{est} for tones of different frequencies, where H_{est} contains estimates of the true values of H(t)"

Joint Claim Construction Worksheet, Appendix A at 22–28.

141. The term "channel estimate matrices" is used in claims 1, 2, 3, 11, 12, and 13. The term "matrix based on the plurality of channel estimates" is used in claim 21. The term "matrix based on said plurality of channel estimates" is used in claim 22. Notably, these terms are similar and should therefore be construed to have the same meaning.

142. It is my opinion that, at the time of the filing of the '450 Patent, a POSITA would understand these terms to mean "matrix H_{est} for tones of different frequencies, where H_{est} contains estimates of the true values of H(t)," as Defendants

propose. My opinion is supported by the disclosures in the '450 Patent as I explain in the following paragraphs.

143. In the background section, the specification states that an RF channel between a transmitting mobile terminal and a receiving mobile terminal may be represented by "a transfer system function, H." '450 Patent, 3:53–57. "The relationship between a time varying transmitted signal, x(t), a time varying received signal, y(t), and the systems function may be represented as shown in equation [1]:

$y(t)=H\times x(t)+n(t)$, where equation[1]

n(t) represents noise which may be introduced as the signal travels through the communications medium and the receiver itself. In MIMO systems, the elements in equation[1] may be represented as vectors and matrices." *Id*. at 3:57–66.

144. Due to signal fading effects that may be time varying in nature, the transfer function H may be represented as a function of time, H(t). *Id*. at 4:5–9. The specification explains that, for IEEE 802.11 systems, the receiving terminal may compute H(t) for each frame of information received from a transmitting terminal. *Id*. at 4:10–14. The specification explicitly identifies H(t) as a "channel estimate matrix," which **contains "estimate[s] of the 'true' values of H(t)**."

> The computations which are performed at the receiving mobile terminal may constitute an estimate of the "true" values of H(t) and may be known as "channel estimates". For a frequency selective channel there may be a set of H(t) coefficients for each tone that is transmitted via the RF channel. To the extent that H(t), which may be referred to as the "channel estimate matrix", changes with time and to the extent that the transmitting mobile terminal fails to adapt to those changes, information loss between the transmitting mobile terminal and the receiving mobile terminal may result.

Id. at 4:14–24.

145. The patent discloses that the transfer function H may be different for the forward channel (downlink direction) and the reverse channel (uplink direction). Accordingly, the receiving terminal may compute a "**reverse channel estimate matrix, $\mathbf{H_{up}}$**," and the transmitting terminal may compute a "**forward channel estimate matrix, $\mathbf{H_{down}}$**." *Id*. at 4:66–5:7.

146. The patent discloses an embodiment of the invention utilizing singular value decomposition (SVD) that describes a "**full channel estimate matrix** which is computed by a receiving mobile terminal, $\mathbf{H_{est}}$." *Id*. at 8:52–65.

> H_{est}, may be represented by its SVD:
>
> H_{est} =USV^H, where equation[2]
>
> H_{est} may be a complex matrix of dimensions $N_{rx}\times N_{tx}$, where N_{rx} may be equal to the number of receive antenna at the receiving mobile terminal, and N_{tx} may be equal to the number of transmit antenna at the transmitting mobile terminal, U may be an orthonormal complex matrix of dimensions $N_{rx}N_{rx}$, S may be a diagonal real matrix of dimensions $N_{rx}\times N_{tx}$, and V may be an orthonormal complex matrix of dimensions $N_{tx}\times N_{tx}$ with V^H being the Hermitian transform of the matrix V. The singular values in the matrix S may represent the square roots of the Eigenvalues for the matrix H_{est}, U may represent the left singular vectors for the matrix H_{est} where the columns of U may be the Eigenvectors of the matrix product $H_{est}H_{est}^H$, and V^H may represent the right singular vectors for the matrix H_{est} where the columns of V may be the Eigenvectors of the matrix product $H_{est}^H H_{est}$.

Id. at 8:54–9:4.

147. The patent further discloses that the matrix H_{est} for tones of different frequencies:

> For an RF channel, **$\mathbf{H_{est}}$ may be different for tones of different frequencies** that are transmitted via the RF channel. Thus, a plurality of **channel estimate matrices**, H_{est}, may be computed

> to account for each tone which may be transmitted via the RF channel.

Id. at 9:33–37. Thus, for wireless systems employing different frequencies, a receiving terminal would compute an H_{est} matrix for tones of different frequencies, such as in an IEEE 802.11 based system. *See id*. at 3:14–18 (discussing "orthogonal frequency division multiplexing (OFDM), in which each of the plurality of signals is modulated by a different frequency carrier signal prior to mapping and multiplicative scaling"); *id*. at 4:10–14 (discussing MIMO systems operating in accordance with IEEE 802.11).

148. These passages show that the '450 Patent consistently refers to a "channel estimate matrix" as a matrix H.[4] Similarly, the claim term "matrix based on the/said plurality of channel estimates" must also refer to a matrix H.

149. As the patent explains, a matrix H computed by a receiving terminal "constitute[s] an estimate of the 'true' values of H(t)" (*id*. at 4:14–17), and therefore, the patent uses the notation "H_{est}" to indicate that the matrix H is "an estimate" of the channel (*e.g., id*. at 6:52–56).

150. Because the transfer function H for the RF channel may be "different for tones of different frequencies," a receiving terminal may compute H_{est} "to account for each tone." *Id*. at 9:33–36. The patent describes and claims these H_{est} matrices for each tone as "a plurality of channel estimate matrices, H_{est}." *Id*.

151. As further support for Defendants' construction, I note that the proposed construction is not limited to a specific embodiment, nor does it exclude any of the embodiments disclosed by the specification.

[4] The '862 Patent, which identifies its inventors as two of the '450 Patent inventors, also refers to an estimated "channel response" as a matrix "H." '862 Patent, 3:14–33, 13:36–53.

processing module" terms, I have also reviewed and considered the three publications that BNR identified as extrinsic evidence.[5]

a. ***"decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information"***

'862 Patent Claim Term	BNR's Proposed Construction	Defendants' Proposed Construction
"decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information"	"factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients"	"factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles"

Joint Claim Construction Worksheet, Appendix A at 14–15.

172. The term "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information" is used in claim 9.

---

[5] BNR identified three publications as extrinsic evidence to support their proposed construction for the "baseband processing module …" terms:

Wireless vs. Wired. How Software Define Radio technology addresses issues related to the use of wireless networks when compared to a wired solution White Paper, Lexycom Technologies, Inc. (May 2005). See BNR SDCA00037995 – BNR-SDCA00038005.

Igor S. Simic, Evolution of Mobile Base Station Architectures, Microwave Review at 31 (June 2007). See BNR-SDCA00037973 – BNR-SDCA00037979.

Rajeesh Kutty, A Simple Baseband Processor for RF Transceivers, Analog Devices. See BNR-SDCA00000037967 – BNR-SDCA00037972.

173. It is my opinion that, at the time of the filing of the ’862 Patent, a POSITA would understand this term to mean “factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles,” as Defendants propose. My opinion is supported by the disclosures in the ’862 Patent as I explain in the following paragraphs.

174. BNR and the Defendants agree on the first part of the construction of this term. That is, “decompose the estimated transmitter beamforming unitary matrix (V) to produce . . .” means “factor the estimated transmitter beamforming unitary matrix (V) to produce . . .”. According to the patent specification, “[t]he receiving wireless device may transform the estimated transmitter beamforming unitary matrix using a QR decomposition operation such as a Givens Rotation operation to produce the [transmitter] beamforming information.”[6] ’862 Patent, Abstract. QR decomposition, which refers to a linear algebra technique to decompose a given matrix into the product of two other matrices (Q and R), is also sometimes referred to as QR factorization. Based on this understanding, I agree that a POSITA would understand the term “decompose” to mean “factor,” and therefore, agree that the first part of this term means “factor the estimated transmitter beamforming unitary matrix (V) to produce . . .”

175. The patent discloses the use of a Givens Rotation operation in the context of two embodiments “for providing beamforming feedback information from a receiver to a transmitter,” which are illustrated as Figures 7 and 8. *Id*. at 4:15–20.

[6] The language in the Abstract which identified “*transformer* beamforming information” appears to be a typographical error for what was presumably intended to reference “*transmitter* beamforming information.” The term “transformer” is not used anywhere else in the ’862 patent.

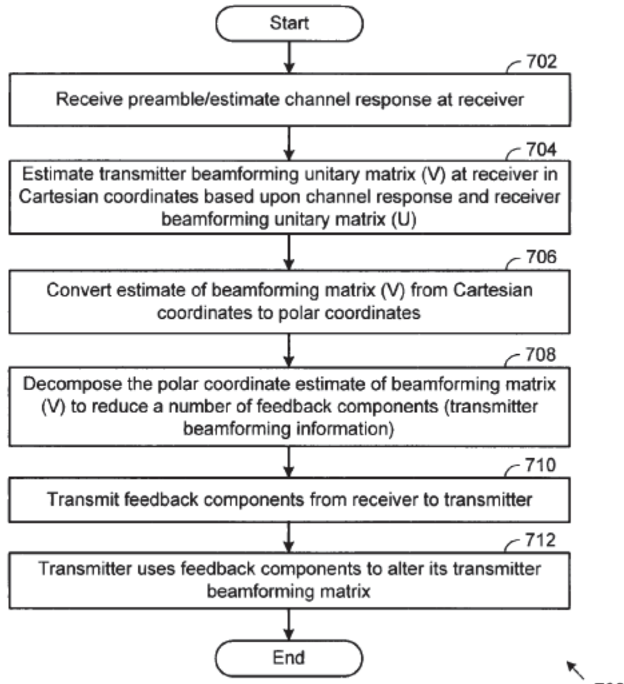
Start
702
Receive preamble/estimate channel response at receiver
704
Estimate transmitter beamforming unitary matrix (V) at receiver in Cartesian coordinates based upon channel response and receiver beamforming unitary matrix (U)
706
Convert estimate of beamforming matrix (V) from Cartesian coordinates to polar coordinates
708
Decompose the polar coordinate estimate of beamforming matrix (V) to reduce a number of feedback components (transmitter beamforming information)
710
Transmit feedback components from receiver to transmitter
712
Transmitter uses feedback components to alter its transmitter beamforming matrix
End
700

FIG. 7

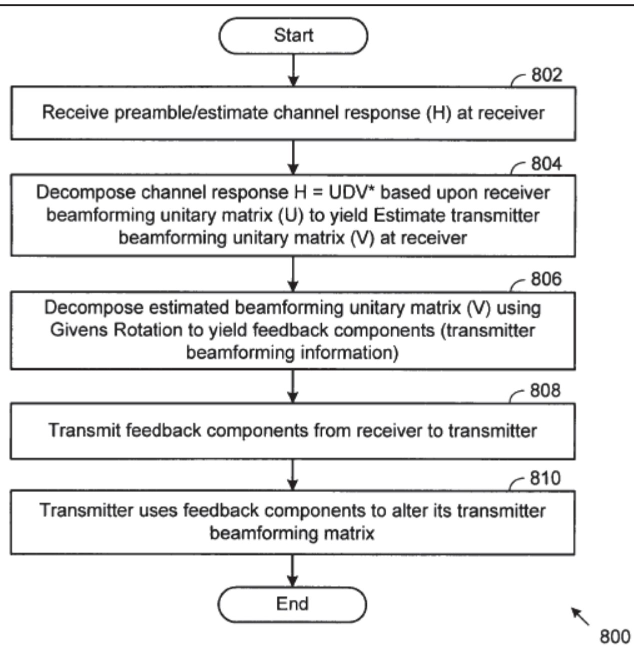
Start
802
Receive preamble/estimate channel response (H) at receiver
804
Decompose channel response H = UDV* based upon receiver beamforming unitary matrix (U) to yield Estimate transmitter beamforming unitary matrix (V) at receiver
806
Decompose estimated beamforming unitary matrix (V) using Givens Rotation to yield feedback components (transmitter beamforming information)
808
Transmit feedback components from receiver to transmitter
810
Transmitter uses feedback components to alter its transmitter beamforming matrix
End
800

FIG. 8

176. Step 708 of the embodiment of Figure 7 discloses a Givens Rotation operation to decompose "the estimated transmitter beamforming unitary matrix (V)." *Id*. at 13:58–65. The matrix (V) to be decomposed is in the form of polar coordinates (which includes angles), after having been converted from Cartesian coordinates in earlier step 706. *Id*. at 13:54–58. The patent explains that the Givens Rotation operation reduces the set of angles in the matrix (V):

> The Givens Rotation relies upon the observation that, with the condition of V*V=VV*=I, **some of angles of the Givens Rotation are redundant**. With a decomposed matrix form for the estimated transmitter beamforming matrix (V), **the set of angles fed back to the transmitting wireless device are reduced.**

Id. at 13:65–14:3.

177. Step 806 of the embodiment of Figure 8 similarly discloses using a Givens Rotation "to produce the transmitter beamforming information":

> With the estimated transmitter beamforming unitary matrix (V) determined, the receiving wireless device then decomposes the estimated transmitter beamforming unitary matrix (V) using a Givens Rotation **to produce the transmitter beamforming information** (step 806). **The products of this Givens Rotation are the transmitter beamforming information.**

Id. at 14:31–37.

178. Consistent with these two embodiments, the patent explains that the transmitter may regenerate the V matrix from the reduced set of angles produced using a Givens Rotation. For example, for a 2x2 MIMO communication (i.e., 2 transmit antennas and 2 receive antennas), the transmitter does not need four angles from the matrix (V) (ψ_1, Φ_1, ψ_2, and Φ_2), but instead "may regenerate V per each tone" using just two angles (ψ_1, Φ_1). *Id*. at 10:38–60.

179. Based on these passages from the specification, a POSITA would understand that the claimed decomposition of the estimated transmitter beamforming unitary matrix (V) produces "a reduced set of angles."

180. It is my opinion that BNR's proposed construction is incorrect. The decomposition of the estimated transmitter beamforming unitary matrix (V) does not produce "a reduced number of quantized coefficients." First, the specification explains the basis for using a Givens Rotation is with respect to "angles," not coefficients. *Id*. at 13:65–14:3 ("some of angles of the Givens Rotation are redundant"). Second, a POSITA would understand from linear algebra that neither a Givens Rotation nor any QR decomposition operation produces "quantized" values. Quantization refers to a transformation of data into integer values. However, the claim language is clear in that the "transmitter beamforming information" is produced by "decompos[ing] the estimated transmitter beamforming unitary matrix (V)," not by quantizing data.

181. Accordingly, it is my opinion that a POSITA would understand the terms "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information" to mean "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced set of angles."

b. "a baseband processing module operable to: receive a preamble sequence carried by the baseband signal; estimate a channel response based upon the preamble sequence; determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U); decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and form a baseband

EXHIBIT P

BELL NORTHERN RESEARCH, LLC

PLAINTIFF

VS.

COOLPAD TECHNOLOGIES, INC., ET AL

DEFENDANTS

DEPOSITION OF

DR. PAUL MIN

MAY 15, 2019

Dr. Paul Min - May 15, 2019

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC,

PLAINTIFF,

vs. No. C.A. NO. 3:18-CV-01783-CAB-BLM

COOLPAD TECHNOLOGIES, INC., ET AL,

DEFENDANTS.

Deposition of Dr. Paul Min, taken on behalf of the Plaintiff, at the offices of Gore Perry Veritext, 515 Olive Street, Suite 300, in the City of St. Louis, State of Missouri, on the 15th day of May, 2019, before Randy R. Dunn, RPR, CRR, CCR MO #193.

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APPEARANCE CONTINUES

THE VIDEOGRAPHER:
Miss Kim Lauer

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VIDEO DEPOSITION

THE VIDEOGRAPHER: Good morning. We are going to the record at 10:08 a.m. on Wednesday, May 15th, 2019.

Please note that the microphones are sensitive and may pick up whispering, private conversations and cellular interference. Please turn off all cell phones or place them away from the microphones as they can interfere with the deposition audio.

Audio and video recording will continue to take place unless all parties agree to go off the record.

This is media unit one of the video recorded deposition of Dr. Paul Min taken by counsel for the plaintiff in the matter of Bell Northern Research, LLC versus Coolpad Technologies, incorporated, et al. Case Number 3:18-CV-01783, filed in the United States District Court, Southern District of California and the consolidated cases. This deposition is being held at Veritext Legal Solutions located at 515 Olive Street in St. Louis, Missouri.

My name is Kimberlee Lauer from Veritext and I'm a videographer. And our court reporter is

Randy Dunn also from Veritext.

I am not authorized to administer an oath, I am not related to any party in this action, nor am I financially interested in the outcome.

Counsel and all present in the room and anyone attending remotely will now please state their appearances and affiliations for the record and if there are any objections to proceeding, please state them at the time of your appearance, beginning please, with the noticing attorney.

MR. UDICK: This is Steve Udick for Skiermont Derby on behalf of plaintiff Bell Northern Research, LLC and with me is Sadaf Abdullah also from Skiermont Derby.

MR. RITCHIE: Thomas Ritchie from Jones Day on behalf of defendants Kyocera Corporation and Kyocera International, Incorporated.

MR. DAMARIO: Tom DaMario from McDermitt, Will & Emory on behalf of the ZTE defendant.

THE VIDEOGRAPHER: If our court reporter would please swear in the witness.

DR. PAUL MIN,

of lawful age, having been first duly sworn to testify the truth, the whole truth, and nothing but the truth in the case aforesaid, deposes and says in reply to oral interrogatories, propounded as follows, to-wit:

EXAMINATION

BY MR. UDICK:

Q Good morning, Dr. Min.
A Good morning.
Q Do you prefer Dr. Min or Professor Min?
A Doesn't matter.
Q We will go with Dr. Min.
A Okay.
Q I understand you have been deposed before; is that right?
A Yes.
Q About how many times?
A Um, maybe 20, 25 times.
Q So I assume you understand the general ground rules of depositions; is that fair?
A Generally.
Q So if I ask a question that you don't understand, please let me know. It is bound to happen, I will try to rephrase. If you answer my

Q A person skilled in the art would understand multimode cell phone 100 described by the '156 patent, must include radio communication equipment, is that one thing?

MR. RITCHIE: Objection, vague.

A One thing you said?

Q (MR. UDICK) Let me rephrase.

From paragraph 100, what is your understanding of what multimode cell phone 100 is?

A Uh, that's what the patent talks about.

Q So it must include radio communication equipment, for example, antenna, amplifier, transmitter, receiver, operation in conjunction with a general purpose computer that is specially programmed to perform wireless communications, typically in compliance with telecommunication industry standards. For example, 3GPP and ETSI, right?

A That's what I said.

Q And then you refer to a phone book data calling history and user preference.

Do you see that?

A Yes, as a part of a multimode cell phone.

Q Is that a part of cell phone functionality?

MR. RITCHIE: Objection, vague.

A So at the time 2000, let's say earlier date of the two possible priority date, 2000. People knew what the cell phone was. Cell phone functionality could be a lot of things and multimode, multimode cell phone, I think the patent itself described it too.

For example, in Column 1 of the '156 patent as a background and starting from line about 13, talks about multimode cell phone, such as the 3-in-1 cell phone. And cell phone has advanced in additional capability to operate as a cordless phone and then it talks about all of that. And then it goes on to say in the next sentence, this provides a cell phone that has advantageous over competitors cell phones, which are not similarly capable, including the ability and convenience of storing all phone book data, calling history and user preference.

So here we are talking about cell phone functionality to include all of that.

So I'm just saying as a person of ordinary skill in the art understands that cell phone functionality could include all of those. I mean there are cheap phones that maybe didn't have all of that, but many cell phones, whether it is a multimode phone or not, had all of that capability.

Q (MR. UDICK) So I want you to keep the declaration out and make page 41 visible, I believe that has Figure 1.

A Okay.

Q And also have the patent beside you.

A Okay.

Q Look at Column 3 at lines 56?

A Okay.

Q Then starts importantly?

A Okay.

Q Do you see that it says with cell phone functionality 100A?

A Okay.

Q Now look at Figure 1.

A Okay.

Q What is 100A in Figure 1?

A In Figure 1?

Q Correct?

A It is cell phone.

Q What is 100 in Figure 1?

A I'm sorry, 100. Multimode cell phone.

Q And what is 100A then in Figure 1?

A It is a cell phone. In Figure 1 it is a

the transmitter beamforming information; is that right?
A Yes.
Q And your construction is factor the estimated transmitter beamforming unitary matrix V to produce a reduced set of angles.
Did I get that right?
A Yes.
Q And BNR's proposed construction is factor the estimated transmitter beamforming unitary matrix V to produce a reduced number of quantized coefficients.
Did I read that correctly?
A Yes.
Q There's no dispute for the construction from the word factor through the word produce; is that right?
A That's right.
Q And the remaining of it is kind of the dispute at issue, right?
A Yes.
Q So I'd like to direct you to the '862 patent.
A Okay.
Q If you go to column 15 and line 34.

Beginning as the reader will appreciate. Do you see that?

A Yes.

Q Can you read that sentence into the record?

A As the reader will appreciate, the coefficients of the Givens Rotation and the phase matrix coefficients serve as the transmitter beamforming information that is sent from the receiving wireless communication device to the transmitting wireless communicating device.

Q Now under your construction, in what format are the angles transmitted to the transmitting wireless device?

MR. RITCHIE: Objection, vague.

A So what, what the patent specification says is you do unitary matrix V and you then decompose it using the Givens Rotation. Actually, you do it multiple times as necessary depending on the size of the V and then after that, the actually data sent back to the transmitter is, uh, quantized information.

Now, having said that, that is not really what the claim says.

The claim language does not say

anything about transmitting, what is being transmitted. It just says, you decompose estimated transmitter beamforming unitary matrix V to produce the transmitter beamforming information.

Afterward, you do quantization, so be it, but that's not what the claim language says.

Q (MR. UDICK) So you said earlier in your answer that the -- after the Givens Rotation, actually, data sent back to the transmitter is quantized information. Is that what you understand as a person of skill in the art reading the claim term?

A No, not the claim term. That's what -- the excerpt from the patent specification you asked me to read, that's what that sentence is trying to say. The sentence starting from line 34 in Column 15, it talks about that is sent from receivable, receiving wireless communication device to transmitting wireless communication device.

So that here we are talking about what is actually being sent, but that's not what the claim is saying. The claim term is only talking about decomposing it.

The idea here is to really more with, as an example shown at the top of column 15, the V

A What is being produced is the transmitter beamforming information, that's the second from the last limitation of claim one.

And that transmitter beamforming information is produced by decomposing the estimated transmitter beamforming unitary matrix V and that decomposition is shown on the left hand, the Column 15 at the top. The V is decomposing two matrices at the second line in that equation shown at the top of Column 15.

That shows two angles, phi and psi.

Q (MR. UDICK) But also shows cosign phi and psi, right?

A That's what I'm saying, the two angles. The cosign and sign, the position of those are fixed. That's just Givens Rotation. So what is shown here is the angle, the one, one the source is fixed. So the angle phi and angle psi. If you know those two, you know what V is.

Q It sends back more than just angles, right? One isn't an angle, is it?

A I'm sorry?

Q Is one an angle.

A No.

MR. RITCHIE: Objection, vague.

A The form of this two matrices are fixed.
Q (MR. UDICK) So the transmitter beamforming information includes, in your opinion, two angles and a one?
A No, not one, two angles. That's what it says.
Q How many bits would be required to transmit an angle?
A We can use --
MR. RITCHIE: Objection, calls for speculation.
A You can use as many or as little as you want.
Q (MR. UDICK) What's the minimum that you could use to transmit an angle?
A I mean, if you want to transmit a true valuable angle, then you need infinite bits, it is a real number.
Q That's more than the Cartesian coordinate solution described in the patent, isn't it?
A No, that's not true because the Cartesian coefficient also are real numbers and to send that true value of the real number you need the infinity number of bits.
Q So you understand the scope of the

purpose -- the invention of the patent is to reduce the amount of beam of information being sent back as feedback, right?

A That is --

MR. RITCHIE: Objection, calls for a legal conclusion.

A That is a goal as I understand the patent.

Q (MR. UDICK) And, in fact, the title of the patent is, Efficient Feedback of Channel Information in a Closed Loop Beamforming Wireless Communication System, right?

A That is the title.

Q So it wouldn't make sense to invent something that sends back infinity number of bits, right?

MR. RITCHIE: Objection, calls for speculation.

A Once again, to get the true value of none -- just the Cartesian it requires infinity number of bits, but in reality no information is sent that way, you fix so many number of bits.

But if you think about Cartesian, as an example you have a V matrix shown in figure, Column 15 at the top, there are four entries in this two by two matrix. Each of those elements in two by two matrix, which is a four element, would have two components. Rear part and imaginary part. So we are talking about eight different components, eight different coefficient numbers that you need to send.

In comparison, the second line after the decomposition is done, you only have two.

So eight numbers being sent versus two numbers being sent. And you fix how many bits that you use for each of those numbers, two is less than eight.

So you will gain the efficiency by just having the reduced set of coefficient or angle in this case. Number versus the angle, eight versus two. You get that efficiency.

Quantization isn't something extra that you do to reduce even further, but the scope itself of the patent, as you said, the goal of a patent is to reduce the amount of data being sent to make the feedback information more efficient. That gets achieved by just the representation you need matrix V by decomposing it into a Givens Rotation and making that into just two angles, as opposed to eight coefficients in a partition colony.

Q (MR. UDICK) In your answer you said that, so eight numbers being sent versus two numbers being sent and you fix how many bits that you use for each of those number, right?

MR. RITCHIE: Objection, mischaracterizes his earlier testimony.

A It just means that you cannot send a real number in using any kind of zero communication.

Q (MR. UDICK) So you have to form it to a certain number of bits; is that right?

MR. RITCHIE: Objection, vague.

A In any formable digital communication, you would have to fix the -- what we call the precision of the number. Sometimes you use 8 bits, 16 bits, 32 bits, sometimes even 64 bits, that's just to indicate a floating number of any kind.

So as an example, let's say you use a 16 bit for each floating number, so that's something with a decimal partition. Then if you have a 8 coefficient, each with a 16 bit, that gives you so many number of bits. As opposed to two angles, which each of which is again a floating number, use it for 16 bit. You have the same procedure for all cases for each number, but the number of bits in total is only 1/4th for the case of a decomposed unitary matrix using the two angles. So you gain the efficiency.

And if you are not reducing further and using quantization, you can do so and that's what this embodiment described between line nine through 33 of Column 15 says, but that is not what is claimed in claim one. Your claim one says you decompose to get the angles, reduce set of angles and send that instead of the coefficient that originally appeared in the unit three matrix V after you do singular unitary decomposition.

Q (MR. UDICK) First you agree that quantization involves transforming angles in the specific number of bits; is that right?

A Quantization limits the number of bits to be used for angle, that is correct.

Q So then you just said, it is interesting, decompose to get the angle, to reduce the angles and send that coefficient that originally appeared.

That was, that was one of your last answers. So the coefficients, when you said coefficient, you meant coefficient in U.S. or V transposed in this patent?

A In this case the V matrix. So unitary matrix V has as an example for two by two, four entries in the two by two matrix and each entry having real and imaginary part. So it gives you decomposition. So we are talking about something else.

Q And that's right, and if you do that other decomposition, the output is still in matrix form, right?

MR. RITCHIE: Objection, vague.

A In product of two matrices.

Q (MR. UDICK) And the values in a matrix are called coefficients, right?

A Yes, but it represents the values in the matrices is a coefficient, but we're talking about transmitter beamforming information, that is angle. You are not talking about sending the value of whole sign psi and sign psi or E to the J phi. You are not talking about sending that value. You are talking about sending an angle part of those values.

Q Sorry. After you do the decomposition, you have to extract certain values to send; is that right?

A Those are the transmitter beamforming information.

Q So under your interpretation, quantization would also occur because it is no different, it is -- values outside of a matrix are not the immediate result of a Givens Rotation, correct?

MR. RITCHIE: Objection, mischaracterizes earlier testimony.
A You say values outside --
MR. RITCHIE: Vague, calls for speculation.
Q (MR. UDICK) The result of a Givens Rotation is two matrices, right?
A Yes, product of the two matrices.
Q And you already said that the values of the matrices are called coefficients, right, commonly?
A Yeah, sure. That's some number.
Q In the '450 patent, we refer to it as coefficients?
A Sure.
Q When we've talked about the two, we refer to it as coefficients. When we talked about values within a matrix thus far?
A The increase in the matrices of coefficient, yeah.
Q So the reason you're not, you don't agree that quantization occurs is because it's not part of the Givens Rotation, right?
MR. RITCHIE: Objection, mischaracterizes earlier testimony.

MR. UDICK: Let's go off the record for half a second, I believe I don't.

(Off the record.)

THE VIDEOGRAPHER: It is 2:24. We are off the record.

(Off the record.)

THE VIDEOGRAPHER: It is 2:24, we are back on the record.

MR. UDICK: I have no further questions either.

MR. RITCHIE: Dr. Min would like an opportunity when the final transcript is available to review that transcript, make any necessary corrections to errors in transcriptions, et cetera, and sign the transcript.

THE VIDEOGRAPHER: It is 2:25 p.m. This concludes today's testimony given by Dr. Paul Min. The total number of media units was three and will be retained by Veritext Legal Solutions.

(Signature not waived.)

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SS.

County of St. Louis

I, Randy R. Dunn, a Licensed Certified Court Reporter by the Supreme Court in and for the State of Missouri, duly commissioned, qualified and authorized to administer oaths and to certify to depositions, do hereby certify that pursuant to Notice in the civil cause now pending and undetermined in the Federal District Court, State of California, to be used in the trial of said cause in said court, I was attended at the offices of Gore Perry 515 Olive Street, Suite 300, in the City of St. Louis, State of Missouri, by the aforesaid attorneys; on the 15th day of May, 2019.

The said witness, being of sound mind and being by me first carefully examined and duly cautioned and sworn to testify the truth, the whole truth, and nothing but the truth in the case aforesaid, thereupon testified as is shown in the foregoing transcript, said testimony being by me reported in shorthand and caused to be transcribed into typewriting, and that the foregoing page correctly set forth the testimony of the aforementioned witness, together with the questions propounded by counsel and remarks and objections of counsel thereto, and is in all respects a full, true, correct and complete transcript of the questions propounded to and the answers given by said witness; that signature of the deponent was not waived by agreement of counsel.

I further certify that I am not of counsel or attorney for either of the parties to said suit, not related to nor interested in any of the parties or their attorneys.

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EXHIBIT Q

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-AN] **—foun′tained,** *adj.* **—foun′tain·less,** *adj.* **—foun′tain·like′,** *adj.* —**Syn.** 2. birthplace, cradle, genesis, wellspring.

foun′tain grass′, a perennial grass, *Pennisetum setaceum,* of Ethiopia, having bristly spikes, often rose-purple, grown as an ornamental.

foun·tain·head (foun′tn hed′), *n.* **1.** a fountain or spring from which a stream flows; the head or source of a stream. **2.** a chief source of anything: *a fountainhead of information.* [1575–85; FOUNTAIN + HEAD]

Foun′tain of Youth′, a fabled spring whose waters were supposed to restore health and youth, sought in the Bahamas and Florida by Ponce de León, Narváez, De Soto, and others.

foun′tain pen′, a pen with a refillable reservoir that provides a continuous supply of usually fluid ink to its point. [1700–10]

foun′tain plant′, Joseph's-coat. [1890–95, *Amer.*]

Foun′tain Val′ley, a city in SW California. 55,080.

Fou·qué (fo͞o kā′), *n.* **Frie·drich Hein·rich Karl, Baron de la Motte-** (frē′drikh hīn′rikh kärl, də lä mōt′), 1777–1843, German romanticist: poet and novelist.

Fou·quet (*Fr.* fo͞o ke′), *n.* **1. Jean** or **Je·han** (*both Fr.* zhäN), c1420–c80, French painter. **2. Ni·co·las** (nē kô-lä′), (*Marquis de Belle-Isle*), 1615–80, French statesman. Also, **Foucquet.**

Fou·quier-Tin·ville (fo͞o kyā taN vēl′), *n.* **An·toine Quen·tin** (äN twAN′ käN taN′), 1747?–95, French revolutionist: prosecutor during the Reign of Terror.

four (fôr, fōr), *n.* **1.** a cardinal number, three plus one. **2.** a symbol of this number, 4 or IV or IIII. **3.** a set of this many persons or things. **4.** a playing card, die face, or half of a domino face with four pips. **5. fours,** *Jazz.* alternate four-bar passages, as played in sequence by different soloists: *with guitar and piano trading fours.* **6.** *Auto.* **a.** an automobile powered by a four-cylinder engine. **b.** the engine itself. **7. on all fours.** See **all fours** (def. 3). **—***adj.* **8.** amounting to four in number. [bef. 1000; ME *four, fower,* OE *fēower;* c. OHG *fior* (G *vier*), Goth *fidwor;* akin to L *quattuor,* Gk *tésseres* (Attic *téttares*)]

four-a-cat (fôr′ə kat′, fōr′-), *n.* See **four old cat.**

four-bag·ger (fôr′bag′ər, fōr′-), *n. Baseball.* See **home run.** [1925–30; FOUR + BAGGER]

four′-ball′ match′ (fôr′bôl′, -bôl′, fôr′-), *Golf.* a match, scored by holes, between two pairs of players, in which the four players tee off and the partners alternate in hitting the pair's ball having the better lie off the tee. [1900–05]

four-bang·er (fôr′bang′ər, fōr′-), *n. Auto. Slang.* a four-cylinder engine.

four′ bits′, *Slang.* 50 cents. [1830–40, *Amer.*] **—four′-bit′,** *adj.*

4 × 4 (fôr′ bī fôr′, fōr′ bī fōr′, bə), a four-wheeled automotive vehicle having four-wheel drive.

four-chan·nel (fôr′chan′l, fōr′-), *adj. Audio.* quadraphonic. [1965–70]

four·ché (fo͝or shā′), *adj. Heraldry.* forked or divided into two at the extremity or in extremities: *a lion's tail fourché; a cross fourché.* Also, **four·chée′.** [1350–1400; ME < F; see FORK, -EE]

four·chette (fo͝or shet′), *n.* **1.** *Anat.* the fold of skin that forms the posterior margin of the vulva. **2.** *Ornith.* furcula; wishbone. **3.** *Zool.* the frog of an animal's foot. **4.** a strip of leather or fabric joining the front and back sections of a glove finger. **5.** *Chiefly Bridge.* a tenace. [1745–55; < F, dim. of *fourche;* see FORK -ETTE]

four′-col′or prob′lem (fôr′kul′ər, fōr′-), *Math.* the problem, solved in 1976, of proving the theorem that any geographic map can be colored using only four colors so that no connected countries with a common boundary are colored the same color. Also called **four′-col′or the′orem.** [1875–80]

four′-col′or proc′ess, *Print.* a process for reproducing colored illustrations in a close approximation to their original hues by photographing the artwork successively through magenta, cyan, and yellow color-absorbing filters to produce four plates that are printed successively with yellow, red, blue, and black inks. [1895–1900]

Four′ Cor′ners, a point in the SW U.S., at the intersection of 37° N lat. and 109° W long., where the boundaries of four states—Arizona, Utah, Colorado, and New Mexico—meet: the only such point in the U.S.

four-cor·ners (fôr′kôr′nərz, fōr′-), *n.* (*used with a singular or plural v.*) *Northern and Western U.S.* a place where roads cross at right angles; a crossroads. Also, **four′ cor′ners.**

four-cy·cle (fôr′sī′kəl, fōr′-), *adj.* noting or pertaining to an internal-combustion engine in which a complete cycle in each cylinder requires four strokes, one to draw in air or an air-fuel mixture, one to compress it, one to ignite it and do work, and one to scavenge the cylinder. Also, **four-stroke.** Cf. **two-cycle.** [1905–10]

four-di·men·sion·al (fôr′di men′shə nl, fōr′-), *adj. Math.* of a space having points, or a set having elements, which require four coordinates for their unique determination. [1875–80]

Four·drin·i·er (fo͝or drin′ē ər), *n.* a machine for manufacturing paper. [1830–40; named after Henry and Sealy *Fourdrinier,* 19th-century English papermakers]

four-eyed (fôr′īd′, fōr′-), *adj.* **1.** having or seeming to have four eyes. **2.** *Facetious or Disparaging.* wearing eyeglasses. [1880–85]

four′-eyed fish′, a small, surface-swimming fish, *Anableps anableps,* inhabiting shallow, muddy streams of Mexico and Central America, having each eye divided, with the upper half adapted for seeing in air and the lower half for seeing in water. Also, **four′eye fish′** (fôr′ī′, fōr′ī′). Also called **anableps, four-eyes.**

four′-eyed opos′sum, a small opossum, *Metachirops (Philander) opossum,* ranging from Mexico to Brazil, having a white spot above each eye.

four-eyes (fôr′īz′, fōr′-), *n., pl.* **-eyes. 1.** *Facetious or Disparaging.* a person who wears eyeglasses. **2.** See **four-eyed fish.** [1870–75]

4-F (fôr′ef′, fōr′-), *n.* **1.** a U.S. Selective Service classification designating a person considered physically, psychologically, or morally unfit for military duty. **2.** a person so classified.

four′ flush′, *Poker.* a hand having four cards of one suit and one card of another suit; an imperfect flush. [1885–90, *Amer.*]

four-flush (fôr′flush′, fōr′-), *v.i.* **1.** to bluff. **2.** *Poker.* to bluff on the basis of a four flush. [1895–1900, *Amer.*]

four·flush·er (fôr′flush′ər, fōr′-), *n.* a person who makes false or pretentious claims; bluffer. [1900–05, *Amer.;* FOUR FLUSH + -ER[1]]

four·fold (fôr′fōld′, fōr′-), *adj.* **1.** comprising four parts or members. **2.** four times as great or as much. **—***adv.* **3.** in fourfold measure. [bef. 1000; ME *foure fald,* OE *feowerfealdum.* See FOUR, -FOLD]

four′fold block′, *Mach.* a block having four pulleys or sheaves. Cf. **block** (def. 11).

four′fold pur′chase, a tackle that is composed of a rope passed through two fourfold blocks in such a way as to provide mechanical power in the ratio of 1 to 5 or 1 to 4, depending on whether hauling is done on the running or the standing block and without considering friction. Cf. **tackle** (def. 2).

four-foot·ed (fôr′fo͝ot′id, fōr′-), *adj.* having four feet: *He considers his dog to be his four-footed friend.* [1125–75; ME *four foted*]

four′-footed but′terfly. See **brush-footed butterfly.**

four′ free′doms, freedom of speech, freedom of worship, freedom from want, and freedom from fear: stated as goals of U.S. policy by President Franklin D. Roosevelt on January 6, 1941.

four·gon (fo͝or gôN′), *n., pl.* **-gons** (-gôN′). *French.* a long covered wagon for carrying baggage, goods, military supplies, etc.; a van or tumbril.

four-hand·ed (fôr′han′did, fōr′-), *adj.* **1.** involving four hands or players, as a game at cards: *Bridge is usually a four-handed game.* **2.** intended for four hands, as a piece of music for the piano. **3.** having four hands, or four feet adapted for use as hands; quadrumanous. Also, **four-hand** (fôr′hand′, fōr′-) (for defs. 1, 2). [1765–75]

Four′-H′ Club′ (fôr′āch′, fōr′-), an organization sponsored by the U.S. Department of Agriculture to instruct young people, originall in rural areas, in modern farming methods and other useful skills, as carpentry and home economics. Also, **4-H Club.** [so called from its aim to improve head, heart, hands, and health] **—4-H,** *adj.* **—4-H′er,** *n.*

Four′ Horse′men of the Apoc′alypse, four riders on white, red, black, and pale horses symbolizing pestilence, war, famine, and death, respectively. Rev. 6:2–8. Also called **Four′ Horse′men.**

Four′ Hun′dred, the exclusive social set of a city or area. Also, **400.** [1885–90, *Amer.;* allegedly after the capacity of the ballroom in the mansion of Mrs. William Astor, New York hostess of the late 19th century]

four′-hun·dred-day′ clock′ (fôr′hun′drəd dā′, fōr′-), a clock that needs to be wound once a year, having the works exposed under a glass dome and utilizing a torsion pendulum.

401(k) (fôr′ō′wun′kā′, fōr′-), *n.* a savings plan that allows employees to contribute a fixed amount of income to a retirement account and to defer taxes until withdrawal.

Fou·rier (fo͝or′ē ā′, -ē ər; *for 1, 2 also Fr.* fo͞o ryā′), *n.* **1. Fran·çois Ma·rie Charles** (fräN swA′ mA rē′ sharl), 1772–1837, French socialist, writer, and reformer. **2. Jean Bap·tiste Jo·seph** (zhäN bA tēst′ zhô zef′), 1768–1830, French mathematician and physicist. **3.** a crater in the third quadrant of the face of the moon: about 36 miles (58 km) in diameter.

Fou′rier anal′ysis, *Physics, Math.* **1.** the expression of any periodic function as a sum of sine and cosine functions, as in an electromagnetic wave function. Cf. **Fourier series. 2.** See **harmonic analysis.** [1925–30; named after J.B.J. FOURIER]

Fou·ri·er·ism (fo͝or′ē ə riz′əm), *n.* the social system proposed by François Marie Charles Fourier, under which society was to be organized into phalanxes or associations, each large enough for all industrial and social requirements. [1835–45; < F *fouriérisme.* See FOURIER, -ISM] **—Fou′ri·er·ist, Fou·ri·er·ite** (fo͝or′ē. ə rīt′), *n.* **—Fou′ri·er·is′tic,** *adj.*

Fou′rier se′ries, *Math.* an infinite series that involves linear combinations of sines and cosines and approximates a given function on a specified domain. [1875–80; see FOURIER ANALYSIS]

Fou′rier trans′form, *Math.* a mapping of a function, as a signal, that is defined in one domain, as space or time, into another domain, as wavelength or frequency, where the function is represented in terms of sines and cosines. [1920–25; see FOURIER ANALYSIS]

four-in-hand (fôr′in hand′, fōr′-), *n.* **1.** a long necktie to be tied in a slipknot with the ends left hanging. **2.** a vehicle drawn by four horses and driven by one person. **3.** a team of four horses. **—***adj.* **4.** of or pertaining to a four-in-hand. [1785–95]

four-lane (fôr′lān′, fōr′-), *adj.* **1.** (of a highway) having two lanes for traffic in each direction: *a four-lane thruway.* **—***n.* **2.** Also, **four-lan·er** (fôr′lā′nər, fōr′-). a four-lane highwa

four′-leaf clo′ver, a clover leaf having four leaflets instead of the usual three, purported to bring good luck. [1840–50]

four-leg·ged (fôr′leg′id, -legd′, fōr′-), *adj.* **1.** having four legs. **2.** *Naut.* (of a schooner) having four masts. [1655–65]

four′-let·ter word′ (fôr′let′ər, fōr′-), **1.** any of a number of short words, usually of four letters, considered offensive or vulgar because of their reference to excrement or sex. **2.** any word, typically of four letters, that represents something forbidden, disliked, or regarded with extreme distaste: *In the dieter's vocabulary, "cake" is a four-letter word.* [1925–30]

four-mast·ed (fôr′mas′tid, -mä′stid, fōr′-), *adj. Naut.* carrying four masts.

four′-masted brig′, *Naut.* See **jackass bark** (def. 2).

Four′ Moderniza′tions, goals of the political leadership in China after the death of Mao Zedong: modernization of agriculture, industry, national defense, and science and technology. [trans. of Chin *sìge xiàndài-huà*]

Four′ No′ble Truths′, the doctrines of Buddha: all life is suffering, the cause of suffering is ignorant desire, this desire can be destroyed, the means to this is the Eightfold Path.

four-o'clock (fôr′ə klok′, fōr′-), *n.* **1.** a common garden plant, *Mirabilis jalapa,* of the four-o'clock family, having tubular red, white, yellow, or variegated flowers that open late in the afternoon. **2.** any plant of the same genus. [1750–60]

four′-o'clock fam′ily, the plant family Nyctaginaceae, characterized by chiefly tropical herbaceous plants and shrubs having colored, petallike bracts beneath petalless flowers and winged or grooved dry fruit, and including the bougainvillea and four-o'clock.

four′ of a kind′, *Poker.* a set of four cards of the same denominations. [1930–35]

four old cat (fôr′ ə kat′, fōr′), *Games.* three old cat played with four batters. Also, **four′ o'cat′, four-a-cat.** [1850–55]

four-on-the-floor (fôr′on *th*ə flôr′, fōr′on *th*ə flōr′, -ôn-), *Auto.* *n.* **1.** a four-speed manual transmission having the gearshift set into the floor. **—***adj.* **2.** of or pertaining to such a transmission.

four′-part har′mony (fôr′pärt′, fōr′-), harmony in which each chord has four tones, creating, in sum, four melodic lines.

four·pence (fôr′pəns, fōr′-), *n. Brit.* a sum of money worth four English pennies. [1715–25; FOUR + PENCE]

four·pen·ny (fôr′pen′ē, -pə nē, fōr′-), *adj.* **1.** *Carpentry.* **a.** noting a nail 1¼ in. (3.8 cm) long. **b.** noting certain fine nails 1⅜ in. (3.5 cm) long. *Symbol:* 4d **2.** *Brit.* of the amount or value of fourpence. [1375–1425; late ME. See FOUR, -PENNY]

four·plex (fôr′pleks, fōr′-), *n. Archit.* quadplex. [1970–75; FOUR + *-plex,* abstracted from DUPLEX (APARTMENT), in place of QUADRUPLEX]

four-post·er (fôr′pō′stər, fōr′-), *n.* **1.** a bed with four corner posts, as for supporting a canopy, curtains, etc. **2.** a four-masted sailing vessel. [1815–25; FOUR + POST[1] + -ER[1]]

four′ ques′tions, *Judaism.* the four questions about the significance of the Seder service, traditionally asked at the Passover Seder by the youngest person and answered by the reading of the Haggadah.

four·ra·gère (fo͝or′ə zhâr′; *Fr.* fo͞o RA zhER′), *n., pl.* **-gères** (-zhârz′; *Fr.* -zhER′). (in French and U.S. military use) **1.** an ornament of cord worn on the shoulder. **2.** such a cord awarded as an honorary decoration, as to members of a regiment. [1915–20; < F]

fourragère (def. 1)

four′-rowed bar′ley (fôr′rōd′, fōr′-), a class of barley having, in each spike, six rows of grain, with two pairs of rows overlapping. [1880–85]

four·score (fôr′skôr′, fōr′skōr′), *adj.* four times twenty; eighty. [1200–50; ME; see FOUR, SCORE]

four·some (fôr′səm, fōr′-), *n.* **1.** a company or set of four; two couples; a quartet: *to make up a foursome for bridge.* **2.** *Golf.* **a.** a match between two pairs of players, each of whom plays his or her own ball. **b.** Also called **Scotch foursome.** a match between two pairs of players, in which each pair plays one ball and partners stroke alternately. **—***adj.* **3.** consisting of four persons, things, etc.; performed by or requiring four persons. [1540–50; FOUR + -SOME[2]]

four-spot (fôr′spot′, fōr′-), *n.* a playing card or the upward face of a die bearing four pips; a domino, one half of which bears four pips. [1875–80]

four·square (fôr′skwâr′, fōr′-), *adj.* **1.** consisting of four corners and four right angles; square: *a solid, four-square building.* **2.** firm; steady; unswerving: *He maintained a foursquare position in the controversy.* **3.** forthright; frank; blunt: *a foursquare presentation of the*

CONCISE PRONUNCIATION KEY: act, cāpe, dâre, pärt; set, ēqual; if, īce; ox, ōver, ôrder, oil, bo͝ok, bo͞ot, out; up, ûrge; child; sing; shoe; thin, *th*at; zh as in *treasure.* ə = a as in *alone,* e as in *system,* i as in *easily,* o as in *gallop,* u as in *circus;* ᵊ as in *fire* (fīᵊr), *hour* (ouᵊr). l and n can serve as syllabic consonants, as in *cradle* (krād′l), and *button* (but′n). See the full key inside the front cover.

EXHIBIT R

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. COOLPAD TECHNOLOGIES, INC. AND YULONG COMPUTER COMMUNICATIONS, Defendants.	Case No. 3:18-cv-01783-CAB-BLM [LEAD CASE]
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. HUAWEI DEVICE (DONGGUAN) CO., LTD., HUAWEI DEVICE (SHENZHEN) CO., LTD., and HUAWEI DEVICE USA, INC., Defendants.	Case No. 3:18-cv-01784-CAB-BLM

BELL NORTHERN RESEARCH, LLC, Plaintiff, v. KYOCERA CORPORATION and KYOCERA INTERNATIONAL INC., Defendants.	Case No. 3:18-cv-01785-CAB-BLM
BELL NORTHERN RESEARCH, LLC, Plaintiff, v. ZTE CORPORATION, ZTE (USA) INC., ZTE (TX) INC., Defendants.	Case No. 3:18-cv-01786-CAB-BLM

REBUTTAL DECLARATION OF JONATHAN WELLS, PH.D.

I. INTRODUCTION

1. My name is Dr. Jonathan Andrew Wells. I have been retained on behalf of Defendants Huawei Device (Dongguan) Co., Ltd., Huawei Device (Shenzhen) Co., Ltd., and Huawei Device USA, Inc. ("Huawei Defendants") to opine on and provide expert testimony related to: (i) United States Patent No. 7,990,842 ("the '842 patent") (attached to my Opening Declaration as Exhibit B) and (ii) U.S. Patent No. 6,941,156 ("the '156 patent") (attached to my Opening Declaration as Exhibit C). I understand that my opinions and expert testimony are also relevant to proceedings involving one or more of these two patents with respect to Defendants Coolpad Technologies, Inc. and Yulong Computer Communications ("Coolpad Defendants"); Kyocera Corporation and Kyocera International Inc. ("Kyocera Defendants) and ZTE Corporation, ZTE (USA) Inc., and ZTE (TX) Inc. ("ZTE Defendants"), whose cases have been consolidated with the Huawei Defendants for claim construction purposes.

2. On May 1, 2019, I provided a declaration (the "Opening Declaration"), which I understand was served on the Plaintiff Bell Northern Research, LLC ("BNR") in this case. The Opening Declaration set forth the basis and reasons for my opinions from the perspective of an expert in the relevant field of the patents it addressed, and was based on the information available and known to me as of its date. I incorporate herein and refer to my Opening Declaration, as well as the Exhibits thereto, within this Rebuttal Declaration.

3. I understand that, on May 1, 2019, Dr. Vijay K. Madisetti submitted a declaration in support of BNR's claim construction positions. I also understand that, on May 2, 2019, Dr. Madisetti submitted an amended declaration (the "Madisetti Declaration") in support of BNR's claim constructions, which appears to mirror in substance the opinions set forth in the declaration submitted by Dr. Madisetti on May 1, 2019.

4. I submit this Rebuttal Declaration to respond to the opinions set forth in the Madisetti Declaration.

II. U.S. PATENT NO. 7,990,842

A. "Inverse Fourier transformer" (Claim 1)

5. It is my understanding that BNR proposes that this term be given its plain and ordinary meaning, or in the alternative, proposes that this term be construed as "circuit and/or software that at least performs an inverse Fourier transform."

6. Although I was not asked to provide opinions as to this term in my opening declaration, after having reviewed the Madisetti Declaration and the arguments set forth in support of BNR's proposed construction, it is my opinion that BNR's proposal fails to inform a person of skill in the art ("POSITA") of the scope or boundaries of the term, and fails to provide clarity to the jury.

7. In the Madisetti Declaration, Dr. Madisetti states that "Fourier and inverse Fourier transforms map one domain to another, it [is] a generally mathematical concept with broad applicability." Madisetti Decl. ¶ 192. Dr. Madisetti relies on this statement to conclude that "Defendants' proposed construction erroneously restricts the inverse Fourier transform to time and frequency domains, which is not required by the claim language." *Id.* Dr. Madisetti also states: "Fourier transform operates in one-dimension or in multiple-dimensions to map functions between one domain and another domain. These domains can include, but are not limited to, space, time, frequency, or another variable." *Id.* at ¶ 187.

8. Dr. Madisetti is wrong in suggesting that the Inverse Fourier transformer of the '842 patent can map between all of the domains he implies. Although the Fourier transform ***could*** map one domain to another in a broad mathematical sense, this interpretation—and BNR's associated construction—is overly broad in the context of the '842 patent.

9. In wireless communications, which is the field of art for the '842 patent, the Fourier transform operates specifically to map between the time domain and frequency domain. *See* Opening Decl. ¶ 36. Dr. Madisetti cites page 6 of a publication titled *The Fourier Transform and its Applications*. Madisetti Decl. at ¶ 187. At page 8 of that publication, it discusses use of the Fourier transform in circuits to convert between waveforms and spectrums—i.e., between time and frequency domain signals. *See* Exhibit F (Ronald N. Bracewell, *The Fourier Transform and its Application*, 8-10 (3rd ed. 2000) (stating, *e.g.*, "[a] circuit expert finds it obvious that every waveform has a

spectrum"). I further note that the '842 patent regards a "signal generating circuit." '842 patent at Abstract. Similarly, Claim 1 relates to a "signal generator." '842 patent at Claim 1.

10. Moreover, the '842 patent describes the Fourier transform and the inverse Fourier transform exclusively in terms of the time and frequency domains. *See id.* at 4:19-27, 4:30-5:13. The '842 patent does not refer to any "domains" other than the "time domain" or the "frequency domain."

11. I also disagree with Dr. Madisetti's statement that "there is no specific direction for the transform required by the claims." Madisetti Decl. ¶ 192. Dr. Madisetti relies on this statement to conclude that "there is no basis to restrict the inverse Fourier operation to transforming signals from the frequency domain into the time domain." *Id.* However, the '842 patent specifically describes that the fast Fourier transform (FFT) (which is a specific algorithmic implementation of a Fourier transform) converts time domain signals into frequency domain signals. *See also id. at* 4:53-55 ("Inverse Fourier Transform 206 may be an inverse Fast Fourier Transform (IFFT) or Inverse Discrete Fourier Transform (IDFT)."). For example, the '842 specification teaches:

> FIG. 3 is a schematic block diagram of a processor that is configured to process an expanded long training sequence. Processor 300 includes a symbol demapper 302, a frequency domain window 304, a fast Fourier transform (FFT) module 306, a parallel to serial module 308, a digital receiver filter and/or time domain window module 310, and analog to digital converters (A/D) 312. A/D converters 312 convert the sequence into digital signals that are filtered via digital receiver filter 310. Parallel to serial module 308 converts the digital time domain signals into a plurality of serial time domain signals. ***FFT module 306 converts the serial time domain signals into frequency domain signals***. Frequency domain window 304 applies a weighting factor on each frequency domain signal. Symbol demapper 302 generates the coded bits from each of the 64 subcarriers of an OFDM sequence received from the frequency domain window.

Id. at 4:65-5:13 (emphasis added). This indicates that the inverse fast Fourier transform (IFFT) converts frequency domain signals into time domain signals. *See* '842 patent at 4:30-5:13 (describing a "frequency domain window" before an IFFT, and a "time domain window module" after); *see also* Madisetti Decl. at ¶ 187 ("An inverse Fourier transform is the reverse of a Fourier transform.").

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Dated: May 8, 2019

Jonathan Wells, Ph.D.

EXHIBIT S

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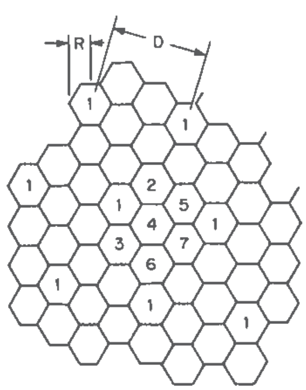
of channels, traffic variables, and the effectiveness of propagation-enhancement techniques. For purposes of explanation, we will temporarily disregard cell size. A typical area divided into cells is shown in Fig. I.2. Each block of seven cells is repeated in such a manner that corresponding numbered cells in adjacent seven-cell blocks are located at a predetermined distance from the nearest cell having the same number. Correspondingly, the 20-MHz-bandwidth radio spectrum is divided into seven disjoint sets, with a different set allocated to each one of the seven cells in the basic block. With a total of 333 channels in 21 sets available, it is possible to assign as many as three sets to each of the seven cells constituting the basic block pattern.

For blanket coverage of cell areas, each cell site is installed at the center of the cell (the dotted-line cell) and covers the whole cell, as shown in Fig. I.3. There is another way of looking at the locations of the cell sites. The three cell sites are installed, one at each alternate corner of the cell and cover the whole cell, as shown in Fig. I.3. In both cases, although the boundary of a cell is defined differently, the cell sites do not need to be moved. For convenience, the cells illustrated in Fig. I.3 are pictured as hexagonal in shape. In actual practice, the cell boundaries are defined by the minimum required signal strength at distances determined by the reception threshold limits. In the AMPS, base stations are referred to as cell sites because they perform supervision and control in addition to the transmitting and receiving functions normally associated with the conventional base station. Mobile-telephone subscribers within a given cell are assigned to a particular cell site serving that cell simply by the



$$K = \frac{(D/R)^2}{3}$$

Figure I.2 Basic cell block: R = radius of each cell; D = distance between two adjacent frequency-reuse cells; K = number of cells in a basic cell block. $K = 7$ in this illustration, and $D/R = 4.6$.

assignment of an idle channel frequency under the control of the mobile-telephone switching office (MTSO). When a mobile unit crosses a cell boundary, as determined by the signal reception threshold limits, a new idle channel frequency is assigned by the new serving cell site. This automatic switching control function is referred to as a "handoff."

The problems of cochannel interference are avoided by ensuring a minimum distance between base stations using the same channel frequencies, and by enhancing signal level and reducing signal fading through the use of diversity schemes. These constraints limit any potential cochannel interference to levels low enough to be compatible with the transmission quality of landline networks.

Two forms of diversity are used to enhance radio propagation, thus improving AMPS cell coverage. These are defined as "macroscopic" and "microscopic" diversity. Macroscopic diversity compensates for large-scale variations in the received signal resulting from obstacles and large deviations in terrain profile between the cell site and the mobile-telephone subscriber. Macroscopic diversity is obtained by installing directional antennas, one for each sector of three sectors at the cell center, or installing at the alternate corners of cells, as shown in Fig. I.3, and transferring control to the antenna providing the strongest average signal from the mobile subscriber in any given time interval. For example, the three cell-site transmitters serving a particular cell area would not radiate simultaneously on an assigned channel frequency. On the basis of a computer analysis of the signals received from the mobile subscriber at each of the three sites, the one with the strongest

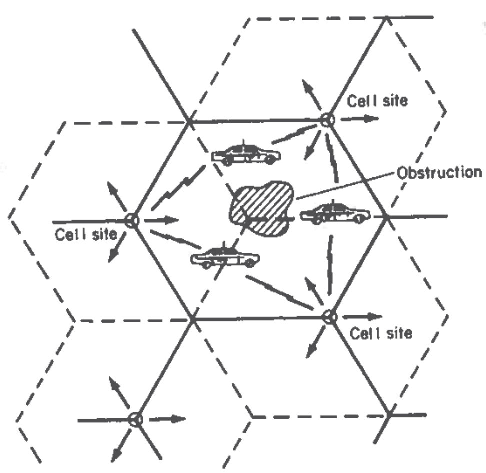


Figure I.3 Use of inward-directed antennas at alternate cell corners to achieve macroscopic diversity with respect to large obstructions.

signal would be selected for use as the serving cell site. Periodic analysis of channels in use would determine the necessity for handoff to a new sector in a cell or an alternate cell site within the cell area (intrahandoff), or handoff to a cell site in an adjacent cell area (interhandoff). All of these decisions would be made automatically without the knowledge or intervention of the user or the operator, and without interruption of the call in progress.

Microscopic diversity compensates for fast variations in the received signal resulting from multipath fading. Microscopic diversity is obtained by receiving dual inputs at both the mobile and cell-site receivers. These dual inputs can be two different frequencies, time slots, antennas, polarizations, etc. The diversity schemes associated with the combining techniques are described in subsequent chapters of this book.

Switch planning The cellular mobile-radiotelephone system can be expected to accommodate the growth of new subscribers in two ways. First, not all of the channels allocated to a cell are initially placed into service. As the numbers of mobile subscribers increase and the traffic intensity increases, transmission facilities for the additional channels are modularly expanded to keep pace with the demand. Second, as the number of channels per cell site approaches the maximum within the channel allocation plan, the area of individual cells can be reduced, thus permitting more cells to be created with less physical separation but with increased reuse of assigned channel frequencies. This reconfiguration of the cellular network permits the same number of assigned channels to adequately serve greater numbers of mobile units within a greater number of smaller cells. The ideal, customized cellular network would not be uniformly divided into cells of equal size but would contain cells of different sizes based on the density of mobile units within the various cell coverage areas. The concept of variable cell size is illustrated in Fig. I.4.

The interface between land mobile units and the commercial telephone landline network is illustrated in Fig. I.5. A call originating from or terminating at a mobile unit is serviced by a cell site connected via landlines to a mobile-telephone switching office (MTSO). The MTSO provides call supervision and control, and extends call access to a commercial telephone landline network via a local central-office (CO) telephone exchange, a toll office, and any number of tandem offices required to complete the call path. The terminating central office completes the connection to the called subscriber at the distant location. Two types of mobile-radio channels are used in setting up a call: paging channels and communication channels. The mobile unit is designed to automatically tune to the strongest paging channel in its local area for continuous monitoring, and to automatically switch to another paging channel when approaching the threshold transition level of reception.

Chapter

1

The Mobile-Radio Signal Environment

1.1 The Mobile-Radio Communication Medium

Radio signals transmitted from a mobile-radio base station are not only subject to the same significant propagation-path losses that are encountered in other types of atmospheric propagations, but are also subject to the path-loss effects of terrestrial propagation. Terrestrial losses are greatly affected by the general topography of the terrain. The low mobile-antenna height, usually very close to ground level, contributes to this additional propagation-path loss. In general, the texture and roughness of the terrain tend to dissipate propagated energy, reducing the received signal strength at the mobile unit and also at the base station. Losses of this type, combined with free-space losses, collectively make up the propagation-path loss.

Mobile-radio signals are also affected by various types of scattering and multipath phenomena—which can cause severe signal fading—attributable to the mobile-radio communications medium. Mobile-radio signal fading compounds the effects of long-term fading and short-term fading, which can be separated statistically and are described in Chap. 3. Long-term fading is typically caused by relatively small-scale variations in topography along the propagation path. Short-term fading is typically caused by the reflectivity of various types of signal scatterers, both stationary and moving. Fading of this kind is referred to as "multipath" fading.

Propagation between a mobile unit and a base station is most susceptible to the effects of multipath fading phenomena, because all communication is essentially at ground level. The effects of multipath phenomena are not significant in air-to-ground and satellite-to-earth-station communications, because the angle of propagation precludes most types of interference caused by surrounding natural land features and man-made structures. The major concern in air-to-ground communication is the Doppler effect resulting from the relatively high flying speed of the communicating aircraft. The important considerations in satellite-to-earth-station communication are direct-path attenuation in space, which severely reduces the level of received signals; the signal delay time resulting from the long-distance up-down transit; and the requirement for highly directional earth-station antennas capable of tracking the satellite beacon.

Generally speaking, the signal strength of a signal transmitted from a base station decreases with distance when measured at various points along a radial path leading away from the base station. Ideally, signal-strength measurements would be made by monitoring and recording the signal received by a mobile unit as it moves away from the base station along a radial route at a constant rate of speed. This measurement technique would be repeated over many different radial routes in order to obtain a significant number of readings that would enable statistical analysis of the overall zone of mobile-radio coverage for a particular base station. In actual practice, it is difficult to achieve the ideal conditions for signal-strength measurements, since existing roads must be used and traffic conditions determine the actual rate of travel, necessitating occasional stops along the way. For optimal radio-signal reception in the mobile-radio use area, both the base-station antenna and the mobile-unit antenna should be located at the highest available point along the propagation path. However, even under the most optimal siting conditions, there are often hills, trees, and various man-made structures and vehicles that can adversely affect the propagation of mobile-radio signals.

A typical graphic plot of the instantaneous signal strength of a received signal as a function of time, or of $s(t)$, is shown in Fig. 1.1(b). The starting time t corresponds to the starting point x_1 for route x, as shown in Fig. 1.1(a). The route x is called the mobile path. If it is possible for the speed V of the mobile unit to remain constant during the recording period, then $s(t)$ recorded on a time scale can be used for $s(x)$ by simply changing the time scale into a distance scale, where $x = Vt$. However, if the speed of the mobile unit varies during the recording period, then $s(t)$ must be velocity-weighted in order to obtain a true representation, as illustrated by $s(x)$ in Fig. 1.1(c). The graph of the instantaneous signal strength of a received signal as a function of distance, $s(x)$, from the base station along a particular route is used to calculate the path loss of that route, even though the graph of $s(t)$ is the actual raw data obtained from the field.

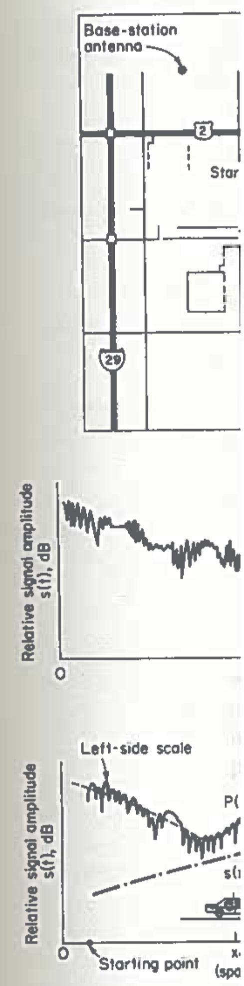


Figure 1.1 A typical rec
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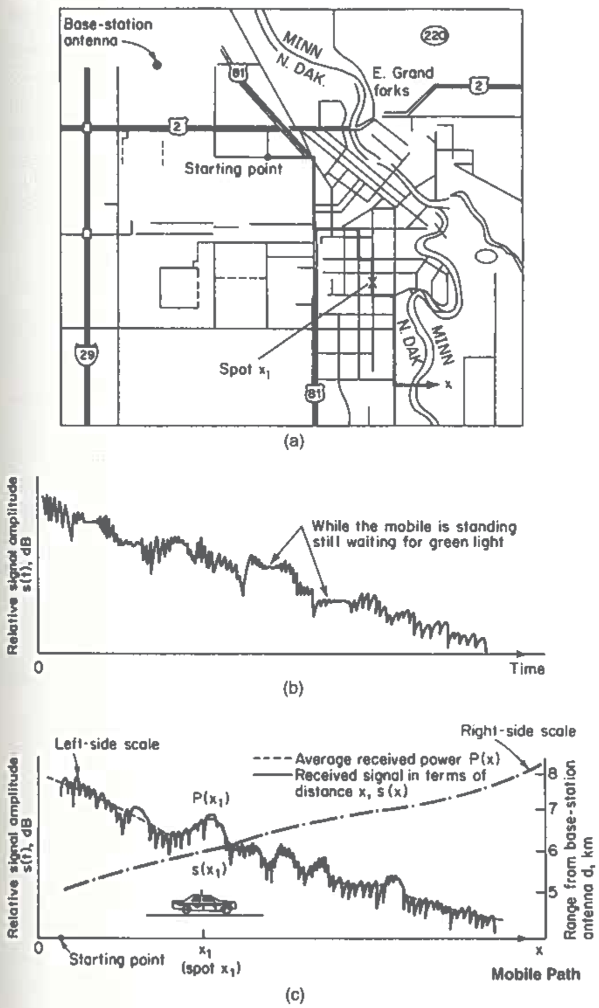

Figure 1.1 A typical record of data: (*a*) a typical navigator's map; (*b*) *s*(*t*) expressed on time scale; (*c*) *s*(*t*) expressed on distance scale.

Example 1.1 The following example illustrates the procedure for plotting *s*(*t*) from the signal data recorded as the mobile unit is in motion with respect to the base-station antenna. During the time when signal data are being recorded, a "wheel-tick" device is used to record the actual speed of the mobile unit on a corresponding time scale, as shown in Fig. E1.1.1, where distance is plotted on the *y* axis and time is plotted on the *x* axis.

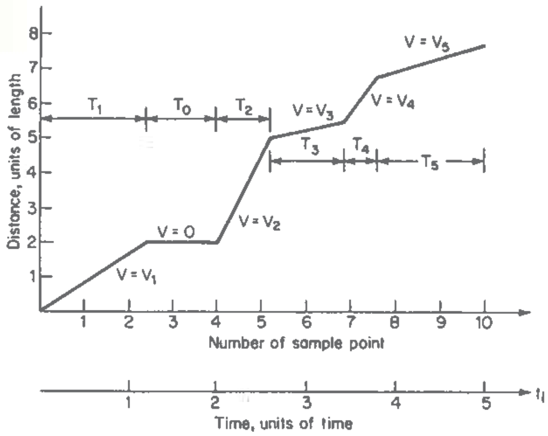

Figure E1.1.1 Sampling points in time corresponding to unequally spaced samples in length due to the variation of vehicular speed.

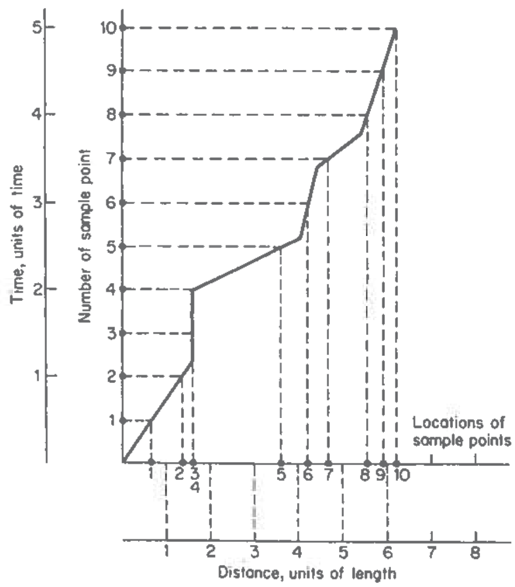

Figure E1.1.2 Converting sampling points from time frame to distance frame.

In the example shown in the figure, the mobile unit has recorded five different speeds and one complete stop. The y coordinate shows the distance of the mobile unit from the base-station antenna at any given time along the x coordinate. The correlation between sampling points in the time frame and those in the distance frame shows that the speed of the mobile unit was not constant throughout the period when measurements were being taken.

A different but related perspective is obtained from Fig. E1.1.2, where distance is plotted along the x axis and time along the y axis. Since the average field strength at each sampling point is the average of the field-strength measurements within the distance interval, the resultant plot shows that the distribution along the distance scale is not evenly distributed. It is therefore required that the engineer conducting the study determine that the distance intervals at which field-strength samples are recorded are consistent with the speed and motion characteristics of the mobile unit.

The measurements here were recorded at the mobile receiver as the mobile unit traveled from the starting point along a route x, as indicated on the map of Fig. 1.1(a). The dotted line in Fig. 1.1(c) represents the average power of the signal received at the mobile unit as a function of distance, or $P(x)$, for that particular path. In practice, the average received power at a distance x_1, $P(x_1)$, can be obtained directly, by averaging the instantaneous signal-strength measurements recorded within an interval of a certain length at a specified distance from the base station. The methods used to calculate the average received power and to determine the propagation-path loss at various radial distances along a path are described in greater detail in Chap. 3.

In the mobile-radio communications environment there are times when the mobile unit will be in motion, and other times when the mobile unit will be stationary. When the mobile unit is moving, it moves at various rates of speed and travels in various directions. As the mobile unit proceeds along its route, it passes many types of local scatterers, including numerous other vehicles in motion.

The presence of scatterers along the path constitutes a constantly changing environment that introduces many variables that can scatter, reflect, and dissipate the propagated mobile-radio signal energy. These effects often result in multiple signal paths that arrive at the receiving antenna displaced with respect to each other in time and space. When this happens, it has the effect of lengthening the time allotted to a discrete portion of the signal information and can cause signal smearing. This phenomenon is referred to as "delay spread." Also, the arrival of two closely spaced frequencies with different time-delay spreads can cause the statistical properties of the two multipath signals to be weakly correlated. The maximum frequency difference between frequencies having a strong potential for correlation is referred to as the "coherence bandwidth" of the mobile-radio transmission path. Coherence correlation then can be avoided by discretionary assignment of channel frequencies on the basis of fre-

Chapter

11

Signal Processes

11.1 Mobile-Radio-System Functional Design—Signaling Problems

Many of the problems commonly associated with the mobile-radio environment have already been discussed in the preceding chapters. To briefly summarize, the natural phenomena that result in excess path loss over that normally occurring as free-space path loss were discussed in Chaps. 3 and 4. Multipath fading and the effects of random FM were discussed in Chaps. 6 and 7. Improving signal reception by increasing transmitted power and/or transmission bandwidth was discussed in Chap. 8. The option of using diversity techniques instead of increasing the transmitted power to improve performance was discussed in Chap. 9. And finally, the techniques for improving performance through the use of diversity combining were described in Chap. 10. In this chapter, the problems encountered in sending and receiving both voice, which uses analog transmission, and control signals, which use digital data transmission, through the mobile-radio environment are discussed. By designing a waveform for the control signal, we can filter the voice and the control signal at the baseband.

Problems relating to signal transmission in the mobile-radio environment are usually associated with the variables of distance and vehicular velocity, the waveforms of the transmitted pulses, and the time-delay spread attributable to the mobile-transmission medium. These problem areas are briefly described in the following paragraphs.

Distance-dependency factors

In Sec. 8.3 of Chap. 8, the error rate was found to be a function of the carrier-to-noise ratio (cnr). The cnr is affected by the distance between the transmitting location and the receiving location. If the transmitted power remains fixed, the bit-error rate increases as the distance increases. The bit-error rate is also a function of the signaling rate. The Shannon channel-capacity formula can be used to verify that the bit-error rate will increase as the distance increases:

$$C = B \log_2 \left(1 + \frac{S_c}{N}\right) \tag{11.1}$$

where C is the maximum capacity for a given signaling rate, B is the transmission bandwidth, S_c is the carrier power, and N is the received noise.* To show that the bit-error rate increases as the signal rate decreases with distance, it is necessary to relate S_c in Eq. (11.1) to a function of distance. On the basis of Eq. (4.42), the received power as a function of distance can be expressed:

$$P_d = P_R + \gamma \log \frac{R}{d} \tag{11.2}$$

where R is a distance of 1 mi, P_R is the received power at the 1-mi intercept point, $\gamma = 38.4$ dB per decade is the slope of the path loss in a suburban area, and P_d is the received power of the signal carrier, or the S_c of Eq. (11.1). Hence, the channel capacity for the signaling rate is:

$$C = B \log_2 (1 + 10^{(P_d - 10 \log N)/10}) \tag{11.3}$$

Equation (11.3) indicates the dependency of the signaling rate on path distance and therefore can be used to determine the signaling rate.

Example 11.1. Given a power $P_R = -61.7$ dBm at the 1-mi intercept point, a slope of path loss of $\gamma = 38.4$ dB per decade, a bandwidth of 25 kHz, and a noise level of -120 dBm, what is the maximum signaling rate that can be used for a communications link of 10 mi?

solution The received power is derived from Eq. (11.2), as follows:

$$P_d = -61.7 - 38.4 = -100.1 \text{ dBm} \tag{E11.1.1}$$

To obtain the maximum signaling rate for a communications link of 10 mi, Eq. (11.3) is applied as follows:

$$C = 25 \times 10^3 \log_2 (1 + 10^{(-100.1 + 120)/10})$$
$$= 165.6 \text{ kb/s} \tag{E11.1.2}$$

* The Shannon channel-capacity formula is applied to a Gaussian noise channel. In the mobile-radio environment, the capacity should be less than Eq. (11.1) except in the case of a Rician-fading signal that approaches a Gaussian as its snr becomes large. Hence Eq. (11.1) serves as an upper limit. The channel capacity in Rayleigh fading environments appears in Sec. 17.1.

EXHIBIT T

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Vogel et al.

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(45) **Date of Patent: *Dec. 24, 2002**

(54) **APPARATUS FOR MEASURING THE DISTANCE BETWEEN A MOBILE STATION AND A BASE STATION IN A MOBILE RADIOCOMMUNICATIONS SYSTEM**

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(73) Assignee: **Alcatel**, Paris (FR)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(30) **Foreign Application Priority Data**

Oct. 27, 1997 (FR) 97 13434

(51) **Int. Cl.**[7] **H04M 7/20**
(52) **U.S. Cl.** **455/67.1**; 455/115
(58) **Field of Search** 455/67.1, 67.6, 455/63, 65, 33.1, 440, 422, 575, 562, 456, 423, 424, 67.3, 504–506, 272, 278.1, 296, 553, 458, 457, 463, 115, 324; 542/463, 149, 189, 152, 34, 417, 442, 386, 363, 450, 457, 464, 465

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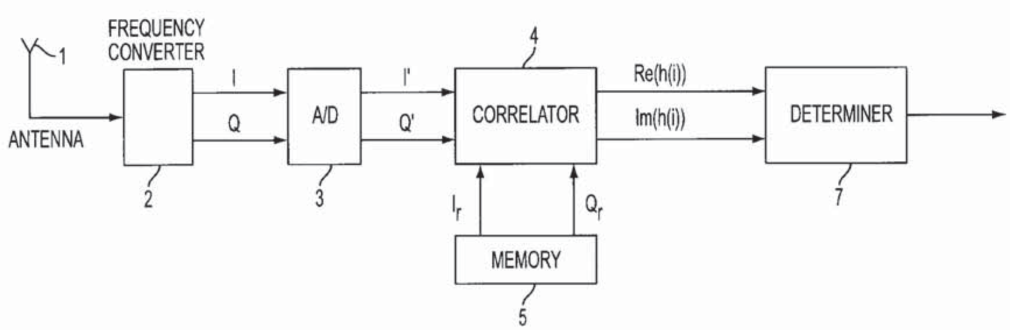
(57) **ABSTRACT**

Apparatus for measuring the distance between a mobile station and a base station in a mobile radio-communications system, the apparatus including a device for determining the reception instant at which the mobile station receives predetermined data transmitted by the base station, the circuit including a correlator for correlating an in-phase component and a quadrature component of a modulated signal received by the mobile station respectively with an in-phase component and a quadrature component of a reference signal generated in the mobile station and corresponding to the predetermined data, correlator delivering real components and imaginary components of correlation coefficients, and the apparatus being characterized in that it further includes a processor for using the real components and the imaginary components of the correlation coefficients to determine a complex magnitude whose phase varies continuously as a function of the reception instant.

8 Claims, 3 Drawing Sheets



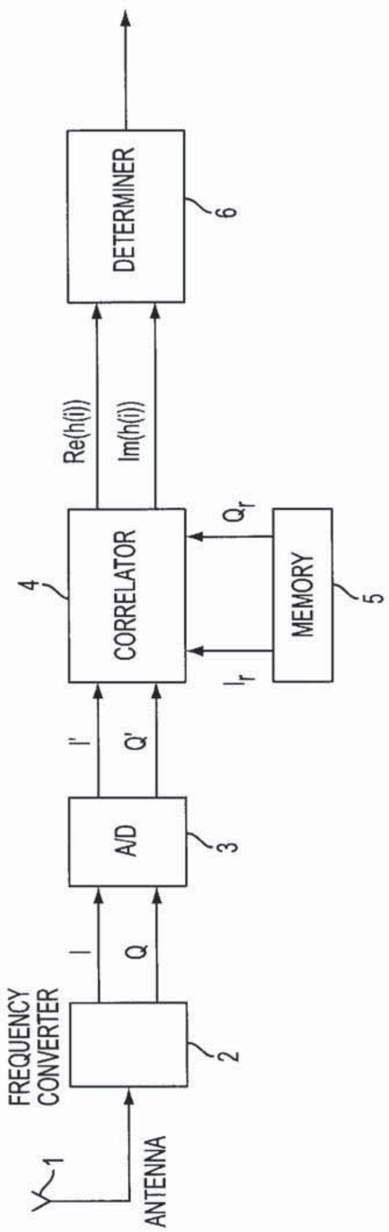


FIG. 1
(PRIOR ART)

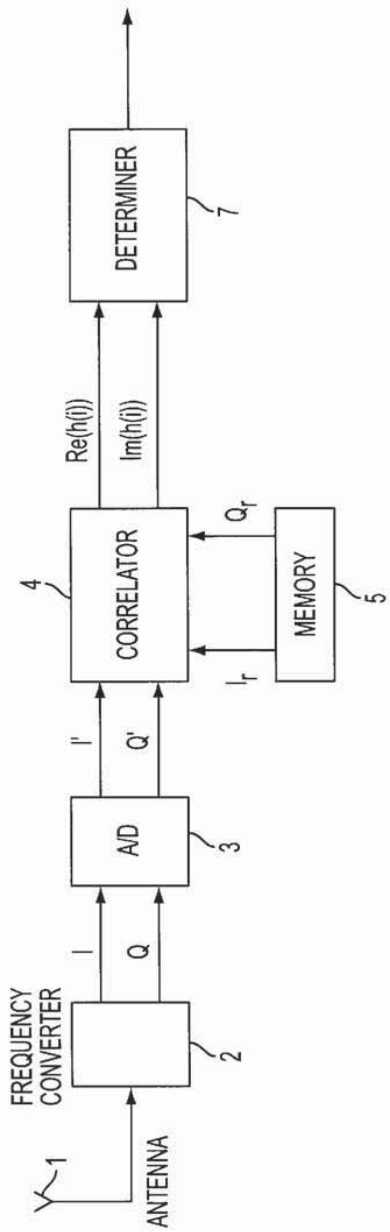


FIG. 3

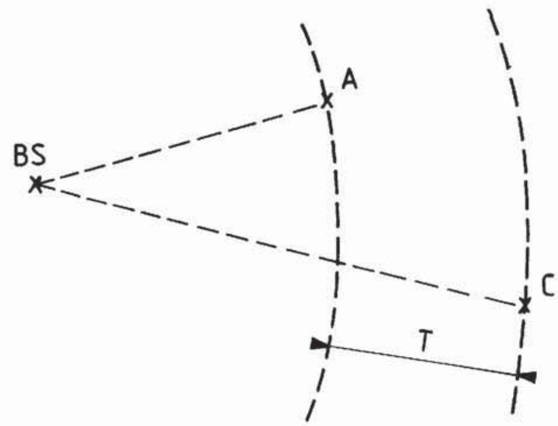


FIG_2a

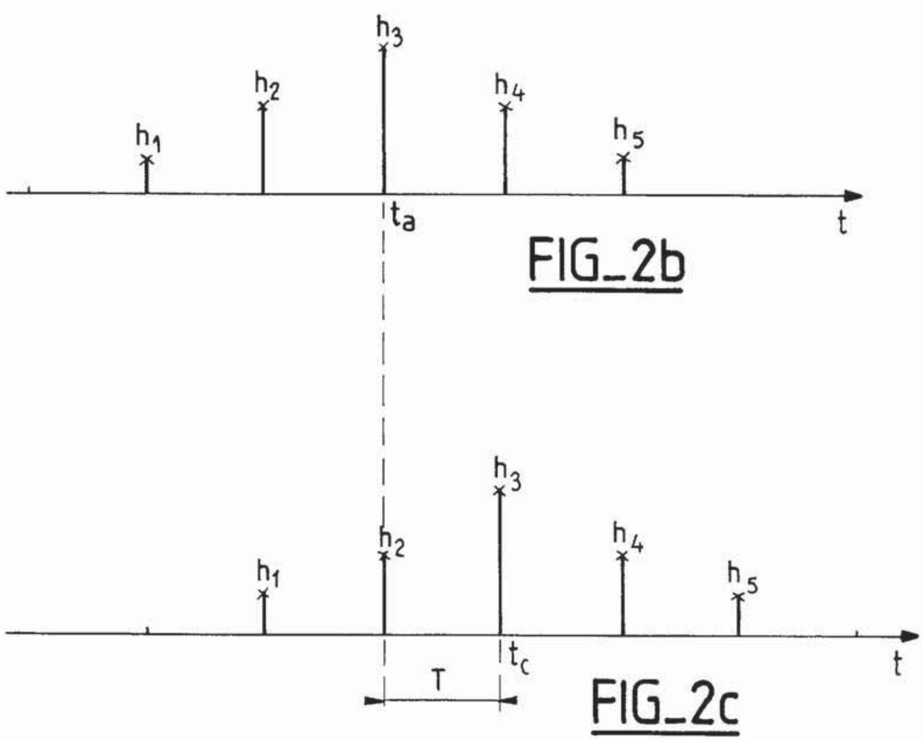


FIG_2b

FIG_2c

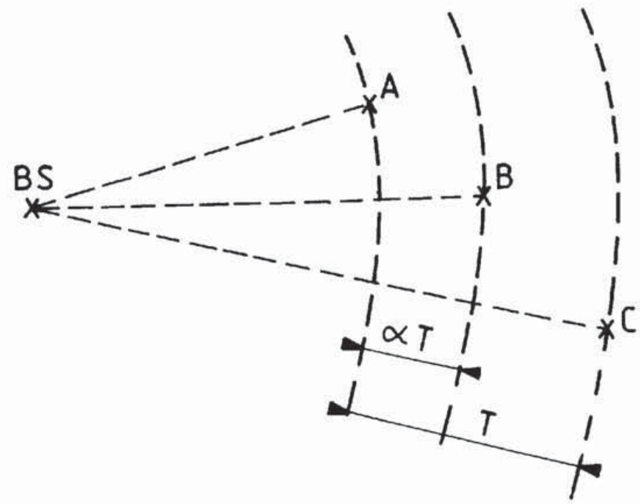


FIG_4a

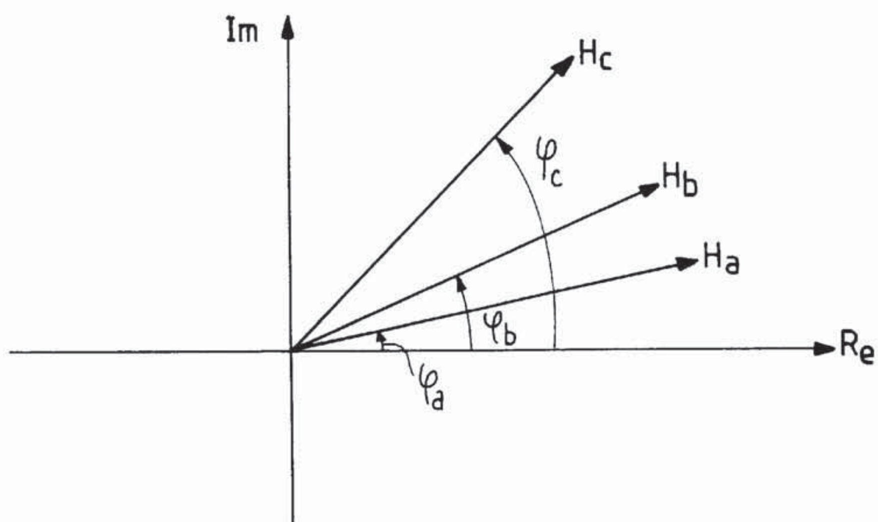


FIG_4b

APPARATUS FOR MEASURING THE DISTANCE BETWEEN A MOBILE STATION AND A BASE STATION IN A MOBILE RADIOCOMMUNICATIONS SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates generally to mobile radiocommunications systems.

The present invention relates more particularly to apparatus for measuring the distance, or the propagation time, between a mobile station and a base station in such a system.

Such knowledge of distance or of propagation time can be used for various purposes, such as the following, given by way of example:

- in a mobile radiocommunications system of the Time Division Multiple Access (TDMA) type, such as in particular the Global System for Mobile communications (GSM), such knowledge can be used for the purpose of determining the timing advance to be applied to information from the mobile station so as to enable said information to be received at the base station in that one of the time channels which has been allocated to said mobile station, regardless of the propagation time between said mobile station and said base station; and
- in a mobile radiocommunications system of the cellular type (also such as the above-mentioned GSM), such knowledge can be used for the purpose of controlling the transmission power of the mobile station as a function of the distance between it and the base station so as to reduce the overall interference level in the system, or else so as to locate the mobile station, e.g. by combining the result of such a measurement of the distance between the mobile station and a base station with the results of measurements of the distances between said mobile station and other base stations.

To determine the propagation time, or the distance, between a mobile station and a base station in a mobile radiocommunications system, it is known to be possible to determine the reception instant at which predetermined data transmitted by the base station is received by the mobile station, such predetermined data being, in particular, a "training sequence" (used in known manner to estimate the transmission channel prior to equalizing the signals received over said transmission channel). Once said reception instant has been determined, the base station can be informed of it, and, by comparing it with the transmission instant at which said data was transmitted, and also given that the mobile station is synchronized continuously on the base station, said base station can deduce the propagation time, i.e. the looked-for distance.

To determine such a reception instant at which the mobile station receives predetermined data, it is also known to be possible to correlate the modulated signal as received by the mobile station with a reference signal generated in the mobile station and corresponding to said predetermined data. In known manner, such correlation is performed on signals that have been sampled and digitized, and it involves performing similarity measurements on the two signals for various positions in time of one signal relative to the other, the positions being obtained by shifting the reference signal relative to the received signal by one sampling period each time. That one of the positions for which the similarity between the two signals is the greatest is thus representative of the reception instant at which the mobile station receives said predetermined data.

Using known methods, the accuracy of an instantaneous measurement of the propagation time cannot be better than the sampling period (or the accuracy of an instantaneous measurement of distance cannot be better than the product of the sampling period multiplied by the propagation speed of the signals). By way of example, for a mobile radiocommunications system such as the above-mentioned GSM, the accuracy of such a distance measurement is thus about one kilometer.

SUMMARY OF THE INVENTION

An object of the present invention is to improve that accuracy.

The present invention provides apparatus for measuring the distance between a mobile station and a base station in a mobile radiocommunications system, said apparatus including means for determining the reception instant at which the mobile station receives predetermined data transmitted by the base station, which means themselves include correlation means for correlating an in-phase component and a quadrature component of a modulated signal received by the mobile station respectively with an in-phase component and with a quadrature component of a reference signal generated in the mobile station and corresponding to said predetermined data, said correlation means delivering real components and imaginary components of correlation coefficients, and said apparatus being characterized in that it further includes means for using the real components and the imaginary components of the correlation coefficients to determine a complex magnitude whose phase varies continuously as a function of said reception instant.

The present invention further provides a mobile station including such means for measuring the reception instant at which the mobile station receives predetermined data transmitted by a base station in a mobile radiocommunications system.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and characteristics of the present invention appear on reading the following description of an embodiment given with reference to the accompanying drawings, in which:

FIG. **1** is a block diagram serving to recall the type of means to be provided in a mobile station in order to measure the distance between the mobile station and a base station in the prior art;

FIGS. **2***a*, **2***b*, and **2***c* are diagrams serving to recall the principle of such distance measurement in the prior art;

FIG. **3** is a block diagram serving to show the type of means to be provided in a mobile station in order to measure the distance between the mobile station and a base station in the invention; and

FIGS. **4***a* and **4***b* are diagrams serving to explain the principle of such distance measurement in the invention.

DETAILED DESCRIPTION OF THE INVENTION

The block diagram shown in FIG. **1** includes the following, in succession:

an antenna **1**;

- a frequency conversion stage **2** delivering, in known manner, two components, namely an in-phase component I and a quadrature component Q, of a modulated signal received by the mobile station via the antenna **1**;

an analog-to-digital converter **3** delivering components I' and Q' corresponding respectively to the components I and Q; and

a correlator **4** receiving the components I' and Q' corresponding to the modulated signal received by the mobile station, and also receiving an in-phase component I_r and a quadrature component Q_r corresponding to a reference signal generated in the mobile station and corresponding to predetermined data transmitted by the base station, the components I_r and Q_r being delivered by a memory **5** in this example.

The correlator **4** performs correlation on the in-phase components and correlation on the quadrature components, and it thus delivers two sets of coefficients, one of which is referenced Re(h(i)), the other one being referenced Im(h(i)), where i varies in the range 1 to k (where k designates the number of respective time positions considered of the received signal and of the reference signal), and Re(h(i)) and Im(h(i)) respectively designate the real component and the imaginary component of the correlation coefficient h(i).

The apparatus recalled in FIG. **1** further includes means **6** for determining which of the correlation coefficients h(i) is of greatest amplitude, the instant at which the coefficient is obtained thus being representative of the reception instant at which the mobile station receives said predetermined data. The base station can be informed of said reception instant, and, by comparing it with the transmission instant at which the data was transmitted, and also given that the mobile station is synchronized continuously on the base station, said base station can deduce the propagation time, i.e. the looked-for distance.

FIG. **2***b* shows an example of correlation coefficients h(i) obtained as a function of time t, the correlation coefficient of greatest amplitude (coefficient h_3 in this example) being obtained, in this example, at an instant t_a corresponding to a mobile station situated, as shown in FIG. **2***a*, at a point A.

FIG. **2***c* shows another example of correlation coefficients h(i) obtained as a function of time, the correlation coefficient of greatest amplitude (also coefficient h_3 in this example) being obtained, in this example, at an instant t_c corresponding to a mobile station situated, as shown in FIG. **2***a*, at a point C distant from point A by a distance corresponding to a propagation time difference equal to T (where T designates the sampling period).

In the prior art thus recalled, it is not possible to have access to a reception instant corresponding to a mobile station situated, as shown in FIG. **4***a*, at a point B distant from point A by a distance corresponding to a propagation time difference equal to αT (where $0<\alpha<1$), where T designates the sampling period.

With the present invention, it becomes possible to have access to such reception instants.

As shown in FIG. **3**, the apparatus of the invention differs from the apparatus shown in FIG. **1** in that, instead of including the means **6**, it includes means **7** for using the real components and the imaginary components of correlation coefficients h(i) to determine a complex magnitude whose phase varies continuously as a function of said reception instant. The correlation coefficients taken into account by the means **7** may be either all of the coefficients, or only the more significant components if some of them are of too small an amplitude.

By way of example, the real component of said complex magnitude may be equal to the sum of the real components of the correlation coefficients h(i) in question, and the imaginary component of said complex magnitude may be equal to the sum of the imaginary components of the correlation coefficients h(i) in question, said complex magnitude then being written as follows:

$$\sum_i \mathrm{Re}(h(i)) + j\cdot\sum_i \mathrm{Im}(h(i))$$

In another example, said complex magnitude may also be equal to the sum of the moduli of the complex coefficients h(i) in question, each multiplied by the complex value exp(j.i.π/2), said complex magnitude then being written as follows:

$$\sum_i |\mathrm{Re}(h(i)) + j\cdot \mathrm{Im}(h(i))|\cdot \exp\left(j\cdot i\cdot\frac{\pi}{2}\right)$$

In another example applicable to both of the above examples, said sums could also be weighted sums. In other examples, functions other than sums or weighted sums can be used provided that the phase of the resulting complex magnitude varies continuously as a function of said reception instant. The variation in said complex magnitude may take place in compliance with a function that is affine or linear.

Thus, in the complex plane shown in FIG. **4***b*, the vector H_a corresponding to the complex magnitude obtained for a mobile station located at point A forms an angle ϕ_a with the axis Re of the real values, the vector H_b corresponding to the complex magnitude obtained for a mobile station located at point B forms an angle ϕ_b with the axis of the real values, and the vector H_c corresponding to the complex magnitude obtained for a mobile station located at point C forms an angle ϕ_c with the axis of the real values, the angle ϕ (ϕ_a, ϕ_b, ϕ_c) being, for example, a linear function of the reception instant.

It is thus possible to have access to a reception instant corresponding to a mobile station situated, as shown in FIG. **4***a*, at a point B distant from point A by a distance corresponding to a propagation time difference is equal to α.T (where $0<\alpha<1$), where T designates the sampling period.

The present invention thus makes it possible to obtain accuracy better than the sampling period for measuring said reception instant at which the mobile station receives predetermined data, and thus for measuring the propagation time (or the distance) between the mobile station and the base station, this accuracy then being limited only by the quality of the received signals.

What is claimed is:

1. A method for measuring the distance between a mobile station and a base station in a mobile radio communications system, comprising:

receiving a modulated signal at said mobile station having in-phase components I and quadrature components Q;

converting said modulated signal to a received digital signal having received signal components including respective in-phase components I' and respective quadrature components Q';

obtaining predetermined components including in-phase reference components Ir and predetermined quadrature reference components Qr;

correlating said received signal components with said predetermined components to provide correlation coefficients h(i), where i varies in a range of 1 to k, and k designates a number of respective time positions with respect to said received digital signal;

determining from said correlation coefficients h(i) two sets of coefficients, including a set of real components Re(h(i)) and a set of imaginary components Im(h(i));

identifying one of said correlation coefficients h(i) having a greatest correlation;

determining a first distance value based on said one of said correlation coefficients h(i) having said greatest correlation;

defining a complex plane with real and imaginary axes;

defining a vector Ha corresponding to a complex magnitude with respect to said one of said correlation coefficients h(i) having said greatest correlation;

defining a vector Hb corresponding to a complex magnitude with respect to a mobile station;

determining an angle ϕa of said vector Ha with respect to said real axis;

determining an angle ϕb of said vector Hb with respect to said real axis as a function of said real components Re(h(i)) and said imaginary components (Im(h(i));

determining a distance increment relating to the difference between ϕa and ϕb; and

combining said distance increment with said first distance value to provide a final distance value representing said distance between said mobile station and said base station.

2. A method for measuring a distance between a mobile station and a base station in a mobile radio-communications system, comprising:

converting a received modulated signal, having in-phase components I and quadrature components Q, to a received digital signal having received signal components including respective in-phase components I' and respective quadrature components Q';

obtaining predetermined components including in-phase reference components Ir and quadrature reference components Qr;

correlating I and Q with Ir and Qr to provide correlation coefficients h(i), where i varies in a range of 1 to k, and k designates a number of respective time positions with respect to said received digital signal;

determining from h(i) a set of real components Re(h(i)) and a set of imaginary components Im(h(i));

determining a first distance value based on one of h(i) having a greatest correlation;

defining a vector Ha corresponding to a complex magnitude with respect to said one of h(i) having said greatest correlation, with an angle ϕa with respect to a real axis in a complex plane;

defining a vector Hb corresponding to a complex magnitude with respect to a mobile station, with an angle ϕb, with respect to said real axis, as a function of Re(h(i)) and Im(h(i));

modifying the first distance value based on a difference between ϕa and ϕb to provide a final distance value representing said distance between said mobile station and said base station.

3. The method for measuring the distance between the mobile station and the base station as set forth in claim **2**, wherein the modifying of the first distance value is performed as a function of the difference between ϕa and ϕb, the function being linear or affine.

4. A mobile station for a mobile radio communications system, comprising:

a signal analyzer for:

converting a received modulated signal, having in-phase components I and quadrature components Q, to a received digital signal having received signal components including respective in-phase components I' and respective quadrature components Q', and

obtaining predetermined components including in-phase reference components Ir and quadrature reference components Qr;

a correlator for:

correlating I and Q with Ir and Qr to provide correlation coefficients h(i), where i varies in a range of 1 to k, and k designates a number of respective time positions with respect to said received digital signal; and

determining from h(i) a set of real components Re(h(i)) and a set of imaginary components Im(h(i)); and

a coefficient processor for:

determining a first distance value based on one of h(i) having a greatest correlation,

defining a vector Ha corresponding to a complex magnitude with respect to said one of h(i) having said greatest correlation, with an angle ϕa with respect to a real axis in a complex plane,

defining a vector Hb corresponding to a complex magnitude with respect to a mobile station, with an angle ϕb, with respect to said real axis, as a function of Re(h(i)) and Im(h(i)), and

modifying the first distance value based on a difference between to provide a final distance value representing said distance between said mobile station and said base station.

5. The mobile station for a mobile radio communications system as set forth in claim **4**, wherein the coefficient processor modifies the first distance value as a function of the difference between ϕa and ϕb, the function being linear or affine.

6. A mobile station for a mobile radio communications system, comprising:

signal analysis means for:

converting a received modulated signal, having in-phase components I and quadrature components Q, to a received digital signal having received signal components including respective in-phase components I' and respective quadrature components Q', and

obtaining predetermined components including in-phase reference components Ir and quadrature reference components Qr;

correlation means for:

correlating I and Q with Ir and Qr to provide correlation coefficients h(i), where i varies in a range of 1 to k, and k designates a number of respective time positions with respect to said received digital signal, and

determining from h(i) a set of real components Re(h(i)) and a set of imaginary components Im(h(i)); and

coefficient processing means for:

determining a first distance value based on one of h(i) having a greatest correlation,

defining a vector Ha corresponding to a complex magnitude with respect to said one of h(i) having said greatest correlation, with an angle ϕa with respect to a real axis in a complex plane,

defining a vector Hb corresponding to a complex magnitude with respect to a mobile station, with an angle ϕb, with respect to said real axis, as a function of Re(h(i)) and Im(h(i)), and

modifying the first distance value based on a difference between to provide a final distance value representing said distance between said mobile station and said base station.

7. The mobile station for a mobile radio communications system as set forth in claim **6**, wherein the coefficient processor modifies the first distance value as a function of the difference between ϕa and ϕb, the function being linear or affine.

8. A method for measuring the distance between a mobile station and a base station in a mobile radio communications system, comprising:

converting a received modulated signal to a received digital signal having received signal components, including respective in-phase components and respective quadrature components;

obtaining predetermined reference components including in-phase reference components and predetermined quadrature reference components;

correlating said received signal and said predetermined reference components to provide correlation coefficients;

determining, from said correlation coefficients, a set of real components and a set of imaginary components;

determining a first distance value based on one of said correlation coefficients having a greatest correlation;

using the set of real components and the set of imaginary components to determine a complex magnitude, including:

determining an angle of a first vector corresponding to a complex magnitude with respect to said one of said correlation coefficients having said greatest correlation, with respect to a real axis of a complex plane;

defining an angle of a second vector corresponding to a complex magnitude with respect to a mobile station, with respect to said real axis, as a function of said sets of real and imaginary components;

determining a distance increment relating to the difference between said angles of said first and second vectors; and

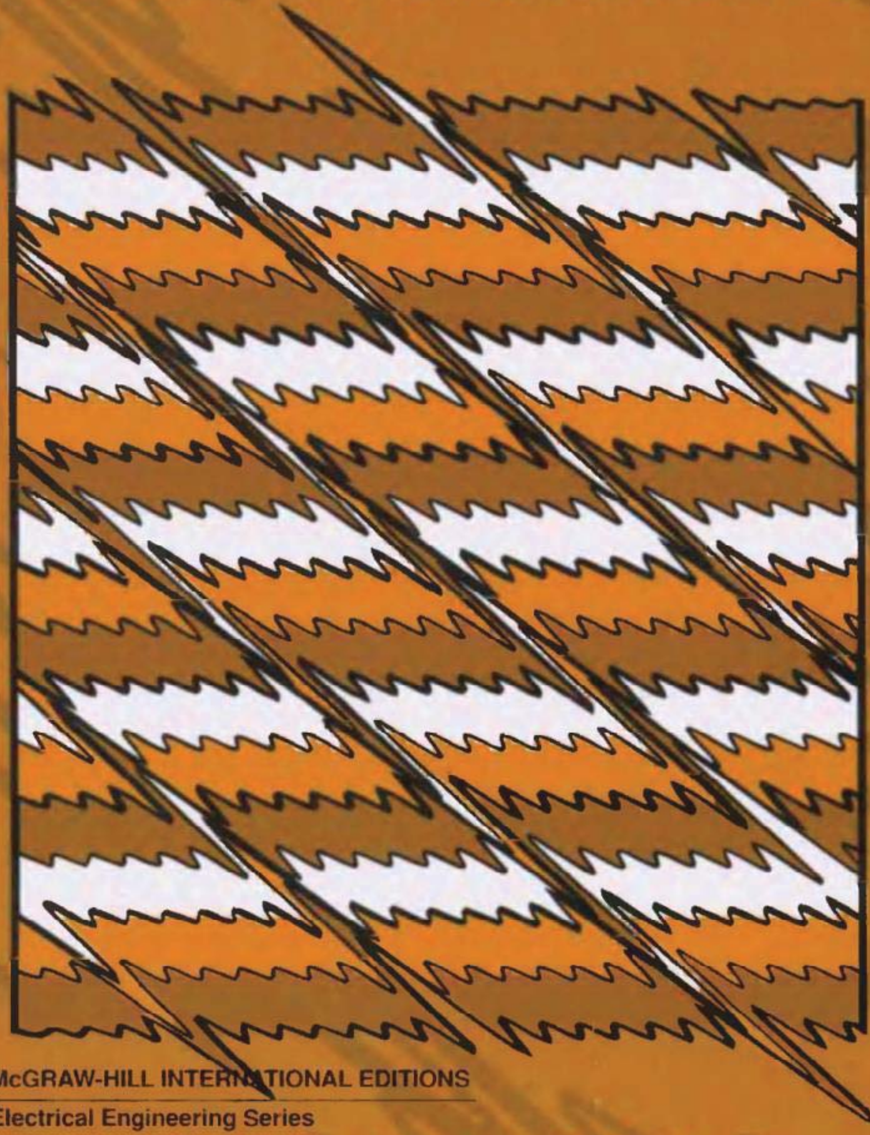
combining said distance increment with said first distance value to provide a final distance value representing said distance between said mobile station and said base station.

* * * * *

EXHIBIT U

THIRD EDITION

THE FOURIER TRANSFORM AND ITS APPLICATIONS



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2

Groundwork

Most of the material in this chapter is stated without proof. This is done because the proofs entail discussions that are lengthy (in fact, they form the bulk of conventional studies in Fourier theory) and remote from the subject matter of the present work.

Omitting the proofs enables us to take the transform formulas and their known conditions as our point of departure. Since suitable notation is an important part of the work, it too is set out in this chapter.

THE FOURIER TRANSFORM AND FOURIER'S INTEGRAL THEOREM

The Fourier transform of $f(x)$ is defined as

$$\int_{-\infty}^{\infty} f(x)e^{-i2\pi xs}\,dx.$$

This integral, which is a function of s, may be written $F(s)$. Transforming $F(s)$ by the same formula, we have

$$\int_{-\infty}^{\infty} f(s)e^{-i2\pi ws}\,ds.$$

When $F(x)$ is an even function of x, that is, when $f(x) = f(-x)$, the repeated transformation yields $f(w)$, the same function we began with. This is the cyclical property of the Fourier transformation, and since the cycle is of two steps, the reciprocal property is implied: if $F(s)$ is the Fourier transform of $f(x)$, then $f(x)$ is the Fourier transform of $F(s)$.

The cyclical and reciprocal properties are imperfect, however, because when $f(x)$ is odd—that is, when $f(x) = -f(-x)$—the repeated transformation yields

$f(-w)$. In general, whether $f(x)$ is even or odd or neither, repeated transformation yields $f(-w)$.

The customary formulas exhibiting the reversibility of the Fourier transformation are

$$F(s) = \int_{-\infty}^{\infty} f(x)e^{-i2\pi xs}\,dx$$

$$f(x) = \int_{-\infty}^{\infty} F(s)e^{i2\pi xs}\,ds.$$

In this form, two successive transformations are made to yield the original function. The second transformation, however, is not exactly the same as the first, and where it is necessary to distinguish between these two sorts of Fourier transform, we shall say that $F(s)$ is the minus-i transform of $f(x)$ and that $f(x)$ is the plus-i transform of $F(s)$.

Writing the two successive transformations as a repeated integral, we obtain the usual statement of Fourier's integral theorem:

$$f(x) = \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\infty} f(x)e^{-i2\pi xs}\,dx \right] e^{i2\pi xs}\,ds.$$

The conditions under which this is true are given in the next section, but it must be stated at once that where $f(x)$ is discontinuous the left-hand side should be replaced by $\frac{1}{2}[f(x+) + f(x-)]$, that is, by the mean of the unequal limits of $f(x)$ as x is approached from above and below.

The factor 2π appearing in the transform formulas may be lumped with s to yield the following version (system 2):

$$F(s) = \int_{-\infty}^{\infty} f(x)e^{-ixs}\,dx$$

$$f(x) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(s)e^{ixs}\,ds.$$

And for the sake of symmetry, authors occasionally write (system 3):

$$F(s) = \frac{1}{(2\pi)^{\frac{1}{2}}} \int_{-\infty}^{\infty} f(x)e^{-ixs}\,dx$$

$$f(x) = \frac{1}{(2\pi)^{\frac{1}{2}}} \int_{-\infty}^{\infty} F(s)e^{ixs}\,ds.$$

All three versions are in common use, but here we shall keep the 2π in the exponent (system 1). If $f(x)$ and $F(s)$ are a transform pair in system 1, then $f(x)$ and $F(s/2\pi)$ are a transform pair in system 2, and $[x/2\pi)^{\frac{1}{2}}]$ and $F(s/2\pi)^{\frac{1}{2}}]$ are a transform pair in system 3. An example of a transform pair in each of the three systems follows.

EXHIBIT V

Discrete Fourier Transform based Multimedia Colour Image Authentication for Wireless Communication (DFTMCIAWC)

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Abstract- **This paper presents a novel steganographic schemes based on Discrete Fourier Transformation (DFT) and demonstrates the multimedia colour image authentication process in frequency domain for wireless communication(DFTMCIAWC). Authentication is done through embedding secrete message/image into the transformed frequency components of the source image at message originating node. The DFT is applied on sub-image block called mask of size 2 x 2 in row major order where authenticating message/image bit is fabricated within the real frequency component of each source image byte except the first frequency component of each mask. In order to retain the quantum value positive and non fractional in spatial domain, a delicate re-adjustment phase is used in the first frequency component of each mask as a post embedding handler. Robustness is achieved through embedding secrete message/image into both positive and negatives frequency component of source image and invisibility is satisfied in spatial domain using delicate re-adjust phase. Inverse DFT (IDFT) is performed after embedding to transform embedded image from frequency domain to spatial domain and the embedded image is transmitted across the network. At the destination node authentication is done through extraction process of embedded image. Experimental results demonstrate that the proposed algorithm performs better than discrete cosine transformation and quaternion Fourier transformation based schemes, and provide security and originality of data in wireless domain.**

Keywords- **Discrete Fourier Transform based Multimedia Colour Image Authentication for Wireless Communication (DFTMCIAWC) quaternion Fourier transformation (QFT), DFT, IDFT**

I. INTRODUCTION

Message transmission via the internet suffers problems such as information security, copyright protection etc. Secured communication is possible with the help of encryption technique which is a disordered and confusing message that makes suspicious enough to eavesdroppers[19]. Without creating any special attention of attackers steganographic methods [1] overcome the problem by hiding the secrete information behind the source. Image authentication is needed to prevent unauthorized access in various e-commerce application areas which can be achieved by hiding data within the image. Data hiding [3, 7, 10] in the image has become an important technique for image authentication and identification. Therefore, military, medical and quality control images must be protected against attempts to manipulations during transmission across the wireless network. Digital image authentication [11] schemes mainly falls into two categories-spatial-domain and frequency-domain techniques. Digital image authentication technique has become a challenging research area focused on through wireless communication to prevent the unauthorised or illegal access and sharing. In wireless communication the probability the signal impairment is maximum than the wired communication due to noise integration within the source signal. And also prevent the signal attenuation is necessary in this communication technique to preserve original signal strength. As a result secrete data will be kept as it is.

Enormous works has been done in spatial-domain for digital image authentication. The most common methods Chandramouli et al. [5] developed a useful method by masking, filtering and transformations of the least significant bit (LSB) on the source image. Dumitrescu et al. [6] construct an algorithm for detecting LSB steganography. H. H. Pang [9] used hash value obtained from a file name and password and a position of header of hidden file is located. Pavan et al. [8] and N. N. EL-Emam [2] used entropy based technique for detecting the suitable areas in the image where data can be embedded with minimum distortion. Ker [12] and C. Yang [13] presented general structural steganalysis framework for embedding in two LSBs and Multiple LSBs. H.C. Wu [14] and C-H Yang [15] constructed LSB replacement method into the edge areas using pixel value differencing (PVD). All of the above techniques discussed may be implemented easily in wireless network using existing standard protocol.

Various works exist in frequency domain out of which most common are discrete cosine transformation (DCT), quaternion Fourier transformation (QFT), discrete Fourier transformation (DFT), discrete wavelet transformation (DWT), and the discrete Hadamard transformation (DHT). Here embedding is done in the frequency component of the image pixel in frequency domain. The human visual system is more sensitive to low frequency components than the high frequency component. To avoid severe distortion [19] of the original image the midrange frequencies are best suitable for embedding to obtain a balance between imperceptibility and robustness. I. Cox et al.'s [16, 17] algorithm inserts watermarks into the frequency components over all the pixels. N. Ahmidi et al. [18] used DCT based scheme where just noticeable difference profile to determine maximum amount of watermark signal that can be tolerated at each region in the image without degrading visual quality[4]. P. Bas et al. [20] developed a color image watermarking scheme using the hypercomplex numbers representation and the quaternion Fourier transformation. Vector watermarking schemes is developed by T. K. Tsui [21] using complex and quaternion Fourier transformation.

The proposed DFTMCIAWC emphasizes on information and image protection across the nodes of wireless network against unauthorized access in frequency domain to achieve a better tradeoff between robustness, perceptibility and in preserving the signal strength. This paper used discrete Fourier transformation to get frequency component of each pixel value and exploit embedding process invariant of positive or negative frequency component. The DFT of a spatial-domain value f(x, y) for the image size M x N is defined in equation 1 for frequency domain transformation.

$$F(u,v) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \qquad (1)$$

where u = 0 to M – 1 and v = 0 to N-1.

The variables u and v are the transform or frequency variables and x, y are the spatial or image variables and f(x, y)s are intensity values of pixels in spatial-domain. Similarly inverse discrete Fourier transformation (IDFT) is used to convert frequency component to the spatial-domain value, and is defined in equation 2 for transformation from frequency to spatial-domain.

$$f(x,y) = \frac{1}{\sqrt{MN}} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v)\, e^{j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \qquad (2)$$

where u = 0 to M – 1 and v = 0 to N-1.

This paper present a technique for image authentication by inserting large amount of messages/image along with message digest MD into the source image for image identification and also for secure message transmission within the image across various nodes. The insertion position is chosen using the mathematical formula s % k, where s is the position of image pixel and k is the number of available positions within each real frequency component from LSB where insertion can be made. The value of k varies from 2 to 8.

Problem motivation and formulation is given in section II. Section III of the paper deals with the proposed technique. Results, comparison and analysis are given in section IV. Conclusions are drawn in section V.

II. Motivation and Formulation of DFT and IDFT in DFTMCIAWC Technique

The main motivation of the authentication problem is to achieve a better tradeoff between robustness and perceptibility. Robustness can be achieved by increasing the strength of the embedded authenticating message/image without visible distortion. Many human visual system based watermarking have been invented. Small portion of them are designed for colour images. These are not so robust for embedding large amount of information without image quality distortion. This paper aims to exploit proper quantum value handling in frequency domain and embeds large amount of information. In this technique each time we have taken an image block of size 2 x 2 and applying DFT. Considering a mask of size 2 x 2 and the values are {a, b, c, d} from the source image. The formulation of a mask in DFT is as follows:- After DFT the frequency components for four image bytes are F(a) = ½ (a + b + c + d) = W (say), F(b) = ½ (a – b + c – d) = X (say), F(c) = ½ (a + b – c – d) = Y (say), and F(d) = ½ (a – b – c + d) = Z (say) for four a, b, c, and d spatial domain image bytes. Here W, X, Y, and Z are all frequency component for a, b, c, and d spatial domain values respectively and all imaginary components are zeros because the imaginary component is the multiple of Π (pi). Embedding is done on X, Y, Z but not on W because W is used as re-adjust phase to balance the quantum values between original and embedded data. The corresponding IDFT values are $F^{-1}(W)$ = ½ (W + X + Y + Z), $F^{-1}(X)$ = ½ (W – X + Y –Z), $F^{-1}(Y)$ = ½ (W + X –Y –Z), and $F^{-1}(Z)$ = ½ (W – X – Y + Z). After re-adjusting phase all IDFT values are non negative and without fractional values.

III. The Technique

DFTMCIAWC used 24 bit colour image in which each pixel is the composition of red (R), green (G) and blue (B) of each 8-bit image. It embeds authenticating message/image $AI_{p,q}$ of size 3*(p x q) bits along with 128 bits MD and dimension of authenticating message/image (32 bits) for the authentication of the source image $SI_{m,n}$ of size m x n bytes. 2 x 2 image block called mask is chosen from the source image matrix in row major order and transform it into frequency domain using equation 1. One bit of authenticating message/image is inserted into real part of each frequency component of source image block between 1st to 5th positions from LSB excluding the first frequency component of each image block to maintain the imperceptibility and robustness. The insertion position within each real frequency component of the authenticating bit is calculated using the formula k % s where k is the source image byte position in spatial-domain and s=2 …7 which is supplied by user to obtain the insertion potions of authenticating bits among s positions in each frequency component, and this s positions are taken from LSB of each component. After embedding the authenticating data in frequency domain then the IDFT is applied using equation 2 to transform it from frequency to spatial domain as final operation before transmission across the nodes of wireless network. The reverse operation is performed at the receiving node to extract bits of authenticating message/image and message digest MD for authentication at destination of the wireless nodes.

In the frequency-domain all spatial-domain values are in form (a + ib), i.e. the complex frequency component. In DFTMCIAWC we cleverly chose the image block of size 2 x 2 from the source image to avoid the non-zero imaginary frequency component in the transformed value. The DFT for the 2 x 2 mask is F(u, v) = ½∑∑f(x, y)[cos2Π(ux/2 + vy/2) – i sin2Π(ux/2 + vy/2)] =∑∑f(x , y)[cosΠ(ux + vy) – i sinΠ(ux + vy)] where value of spatial variables x, y are 0, 1 and the value of frequency variables u, v are 0,1. For any value of x, y, u, and u the value of the imaginary component is zero and value of the real component is either +1 or -1. So for transformation of all elements of 2 x 2 matrix will be in the form of a + i*0 i.e. either +a or -a. The proposed DFTMCIAWC technique embeds authenticating data into the frequency component of source image for any change of frequency component it can affect the spectrum value which may change the quantum value in spatial domain. To maintain the balance in each mask first frequency component is used for re-adjustment phase and remaining three of each mask is used for embedding authenticating data.

In the proposed algorithm after embedding, inverse discrete Fourier transformation (IDFT) is used to get the embedded image in spatial domain. After applying IDFT on identical mask with embedded data the quantum value may change which can generate the following situations:

i) The converted value may be negative (-ve).

ii) The converted value in spatial domain may be a number with non zero fractional value i.e. pure non integer number.

iii) The converted value may be greater the maximum intensity value (i.e. 255).

The concept of re-adjust phase is to handle the above three serious problems by using the first frequency component of each mask. In this phase if the converted value is -ve or with fractional value then add 1 with the first frequency component in the mask and then apply IDFT. This repeating process continue until all are not non negative and non fractional. For case C if the number is greater than the maximum value then subtract 2 from the first frequency component and then apply IDFT. This process is continuing until any value of the mask is greater than 255. The entire process of the DFTMCIAWC technique is given in Figure 1.

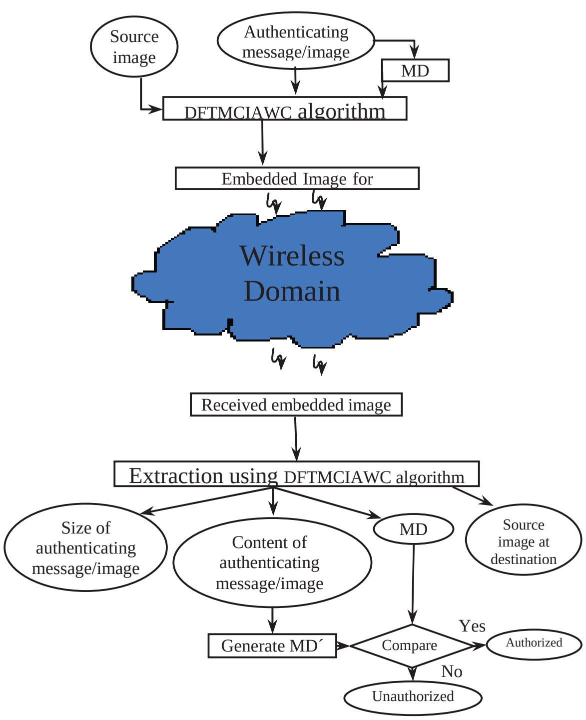

Figure 1: Schematic diagram of DFTMCIAWC Technique

A. Insertion Algorithm.

All insertion is made in frequency domain i.e. each byte of source image in each mask of size 2 x 2 is transformed to frequency domain using DFT using equation 1. The DFTMCIAWC scheme uses colour image as the input to be authenticated by text message/image. The authenticating message/image bits size is 3*(m x n) – (MD+L) where MD and L are the message digest and dimension of the authenticating image respectively for the source image size m x n bytes.

Input: A source image and authenticating message/image at source node of the network..

Output: An authenticated image.

Method: Transforming the image pixel from spatial domain to frequency domain using DFT followed by embedding message/image bits into the real frequency component of each transformed values except the first frequency component of each mask followed by final IDFT to generate embedded image.

Steps:

1. Obtain 128 bits message digest MD from the authenticating message/image.
2. Obtain the size of the authenticating message/image (32 bits, 16 bits for width and 16 bits for height)
3. Read one alphabet/pixel of authenticating message /image at a time.
4. For each authenticating message/image data do
   - Read source image matrix of size 2 × 2 mask from image matrix in row major order and apply DFT.
   - Extract authenticating message/image bit one by one.
   - Compute the position within the real frequency component where authenticating message/image bit is to be inserted (excluding 1st component).
   - Replace the authenticating message/image bit in the computed position within each real part.
5. Repeat step 3 and step 4 for the whole authenticating message/image size, content and message digest MD.
6. Apply inverse DFT using identical mask.
7. Apply re-adjust phase if needed.
8. Transmit across the network.
9. Stop.

B. Extraction Algorithm

The authenticated image is received in spatial domain at destination node. During decoding the embedded image is taken as the input and the authenticating message/image size, image content and message digest MD are extracted data from it. All extraction is done in frequency domain from frequency component.

Input: Embedded image.

Output: The authenticated source image, authenticating message/image, message digest (MD).

Method: Transforming the image pixel from spatial domain to frequency domain using DFT, extracting message/image bits from real frequency component of each transformed image, authenticated image at destination node is generated using IDFT.

Steps:

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1. Read mask of image matrix of size 2 × 2 from embedded image matrix in row major order and apply DFT.
2. For each mask do
   - Compute the position within the real frequency part (excluding 1st frequency component of each mask) for each embedded image quantum value where authenticating message/ image bits are available.
   - Extract the message/image bit.
   - For each 8 (eight) bits extraction construct one alphabet/one primary (R/G/B) colour of image pixel.
3. Repeat step 1 and step 2 to complete decoding as per size of the authenticating message/image.
4. Obtain 128 bits message digest MD′ from the extracted authenticating message/image. Compare MD′ with extracted MD. If MD′ = MD, image is authorized otherwise unauthorized.
5. Apply inverse DFT using identical mask to generate image at destination node.
6. Stop.

IV. Result, Comparison And Analysis

Results, discussion and a comparative study of the proposed DFTMCIAWC with the DCT and QFT based watermarking in terms of visual interpretation, fidelity, and peak signal-to noise analysis is presented. In order to test the robustness of DFTMCIAWC, the technique is applied on more than 50 PPM images from where it may be inferred that the algorithm may overcome various types of attack like visual and statistical attack. The fidelity of source and embedded image almost identical (difference of IF between original and embedded image is of the order of ~.0001) and distinction using human visual system is quite difficult. The original source images 'Giraffe' and 'Sachin' are shown in fig. 2b and 2c. 73728 bytes of information are embedded into each image. The dimension of each source colour image is 512 x 512 and the dimension of authenticating colour image is 160 x 150, shown in fig. 2a. Fig. 2e and 2f are embedded images using DFTMCIAWC. Fig. 2d, 2h, are magnified versions of source 'Giraffe', 'Sachin' images. Fig. 2g and fig. 2i are the magnified version of embedded images using DFTMCIAWC. One bit of authenticating information is embedded at any position between 1st to 4th positions of the frequency component.

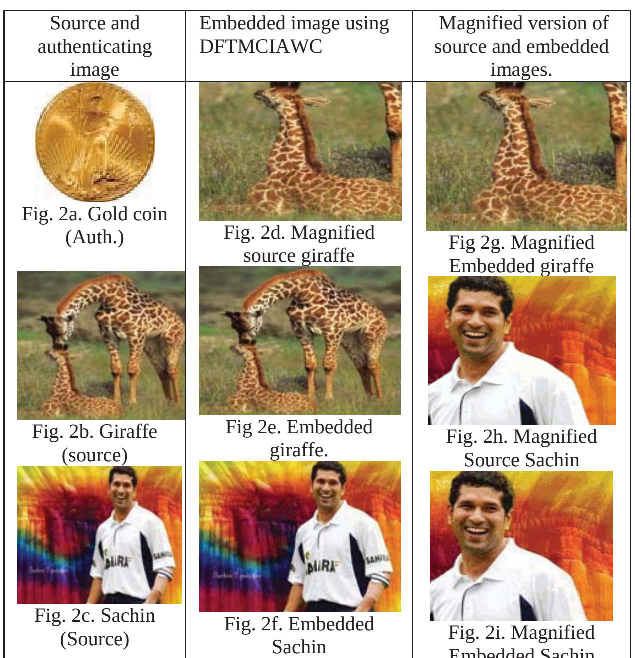


Figure 2: Comparison of fidelity before and after embedding of 'Giraffe', 'Sachin' images using DFTMCIAWC and for the magnified version.

Peak Signal-to-Noise Ratio (PSNR [22]) is used to evaluate qualities of the stegoimages. Image distortion is invisible in all magnified versions. Table I shows the PSNR values for different source images and for different values of k. Here k is the available positions in frequency component where one bit of authenticating data to be embedded. In this process, the capacity of embedding is 73728 bytes with high average PSNR value 44.66 dB with low Mean Square error (MSE [22]) and it shows Image Fidelity (IF [22]) nearer to 1. Table II shows the PSNR values for Lenna image for different existing methods [21] like SCDFT, QFT and DCT where for all existing techniques the dimension of Lenna JPEG image is 512 x 480. From the result it is seen that all existing techniques the PSNRs are low which means bit-error rate are high but in the proposed scheme more bytes of authenticating data can be embedded and the PSNR values are significantly high, means bit-error rate is low. DCT based watermarking scheme do not embed watermarks in every single block of image instead selectively pick the regions which decrease the authenticating data size. QFT and SCDFT have the ability to embed the less amounts of data than DFTMCIAWC. One real system application of the proposed DFTMCIAWC is outlined in sub-section *A*, under this section.

TABLE I. Results of Capacities and PSNR, IF, and MSE in DFTMCIAWC

Source images	Capacity (byte)	PSNR in dB	IF	MSE
Giraffe	73728	44.16	.999875	2.496190
Sachin	73728	44.93	.999895	2.089345
Peppers	73728	44.32	.999855	2.407364
Baboon	73728	45.22	.999907	1.775569
Average	73728	44.66	.999883	2.192117

TABLE II. Results of Capacities and PSNR for Lenna Image in the Existing Technique [21]

Technique	Capacity(bytes)	PSNR in dB
SCDFT	3840	30.1024
QFT	3840	30.9283
DCT	3840	30.4046

A. Real system application of DFTMCIAWC.

The proposed DFTMCIAWC may be applicable in legal document authentication online (like passport, agreement copy, title deed etc.). DFTMCIAWC generates message digest MD of length 128 bits from text part of the legal document and embeds it into stamp image as proof of document authenticity. Any change of document the generated message digest MD will differ from the original one which has been generated during the process of authentication at the destination node of wireless network. As a result any attempt in tempering the document during transmission across the network can be identified. The signature at the end of the document is also fabricated as an authenticating image using same principle. The strength in embedding is high without changing visible property. Figure 3 shows the legal document authentication process where fig. 3a is the stamped signed document and fig. 3b is the authorized image. Here stamp is considered as an image and document, and signature is authenticating data. The technique may be useful in wireless communication.

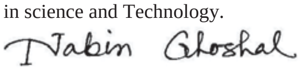
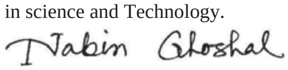
Stamp Document	Legal Document
 We are Indian. We are proud for our country. We always like to look ahead with positive attitude and giving maximum effort to growth our country. We are so much strong in science and Technology.  Cont.… Fig. 3a: Signed Document	 We are Indian. We are proud for our country. We always like to look ahead with positive attitude and giving maximum effort to growth our country. We are so much strong in science and Technology.  Cont.… Fig. 3b: Legal Document

Figure 3: Comparison of fidelity in embedding signature and MD in stamp image using DFTMCIAWC

V. CONCLUSION

DFTMCIAWC technique is an image authentication process in frequency domain to enhance the security compared to the existing algorithms for wireless communication. It provides the protection on secrete data in other domain. For the benefits of wireless communication protocol CSMA/CA the authenticated multimedia color image transmission is most suitable. Authentication using DFTMCIAWC technique relative strength of signals is not to be attenuated. In compare to DCT and QFT based watermarking technique proposed algorithm is applicable for any type of color images and strength is high. First frequency component in each mask is used for adjustment in embedding. The control technique is applied to optimized the noise integration as a result PSNR has been increased with low MSE and IF is nearer to 1. Hence the scheme may be more robust against brute force attack in present context of wireless systems.

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EXHIBIT W

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Spatial Channel and System Characterization

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***Abstract* - With the emergence of the multi-antenna systems, the spatial information becomes particularly significant to the modern communications systems. In this paper we present a new technique to describe and to characterize the channels and systems in space and in wave vector domains. First, we review briefly the wave vector concept, the wave vector spectrum and the 3-dimensional (3D) Fourier transform. Then a set of new impulses and new kernel functions is defined in order to establish a tool to characterize the communications channels and systems. The applications of each kernel function are also discussed. This new technique is a promising and a powerful tool to design and optimize the Multiple-Input Multiple-Output (MIMO) communications systems. The results in this paper are limited to the plane wave scenario.**

I. Introduction

The concept of antenna array appeared in the late 1970s as a promising solution to improve wireless channel capacity. Antenna diversity is the simplest and earliest example of this concept. Antenna array involves array architectures and space-time coding schemes ([1], [2], [3], [4], [5]). The principle of antenna array and space-time code is to exploit the spatial information. Therefore, the space domain and spatial channel models ([6], [7], [8], [9], [10]) play a significant role in communications systems equiped with an antenna array. In [9], the authors used the wave number, which is the inverse of the wavelength, and the distance to characterize the spatial channels. The use of the wave number and distance as a means to describe the system spatial properties is not generalized enough in three-dimension (3D) space. In [10], the authors presented a set of spatial system functions, called channel impulse responses, and correlation functions. These functions are used to characterize the spatial aspects of systems and channels. Wave vectors and position vectors are used instead of wave number and distance. Nonetheless, the set of system functions is not complete and the application of these functions in building new communications systems is not mentioned.

In this paper, we present a generalized and systematic approach of system and channel characterization in space and wave vector. This involves a generalization of the concepts introduced in [9] and [10]. In this paper, the discussion is limited to the plane wave propagation, which approximates the far field propagation scenarios. The new characterization technique presented in this paper provides us with new tools for the design of communications systems, e.g. layout of antenna arrays in MIMO communications systems and design of the frequency-dependent beamforming algorithms.

Section II reviews briefly the concepts of wave vector and wave vector spectrum. Section III introduces the definitions of the new impulse functions defined in space and in wave vector. Section IV presents the spatial channel characterization, including the definitions of the new spatial kernel functions and its application. Section V concludes the paper.

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II. Wave vector and wave vector spectrum

Wave vector is a vector representation of the radio waves. The direction of a wave vector indicates the wave propagation direction and the magnitude equals the wave number. Therefore, a wave family with the same wavelength and the same propagation direction is represented by one wave vector. The magnitude of wave vector $\vec{k}$ is:

$$\left|\vec{k}\right| = \frac{2\pi}{\lambda} = \frac{\omega}{v_p} \tag{1}$$

where λ is the wavelength, ω is the angular frequency and v_p is the propagation velocity.

1) 3D Fourier transform: The 3D Fourier transform converts a signal from the space domain to wave vector domain. On the other hand, the 3D inverse Fourier transform converts a signal from wave vector domain to space domain. The continuous 3D Fourier and inverse Fourier transforms are defined as:

$$G(\vec{k}) = \int g(\vec{r})e^{j\vec{r}\cdot\vec{k}}d^3r \tag{2}$$

$$g(\vec{r}) = \frac{1}{(2\pi)^3}\int G(\vec{k})e^{-j\vec{k}\cdot\vec{r}}d^3k \tag{3}$$

where d^3k represents the $dk_xdk_ydk_z$ differentials and d^3r represents $dr_xdr_ydr_z$; k_x, k_y, k_z and r_x, r_y, r_z are the cartesian coordinates of wave vector $\vec{k}$ and space vector (position vector) $\vec{r}$, respectively.

2) 4-dimension Fourier transform: The wave vector-frequency spectrum involves a combination of a 3D Fourier transform with respect to the space variable and a Fourier transform with respect to the time variable. We have the following relationships:

$$S(f;\vec{k}) = \int\int s(t;\vec{r})e^{-j2\pi ft}e^{j\vec{k}\cdot\vec{r}}dtd^3r \tag{4}$$

$$s(t;\vec{r}) = \frac{1}{(2\pi)^3}\int\int S(f;\vec{k})e^{j2\pi ft}e^{-j\vec{k}\cdot\vec{r}}dfd^3k \tag{5}$$

It is known that the frequency and the wave vector module are related to each other through the propagation velocity. Also the 3D position vector and the time variable are related to each other through the propagation velocity. This implies that the integrals in equations (4) and (5) are not performed over the whole 4D hyperspace, i.e. 3D space and time in (4) and 3D wave vector and frequency in (5), but rather on a 4D hypersuface. This 4D hypersurface is defined by the relationship between the 3D position vector and time variable in (4) and by the relationship between the wave vector and frequency variable in (5). Therefore, equations (4) and (5) can be rewritten as:

$$S(f;\vec{k}) = \int_{H_{s-t}} s(t;\vec{r})e^{-j2\pi ft}e^{j\vec{k}\cdot\vec{r}}dh_{s-t} \tag{6}$$

$$s(t;\vec{r}) = \frac{1}{(2\pi)^3}\int_{H_{w-f}} S(f;\vec{k})e^{j2\pi ft}e^{-j\vec{k}\cdot\vec{r}}dh_{w-f} \tag{7}$$

where H_{s-t} is the hypersurface representing the space-time relationship, $t = \frac{|\vec{r}|}{v_p}$, and H_{w-f} is the hypersurface defined by the wave vector-frequency relationship, $|\vec{k}| = \frac{2\pi f}{v_p}$. Hypersurfaces H_{w-f} and H_{s-t} are dependent on the transmission media characteristics, i.e. the propagation velocity v_p. Decomposition of (6) and (7) leads to the expressions in (8) and (9).

III. Multidimensional Dirac Impulses

In order to characterize the channel and system in any N-dimensional space, we will need to use multidimensional Dirac impulses[11, pp. 23-24]. Let $\vec{x}$ be a N-dimensional vector of the space R^N, we generalize the N-dimensional Dirac impulse as following:

$$\underbrace{\int\cdot\cdot\int}_{N} f(\vec{x})\delta(\vec{x}-\vec{x_0})dx_1dx_2\cdot\cdot dx_N = f(\vec{x_0}) \tag{10}$$

where $f(\vec{x})$ is a function defined in R^N; x_1, x_2, .., x_N are the components of vector $\vec{x}$.

In the following, $\vec{x}$ might be a combination of $\vec{r}$, $\vec{k}$, f and t. $\delta(\vec{r})$, $\delta(\vec{k})$, $\delta(\vec{r},t)$, $\delta(\vec{r},f)$, $\delta(\vec{k},t)$ and $\delta(\vec{k},f)$ are the multidimensional Dirac impulses in space, wave vector, space-time, space-frequency, wave vector-time and wave vector-frequency, respectively. It is well known that the frequency impulse is a constant (*white*) in the time domain and the time impulse is a constant in the frequency domain[12]. Similarly, by using the 3D Fourier transform, the wave vector impulse is a constant in space and in time; the space impulse is a constant in wave vector and in frequency. Therefore, the impulses in wave vector-time domain and in space-frequency domain do not exist.

$$S(f;\vec{k}) = \int s(t;\vec{r})e^{-j2\pi ft}e^{j\vec{k}\cdot\vec{r}}\sqrt{1+\left(\frac{dr_x}{dt}\right)^2+\left(\frac{dr_y}{dt}\right)^2+\left(\frac{dr_z}{dt}\right)^2}\,dt \quad (8)$$

$$s(t;\vec{r}) = \frac{1}{(2\pi)^3}\int S(f;\vec{k})e^{j2\pi ft}e^{-j\vec{k}\cdot\vec{r}}\sqrt{1+\left(\frac{dk_x}{df}\right)^2+\left(\frac{dk_y}{df}\right)^2+\left(\frac{dk_z}{df}\right)^2}\,df \quad (9)$$

1) Space and space-time impulses: The space impulse has an impulse at the space origin, $\vec{0}$. The space-time impulse function, $\delta(\vec{r},t)$, has one more constraint in the time domain: the impulse exists only at the time origin. Therefore, the space-time impulse exists only at the space origin ($\vec{r}=\vec{0}$) and at the time origin ($t=0$). The wave vector-frequency spectrum of the space-time impulse at position $\vec{r}_0$ and time t_0, i.e. $\delta(\vec{r}-\vec{r}_0,t-t_0)$, is:

$$\begin{aligned}\Delta_{w,f}(\vec{k},f) &= \mathcal{F}_{\vec{r},t}\{\delta(\vec{r}-\vec{r}_0,t-t_0)\} \quad (11)\\ &= \int\int \delta(\vec{r}-\vec{r}_0,t-t_0)e^{j\vec{k}\cdot\vec{r}}e^{-j2\pi ft}d^3r dt\\ &= e^{j\vec{k}\cdot\vec{r}_0}e^{-j2\pi ft_0}\end{aligned}$$

2) Wave vector and wave vector-frequency impulse: In practice, we usually refer to an impulse at wave vector $\vec{k}_0$ rather than at wave vector zero. The wave vector impulse at $\vec{k}_0$ is a frequency impulse at frequency f_0 corresponding to wave vector $\vec{k}_0$ and propagating in the direction pointed by $\vec{k}_0$. Therefore, the wave vector impulse $\delta(\vec{k}-\vec{k}_0)$ is also a wave vector-frequency impulse at wave vector $\vec{k}_0$ and frequency f_0, i.e. $f=f_0$. The space-time representation of wave vector-frequency impulse $\delta(\vec{k}-\vec{k}_0,f-f_0)$ is:

$$\begin{aligned}\Delta_{s,t}(\vec{r},t) &= \mathcal{F}^{-1}_{\vec{k},f}\left\{\delta(\vec{k}-\vec{k}_0,f-f_0)\right\} \quad (12)\\ &= \int\int \delta(\vec{k}-\vec{k}_0,f-f_0)e^{-j\vec{k}\cdot\vec{r}}e^{j2\pi ft}d^3k df\\ &= e^{-j\vec{k}_0\cdot\vec{r}}e^{j2\pi f_0 t}\end{aligned}$$

IV. Spatial Channel Characterization

A. Definitions of spatial kernel functions

Considering the 3D Fourier transform, one observes that the signal representations in space and in wave vector are equivalent. At the input of a communications channel, the transmitted signal can be represented in either the space or the wave vector domains. At the output, the received signal can be represented in either the space or the wave vector domains. Therefore a communications channel transforms the signals in either space or wave vector into either space or wave vector domains. In equations (13) to (16), four operators are defined in the form of four channel kernel functions: $K_{ss}(\vec{r_o},\vec{r_i})$, $K_{ww}(\vec{k_o},\vec{k_i})$, $K_{sw}(\vec{r_o},\vec{k_i})$ and $K_{ws}(\vec{k_o},\vec{r_i})$. $\vec{r_i}$ and $\vec{r_o}$ are the positions of the transmitter and the receiver, respectively. $\vec{k_i}$ and $\vec{k_o}$ are the transmit and the receive wave vectors, respectively.

$$s_o(\vec{r_o}) = \int s_i(\vec{r_i})K_{ss}(\vec{r_o},\vec{r_i})d^3r_i \quad (13)$$

$$S_o(\vec{k_o}) = \int S_i(\vec{k_i})K_{ww}(\vec{k_o},\vec{k_i})d^3k_i \quad (14)$$

$$s_o(\vec{r_o}) = \int S_i(\vec{k_i})K_{sw}(\vec{r_o},\vec{k_i})d^3k_i \quad (15)$$

$$S_o(\vec{k_o}) = \int s_i(\vec{r_i})K_{ws}(\vec{k_o},\vec{r_i})d^3r_i \quad (16)$$

where $s_o(\vec{r_o})$ and $S_o(\vec{k_o})$ are the received signal in space and the received signal wave vector spectrum, while $s_i(\vec{r_i})$ and $S_i(\vec{k_i})$ are the transmit signal in space and the transmit signal wave vector spectrum.

B. Applications of the kernel functions

From the above definitions, we interpret the physical meaning and applications of each kernel function:

- $K_{ss}(\vec{r_o},\vec{r_i})$: This kernel function transforms the signal from position $\vec{r_i}$ to $\vec{r_o}$. $K_{ss}(\vec{r_o},\vec{r_i})$ represents the complex spatial channel gain when the transmitter is located at position $\vec{r_i}$ and the receiver is located at position $\vec{r_o}$. It can also be interpreted as the space channel impulse response to a space impulse at position $\vec{r_i}$. In practical communication systems, the complete knowledge on $K_{ss}(\vec{r_o},\vec{r_i})$ can help us to locate the optimal locations to install the transmitter and the receiver and to layout the transmit and receive antenna array. Furthermore, its autocorrelation function can be used to evaluate the sub-channel spatial correlation degree in MIMO communications systems.

- $K_{ww}(\vec{k_o}, \vec{k_i})$: This kernel function presents the relationship between the transmitted and the received signal wave vectors. $K_{ww}(\vec{k_o}, \vec{k_i})$ is the complex wave vector channel gain when the transmitter sends out signals in the direction of $\vec{k_i}$, at the corresponding frequency f_i and the receiver receives signals from the direction of $\vec{k_o}$, at the corresponding frequency f_o. It is the wave vector channel impulse response to a wave vector impulse emitted in the direction $\vec{k_i}$, at frequency f_i. $K_{ww}(\vec{k_o}, \vec{k_i})$ represents the relationship between the AoD (Angle of Departure) spectrum and the AoA (Angle of Arrival) spectrum. The full knowledge on $K_{ww}(\vec{k_o}, \vec{k_i})$ can help designers to optimize the transmit and receive antenna beam forming algorithms.
- $K_{sw}(\vec{r_o}, \vec{k_i})$: This kernel function is the complex space-wave vector channel gain when the transmitter emits signal in the direction of $\vec{k_i}$, at the corresponding frequency f_i, and the receiver located at position $\vec{r_o}$. This kernel function is the space channel impulse response to a sine at frequency f_i emitted from the transmitter in the direction of $\vec{k_i}$.
- $K_{ws}(\vec{k_o}, \vec{r_i})$: This kernel function represents the relationship between transmitted signals in space and the received signals in wave vector. $K_{ws}(\vec{k_o}, \vec{r_i})$ is the complex wave vector-space channel gain when the transmitter is located at position $\vec{r_i}$ and the receiver receives signals from the direction of vector $\vec{k_o}$, at the corresponding frequency f_o. This is the wave vector channel impulse response to a space impulse at position $\vec{r_i}$.

V. Conclusion

In this paper we present a new method to describe and characterize the channel and system in space and in wave vector. The calculation of the 4D Fourier transform is presented. A set of new impulse functions and a set of new kernel functions are defined. The applications of each kernel function are also discussed. The knowledge on the kernel functions is useful to design and to optimize wireless communications systems. This includes the selection of the transmitter and the receiver positions, the layout of the transmit and the receive antenna arrays and the design of the frequency-dependent beam forming algorithms at the transmitter as well as the receiver. One observes that this new methodology is a powerful and promising tool in the development of efficient MIMO communications systems.

It should be reminded that the results of this paper are limited to plane wave scenarios. The development of the system functions based on the above defined kernel functions and in spherical wave propagation scenarios are currently investigated.

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