Filed: June 5, 2024

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MEDIATEK INC. and NXP USA, Inc.
Petitioners,

v.

Bell Northern Research, LLC,
Patent Owner.

IPR2023-01414
U.S. Patent 8,416,862
Filing Date: September 28, 2005
Issue Date: April 9, 2013

CORRECTED PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT 8,416,862

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Element	Claim Language
	Claim 1
[1.P]	1. A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device, the method comprising:
[1a]	[1a] the receiving wireless communication device receiving a preamble sequence from the transmitting wireless device;
[1b]	[1b] the receiving wireless device estimating a channel response based upon the preamble sequence;
[1c]	[1c] the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
[1d]	[1d] the receiving wireless device decomposing the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
[1e]	[1e] the receiving wireless device wirelessly sending the transmitter beamforming information to the transmitting wireless device.
	Claim 2
[2]	2. The method of claim 1 wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises: the receiving wireless device producing the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and the receiving wireless device converting the estimated transmitter beamforming unitary matrix (V) to polar coordinates.
	Claim 3
[3]	3. The method of claim 1 wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: $H=UDV^*$ where, D is a diagonal matrix.
	Claim 4
[4]	4. The method of claim 3, wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises performing a Singular Value Decomposition (SVD) operation.

Claim 9	
[9p]	9. A wireless communication device comprising:
[9a]	[9a] a plurality of Radio Frequency (RF) components operable to receive an RF signal and to convert the RF signal to a baseband signal; and
[9b]	[9b] a baseband processing module operable to:
[9c]	[9c] receive a preamble sequence carried by the baseband signal;
[9d]	[9d] estimate a channel response based upon the preamble sequence;
[9e]	[9e] determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
[9f]	[9f] decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
[9g]	[9g] form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device.
Claim 10	
[10]	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.
Claim 11	
[11]	11. The wireless communication device of claim 9, wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: $H=UDV^*$ where, D is a diagonal matrix.
Claim 12	
[12]	12. The wireless communication device of claim 9, wherein in determining the estimated transmitter beamforming unitary matrix (V) based upon the channel response and the receiver beamforming unitary matrix (U), the baseband processing module performs Singular Value Decomposition (SVD) operations.

I. INTRODUCTION

MediaTek Inc. ("MediaTek") and NXP USA, Inc. ("NXP"), (collectively, "Petitioners") petitions for *Inter Partes* Review ("IPR") of claims 1-4 and 9-12 ("the Challenged Claims") of U.S. Patent 8,416,862 ("the '862 patent"). The '862 patent describes wirelessly "feeding back transmitter beamforming information" from a receiving device to a transmitting device. EX1001, Abstract. But the device claimed was just a conventional variation of typical devices as of the alleged priority date.

Grounds 1-5 raise prior art combinations not raised during prosecution and previously found to present a reasonable likelihood of success in at least one prior IPR settled shortly after institution. IPR2020-00108, *LG Elecs., Inc. v. Bell Northern Research, LLC*, Paper 14, 14-39 (P.T.A.B. May 20, 2020) (not challenging claims 1-4 but granting institution of claims 9-12 on the grounds 1-5 presented herein)*;see also* IPR2021-01590, Paper 2 (challenging claims 1-4 and 9-12 on the same grounds, but settled before institution); IPR2022-00048, Paper 2 (same). Petitioners therefore request the Board to institute IPR of the Challenged Claims.

II. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Parties-In-Interest Under 37 C.F.R. §42.8(b)(1)

MediaTek Inc., MediaTek USA Inc., MediaTek North America Inc., MTK Wireless Limited (UK), Gaintech Co. Limited, MediaTek Investment Singapore Pte. Ltd., NXP Semiconductors N.V., and NXP USA, Inc. are the real parties-in-interest.

No other parties had control over the present Petition, and no other parties funded the present Petition.

Petitioners agree with and adopt herein analyses previously submitted in IPR2020-00108, LG Electronics, Inc. challenging claims 9-12 of the ’862 Patent. The Board Instituted on May 20, 2020 (Paper 14), and terminated on July 29, 2020, following settlement (Paper 22).

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

Petitioners are party to the following proceedings involving the ’862 patent:

- *Bell Northern Research, LLC v. Qualcomm Inc. et al*, 8-23-cv-01065 (CDCA)
- *Bell Northern Research, LLC v. NXP Semiconductors, N.V. et al*, 1-23-cv-00633 (WDTX)
- *Electronic Devices and Semiconductor Devices Having Wireless Communication Capabilities and Components Thereof*, Inv. No. 337-TA-1367 (Violation) 337-TA-1367 (ITC)

The ’862 patent is or was also at issue in the below-listed proceedings, and Petitioners are not real party-in-interest to any of those below-listed proceedings. Also, none of the parties in the below-listed proceedings are a real party-in-interest in the proceedings involving Petitioners or in privity with Petitioners.

- *Bell Northern Research, LLC v. ZTE Corporation et al*, 3-18-cv-01786 (SDCA) (Aug. 1, 2018)
- *Bell Northern Research, LLC v. Kyocera Corporation et al*, 3-18-cv-01785 (SDCA) (Aug. 1, 2018)
- *Bell Northern Research, LLC v. Huawei Device Co., Ltd. et al*, 3-18-cv-01784 (SDCA) (Aug. 1, 2018)

- *Bell Northern Research, LLC v. LG Electronics, Inc. et al*, 3-18-cv-02864 (SDCA) (Dec. 20, 2018)
- *ZTE Corporation et al v. Bell Northern Research, LLC*, IPR2019-01438 (PTAB) (Aug. 2, 2019)
- *Huawei Technologies Co., Ltd. et al v. Bell Northern Research, LLC*, IPR2019-01439 (PTAB) (Aug. 2, 2019)
- *Bell Northern Research, LLC v. Samsung Electronics Co., Ltd. et al*, 2-19-cv-00286 (EDTX) (Aug. 22, 2019)
- *LG Electronics Inc. et al v. Bell Northern Research, LLC*, IPR2020-00108 (PTAB) (Nov. 12, 2019)
- *Samsung Electronics Co., Ltd. v. Bell Northern Research, LLC*, IPR2020-00613 (PTAB) (Feb. 20, 2020)
- *Samsung Electronics Co., Ltd. v. Bell Northern Research, LLC*, IPR2020-00611 (PTAB) (Feb. 20, 2020)
- *Bell Northern Research, LLC v. Apple Inc.*, 6-21-cv-00833 (WDTX) (Aug. 11, 2021)
- *Bell Northern Research, LLC v. Lenovo Group Ltd. et al*, 6-21-cv-00847 (WDTX) (Aug. 13, 2021)
- *Bell Northern Research, LLC v. Dell Technologies Inc. et al*, 6-21-cv-00909 (WDTX) (Sept. 01, 2021)
- *Bell Northern Research, LLC v. CommScope Holding Company, Inc. et al*, 6-21-cv-00941 (WDTX) (Sept. 10, 2021)
- *Bell Northern Research, LLC v. HP Inc.*, 6-21-cv-00939 (WDTX) (Sept. 10, 2021)
- *TCL Industries Holdings Co., Ltd. et al v. Bell Northern Research, LLC*, 3-21-cv-01598 (SDCA) (Sept. 13, 2021)
- *Bell Northern Research, LLC v. TTE Technology, Inc et al*, 2-21-cv-07323 (CDCA) (Sept. 13, 2021)
- *Certain Electronic Devices Having Wireless Communication Capabilities and Components Thereof*, Inv. No. 337-TA-1284 (Violation), 337-TA-1284 (ITC) (Sept. 26, 2021)
- *Bell Northern Research LLC v. OnePlus Technology (Shenzhen) Co Ltd et al*, 3-21-cv-02293 (NDTX) (Sept. 27, 2021)
- *Apple Inc. v. Bell Northern Research, LLC*, IPR2021-01590 (PTAB) (Oct. 4, 2021)

- *OnePlus Technology Shenzhen Co., Ltd. v. Bell Northern Research, LLC*, IPR2022-00048 (PTAB) (Oct. 19, 2021)
- *Bell Northern Research, LLC v. HMD America, Inc. et al*, 1-22-cv-21035 (SDFL) (Apr. 6, 2022)
- *Bell Northern Research, LLC v. HMD America, Inc. et al*, 1-22-cv-22706 (SDFL) (Aug. 25, 2022)
- *Bell Northern Research, LLC v. Huaqin Co. Ltd.*, 1-22-cv-24026 (SDFL) (Dec. 13, 2022)
- *Bell Northern Research, LLC v. ASUSTeK Computer, Inc. et al*, 4-23-cv-00573 (EDTX) (June 20, 2023)

C. Lead And Back-Up Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioners provide the following designation of counsel.

MediaTek Petitioners

Lead Counsel	Backup Counsel
Cory C. Bell (Reg. No. 75,096) cory.bell@finnegan.com Finnegan, Henderson, Farabow, Garrett & Dunner, LLP 2 Seaport Lane, 6th Floor Boston, MA 02210-2001 Tel: 617-646-1641 Fax: 202-408-4400	Luke H. MacDonald (Reg. No. 79,064) luke.macdonald@finnegan.com Finnegan, Henderson, Farabow, Garrett & Dunner, LLP 1875 Explorer Street, Suite 800 Reston, VA 20190-6023 Tel: 571-203-2700 Fax: 202-408-4400

NXP Petitioner

Lead Counsel
Brian K. Erickson USPTO Reg. No. 48,895 DLA Piper LLP (US) 303 Colorado Street Suite 3000 Austin, Texas 78701-4653 Tel.: (512) 457-7059

Fax: (512) 721-2263 brian.erickson@us.dlapiper.com	
Backup Counsel	
Brent Yamashita USPTO Reg. No. 53,808 DLA Piper LLP (US) 2000 University Avenue East Palo Alto, California 94303-2214 Tel.: (650) 833-2348 Fax: (650) 833-2001 brent.yamashita@us.dlapiper.com	Zachary Loney (*Pro hac to be filed)* DLA Piper LLP (US) 303 Colorado Street Suite 3000 Austin, Texas 78701-4653 Tel.: (512) 457-7203 Fax: (512) 721-2283 zachary.loney@us.dlapiper.com
Martin Ellison DLA Piper LLP (US) 2000 Avenue of the Stars Suite 400 North Tower Los Angeles, CA 90067-4735 Tel.: (310) 595-3058 Fax: (310) 595-3342 martin.ellison@us.dlapiper.com	Salvatore Tamburo USPTO Reg. No. 45,153 DLA Piper LLP (US) 500 Eighth Street SW Washington, DC 20004 Tel.: (202) 799-4122 Fax: (202) 863-7822 salvatore.tamburo@us.dlapiper.com
Peiyao Zhang DLA Piper LLP (US) 2000 University Avenue East Palo Alto, California 94303-2214 Tel.: (650) 833-2348 Fax: (650) 833-2001 peiyao.zhang@us.dlapiper.com	

D. Service Information

Petitioners consent to service by e-mail at the following addresses:

- cory.bell@finnegan.com
- luke.macdonald@finnegan.com
- MediaTek-BNR-IPR@finnegan.com

- Brian.erickson@us.dlapiper.com
- Zachary.loney@us.dlapiper.com
- DLANXP-BNR-IPR@us.dlapiper.com

III. PAYMENT OF FEES

The Office may charge any additional fees to Deposit Account No. 06-0916.

IV. REQUIREMENTS FOR IPR UNDER 37 C.F.R. §42.104

A. Grounds for Standing Under 37 C.F.R. §42.104(a)

Petitioners certify that the ’862 patent is available for IPR and Petitioners are not barred or estopped from requesting IPR.

B. Challenge Under 37 C.F.R. §42.104(b) and Relief Requested

Petitioners request an IPR of claims 1-4 and 9-12 on the grounds listed below, and request the claims be found unpatentable. A declaration of Jonathan Wells (EX1003) supports the petition.

Ground	‘862 Patent Claims	Basis for Rejection
1	1-4, 9-12	§103 – Li-748 (EX1004) in view of Tong (EX1005) and Mao (EX1006)
2	1-4, 9-12	§103 – Tong in view of Mao
3	1, 3-4, 9, 11-12	§103 – Li-054 (EX1007) in view of Mao
4	2, 10	§103 – Li-054 in view of Mao and Yang (EX1008)

5	1, 3-4, 9, 11-12	§103 – Poon (EX1009) in view of Mao

V. SUMMARY OF THE ’862 PATENT

A. Background

The ’862 patent explains a typical “transceiver (i.e., receiver and transmitter)” for a wireless communication device was “coupled to the antenna” and included a low noise amplifier, and intermediate frequency, filtering, and data recovery stages. EX1001, 1:60-67; 2:1-10 (conventional conversion of “the amplified RF signal into baseband signals”). The ’862 patent acknowledges transceivers traditionally incorporated beamforming: “a processing technique to create a focused antenna beam by shifting a signal in time or in phase to provide gain of the signal in a desired direction and to attenuate the signal in other directions.” *Id.*, 2:66-3:4. The ’862 patent explains “[i]n order for a transmitter to properly implement beamforming (i.e., determine the beamforming matrix [V]), it needs to know properties of the channel over which the wireless communication is conveyed,” necessitating receiver-provided feedback information so the transmitter can determine the properties. *Id.*, 3:14-19; EX1003, ¶28. The receiver sends feedback to the transmitter by “determin[ing] a channel response (H)” and providing it as “feedback information.” EX1001, 3:19-22; EX1003, ¶28. This resulted in feedback data packs “so large that, during the time it takes to send it to the transmitter, the response of the channel has changed." EX1001, 3:22-25. To reduce feedback size, conventional receivers "decompose[d] the channel using singular value decomposition ("SVD") and sen[t] information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information." *Id.*, 3:26-30; EX1003, ¶28. To reduce feedback size, conventional receivers calculated matrix V based on H=UDV*,[1] where H is channel response matrix, D is diagonal matrix, and U is receiver unitary matrix, and only send information about matrix V. EX1001, 3:30-33; EX1003, ¶28.

Per the '862 patent, "[w]hile this approach reduces the size of the feedback information, its size is still an issue for a MIMO wireless communication." *Id.*, 3:33-35. The '862 patent alleged "a need" "for reducing beamforming feedback information for wireless communications" (3:49-51), but this allegation ignored the state of the art. EX1003, ¶28.

B. Brief Description

The '862 patent describes a wireless communication system including base stations, wireless communication devices, and network hardware. EX1001, FIG. 1,

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[1] While each of matrices H, U, D (also called Σ), and V were referred to by various terminology in the art and the '862 patent, a POSITA would have understood each to identify the same respective matrix in this equation. EX1003, ¶¶53-56.

4:24-27. Base stations are coupled to network hardware to connect to other devices. *Id.*, 4:46-52. Each base station has antenna(s) for communicating with wireless communication devices. *Id.*, 4:52-55.

The wireless communication device can include a host device and a radio. *Id.*, FIG. 3, 7:21-27. The host device includes a radio interface for sending and receiving data. *Id.*, 7:28-30. The interface provides received data to a processing module and provides processed data from the processing module to the radio for transmission. *Id.*, 7:36-40, 7:43-44.

Figure 3 shows a radio with "baseband processing module 100, memory 65, a plurality of radio frequency (RF) transmitters 106-110, a transmit/receive (T/R) module 114, a plurality of antennas 81-85, [and] a plurality of RF receivers 118-120." *Id.*, 7:51-56. The baseband processing module and operational instructions in memory 65 execute digital receiver/transmitter functions, including "digital intermediate frequency to baseband conversion." *Id.*, 7:56-64.

The baseband processing module includes "processing devices," which "may be a microprocessor, micro-controller, … digital circuitry," etc. *Id.*, 8:1-9. In operation, in receive mode, "baseband processing module 100, based on the mode selection signal 102 produces one or more outbound symbol streams 104 from the outbound data 94." *Id.*, 8:46-48. It "converts the inbound symbol streams 124 into inbound data 92, which is provided to the host device 18-32." *Id.*, 9:9-12.

The method of Figure 7 "addresses the feedback of observed transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device." *Id.*, 13:25-32; FIG. 7. The patent admits Figure 7's steps are "typically performed by a baseband processing module" of a receiving wireless device. *Id.*, 13:25-35; FIG. 7.

That method includes conventional steps, including receiving a preamble, estimating a channel response H at the receiver, and estimating the transmitter beamforming matrix V based on the channel response H and receiver beamforming unitary matrix U. *Id.*, 13:36-47. The '862 patent explains "channel response (H), estimated transmitter beamforming unitary matrix (V), and the known receiver beamforming unitary matrix (U) are related" by well-known singular value decomposition (SVD) equation: "H=UDV*, where, D is a diagonal matrix," to determine estimated transmitter beamforming unitary matrix (V). *Id.*, 13:47-53; EX1003, ¶¶28, 39, 53.

To purportedly reduce beamforming feedback information, the '862 patent proposed a known "solution"—decomposing the estimated transmitter beamforming unitary matrix (V) using a "Givens Rotation." *Id.*, 13:58-67; EX1003, ¶39. It explains "the coefficients of the Givens Rotation and the phase matrix coefficients serve as the transmitter beamforming information that is sent from" receiver to transmitter. EX1001, 15:34-38. In particular, the transmitter beamforming information is the product of the Givens Rotation ("the set of angles … are reduced"). *Id.*, 13:63-14:3; *see also* 14:34-36; EX1003, ¶39. Using these techniques, "the feedback of transmitter beamforming information" requires less data. *Id.*, 15:59-61. But, as explained in Grounds 1-5, these solutions were in prior art publications.

C. Critical Date

The '862 patent issued on April 9, 2013, from Application No. 11/237,341 ("'341 application"), filed September 28, 2005. EX1001, cover. It is a continuation-in-part of Application No. 11/168,793 ("'793 application", EX1014), filed June 28, 2005, and claims priority to Provisional Application Nos. 60/673,451 ("'451 provisional", EX1010), filed April 21, 2005, and 60/698,686 ("'686 provisional", EX1011), filed July 13, 2005.

The claims require at least one feature never contemplated in the '451 provisional or '793 application. EX1003, ¶¶48-50. Independent claim 9 recites "a baseband processing module operable to: … decompose the estimated transmitter beamforming unitary matrix (V)…" EX1001, 17:20, 17:28-30. Neither the '451 provisional nor '793 application disclose decomposing matrix V. EX1003, ¶49; *see, generally* EX1010, EX1014. Therefore, the earliest possible priority date of the '642 patent is the filing date of the '686 provisional—July 13, 2005 (the "Critical Date")—which addresses decomposing matrix V. EX1003, ¶50; EX1011, 22:3-5.

Regardless, the prior art of Grounds 1-5 predate April 21, 2005.

D. Ordinary Skill in the Art

A person of ordinary skill in the art at the time of the alleged invention ("POSITA") would have had 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 had equivalent education, work, or experience in this field. EX1003, ¶23.

VI. CLAIM CONSTRUCTION UNDER 37 C.F.R. §42.104(b)(3)

Claim should be construed according to *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005). 37 C.F.R. §42.100. Patent Owner and other parties briefed claim construction issues in other district court litigation and held a *Markman* hearing, followed by a claim construction order. EX1017, EX1018, EX1020, EX1022 (order). There, another party proposed formal constructions for two claim phrases of the '862 patent—(1) "a baseband processing module operable to…" and (2) "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information." But that court indicated the plain and ordinary meaning of the claim language was recognizable without adoption of any formal construction. EX1020, 104:23-107:3-9, 111:4-114:22.

Likewise, the IPR2020-00108 petitioner submitted plain and ordinary meaning for all claims, while Patent Owner asserted certain constructions. The Board found no construction necessary. *LG*, Paper 22, 11-14.

Here, the grounds fall within the scope of the claims regardless of whether the proposed formal construction is adopted. Thus, Petitioners recognize the Board may find no formal claim construction necessary at institution because "claim terms need only be construed to the extent necessary to resolve the controversy." *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011).

Petitioners reserve the right to address any claim construction arguments Patent Owner raises.

A. "a baseband processing module operable to…"

A district court disagreed this term should be interpreted under §112, ¶6, finding "a baseband processing module" was known and recognizable. EX1020, 107:10-109:25, 114:24-115:15, 116:11-118:5; EX1019, 17:13-23:15. In *LG*, the Board likewise did not find means plus function applied. *LG*, Paper 14, 11-14.

If the Board decides this element is means-plus-function, this Petition identifies EX1001, 7:56-59, 8:1-3 as the "specific portions of the specification that describe the structure" corresponding to the recited baseband processing.

B. "a plurality of Radio Frequency (RF) components"

In the Southern District of Florida, a third party argued for construction under §112(6) with the function "receiving an RF signal and converting the RF signal to a baseband signal" but without corresponding structure and therefore indefinite. Ex1023, 8. Patent Owner argued for plain and ordinary meaning but if §112(6) applies the structure "includes one or more antennas and includes one or more amplifiers, one or more intermediate frequency, one or more mixers and RF filters." *Id*. Regardless, the Board need not construe this term because under either of Patent Owner's alternative constructions, the prior art discloses or renders obvious claim 9, as Grounds 1-3 and 5 demonstrate.

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

Another party proposed to construe this term as "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients." EX1017, 26-30. But the court instead found the plain and ordinary meaning was recognizable without construction. EX1020, 104:23-105:2, 106:20-25, 107:3-9.

In *LG*, Patent Owner proposed this term should be interpreted "in accordance with its plain and ordinary meaning, which requires decomposition that results in a reduction of angles or coefficients from the matrix operation." *LG*, Paper 14, 11. But the Board disagreed and found no construction necessary. *Id.*, 11-14.

Accordingly, this term should be interpreted according to its plain and ordinary meaning without formal construction in the present proceeding. *Wellman*, 642 F.3d at 1361. Under that meaning, Grounds 1-5 fall within the scope of this "decompose" operation. Alternatively, even if the Board applies one of the above constructions, at least Grounds 1-2 fall within the scope of this "decompose" operation because the prior art provides the same type of "Givens rotation" mentioned in the '862 patent. EX1001, 13:58-67 ("Givens Rotation").

VII. GROUND 1: CLAIMS 1-4 and 9-12 ARE OBVIOUS IN VIEW OF LI-748, TONG, AND MAO

A. Li-748 Overview

Li-748 (EX1004), filed September 30, 2004 and issued June 26, 2007, is prior art under, *e.g.*, §102(e). EX1004, cover. Li-748 discloses a "closed loop MIMO system" reduces feedback bandwidth "by representing a beamforming matrix using orthogonal generator matrices." *Id.*, Abstract. Li-748 teaches stations 102, 104, which are "part of a wireless local area network" and "include multiple antennas." *Id.*, 1:50-52, 2:6., FIG. 1.

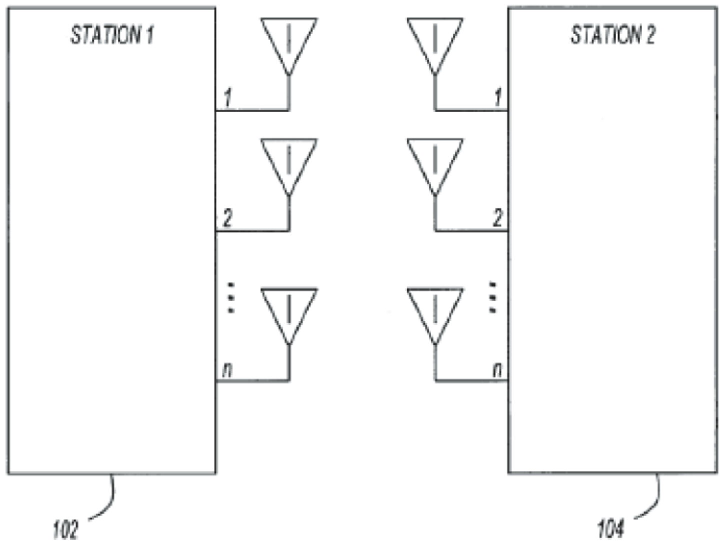


FIG. 1

Id., FIG. 1.

Figure 4 shows "a station capable of representing beamforming matrices." *Id.*, 9:36-40. Station 400 "sends and receives signals using antennas 410, and the signals are processed by the various elements shown in FIG. 4." *Id.*, 9:55-57. It includes a physical layer (430) "coupled to antennas 410 to interact with a wireless network" and "circuitry to support the transmission and reception of radio frequency (RF) signals," including "an RF receiver to receive signals and perform 'front end' processing." *Id.*, 9:55-10:1. It also includes processor 460 and memory 470. *Id.*, 10:7-25.

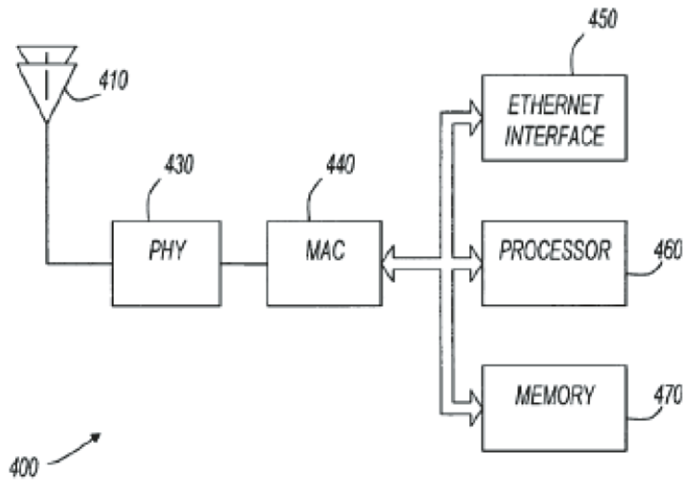


FIG. 4

Id., FIG. 4.

In "closed loop systems, communications bandwidth is utilized to transmit current channel state information between stations, thereby reducing the necessary decoding complexity." *Id.*, 2:44-47. "The current channel state information may be represented by … unitary beamforming matrix V determined using a singular value decomposition (SVD) algorithm." *Id.*, 2:52-54. The "receiver sends each element of the unitary matrix V back to the transmitter." *Id.*, 2:57-59.

Li-748 discloses that a "transmit beamforming matrix may be found using SVD," using the equations H=UDV' and x=Vd, "where d is the n-vector of code bits for n data streams; x is the transmitted signal vector on the antennas; H is the channel matrix; H's singular value decomposition is H=UDV'; U and V are unitary; D is a diagonal matrix[.]" *Id.*, 3:19-32. In particular, Li-748 states to "obtain V at the transmitter, the transmitter may send training symbols to the receiver; the receiver may evaluate H, compute the matrix V'; and the receiver may feedback parameters representing V to the transmitter." *Id.*, 3:32-35.

Li-748 teaches feedback bandwidth is reduced because "the beamforming matrix V is represented by" fewer real numbers. *Id.*, 2:63-67.

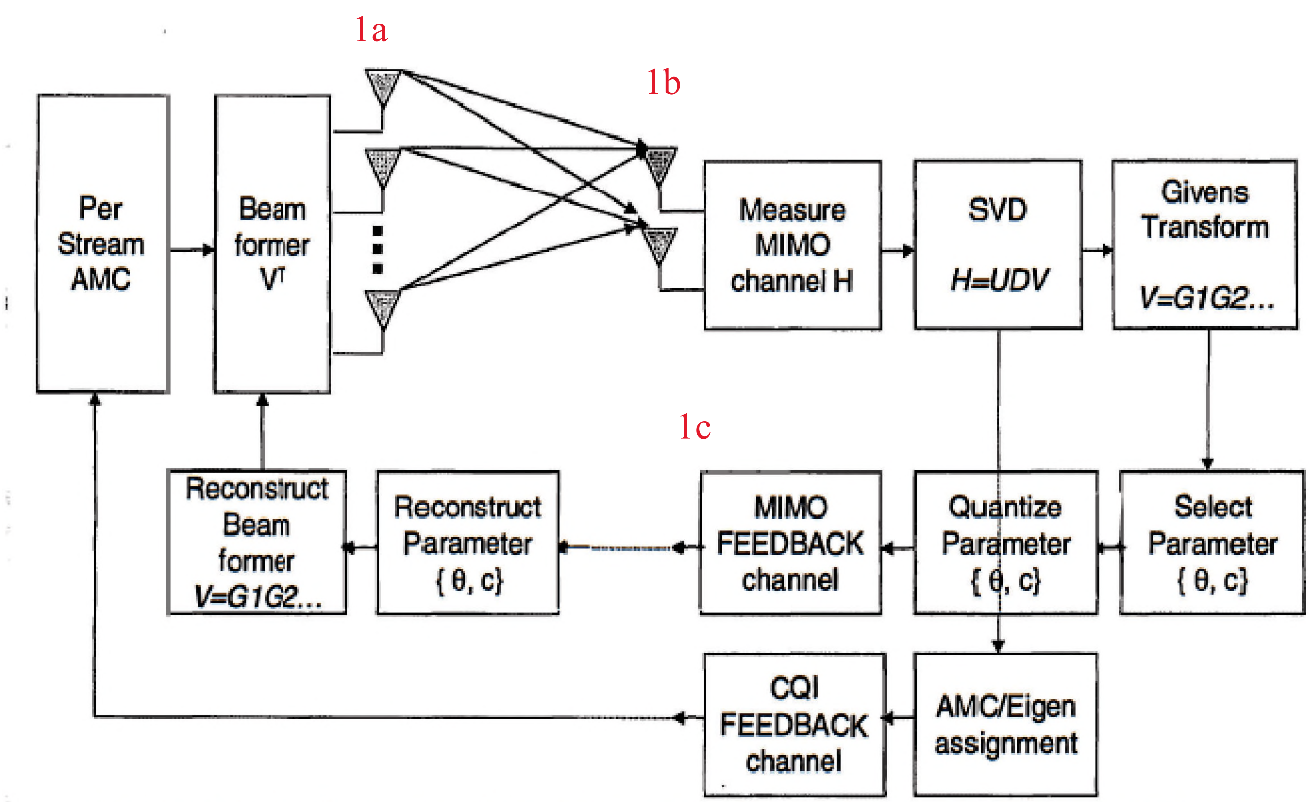
B. Tong Overview

Tong (EX1005), filed June 22, 2005 and published May 8, 2008, is prior art under, *e.g.*, §102(e). EX1005, cover. Tong additionally is prior art under §102(e) based on its 2004 provisional priority dates. *See Dynamic Drinkware, LLC, v. National Graphics, Inc.*, 800 F.3d 1375 (Fed. Cir. 2015). In accordance with *Dynamic Drinkware*, at least Tong's September 30, 2004 Provisional Application No. 60/614,621 ("'621 Provisional", EX1012), provides clear and unambiguous support for Tong's claim 1. EX1003, ¶206. The following table identifies examples of support in the '621 Provisional for each limitation of Tong's claim 1, as Dr. Wells confirms:

Tong (Claim 1) (EX1005)	Exemplary Support ('621 Prov.) (EX1012)
[1p] 1. A MIMO system comprising:	4, FIGs. 1-2, 7, 8, 12, 16, 29

[1a] a transmitter having multiple transmit antennas;	15, FIGs. 7, 8, 12, 16, 29
[1b] at least one receiver, each receiver having at least one receive antenna;	15, FIGs. 7-8, 12, 16, 29
[1c] each receiver being adapted to transmit at least one type of feedback information selected from a group consisting of: information for use in performing beam-forming; antenna selection/grouping information.	15, FIGs. 16, 29

1P **Figure 16**



For V matrix feedback, the BS is able to verify the integrity of the received matrix V by exploiting the orthogonality of the matrix

EX1003, ¶206 (annotated). Additionally, at least the ’621 Provisional and Tong’s Provisional Application No. 60/619,461 (EX1013, filed October 15, 2004) provide written description support for all Tong’s aspects cited herein. *See* EX1003, ¶207.

Tong discloses closed loop MIMO wireless communication. EX1005, Abstract. Tong discloses “a base station controller (BSC) 10 which controls wireless communications within multiple cells 12," including base stations 14 and mobile terminals 16. *Id.*, FIG. 1.

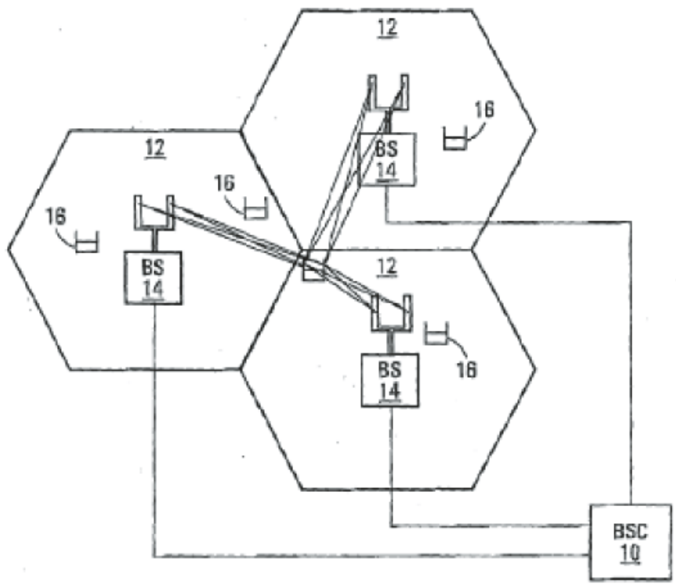


FIG. 1

Id., FIG. 1.

Figure 3 shows a high-level overview of mobile terminal 16 with "a control system 32, a baseband processor 34, transmit circuitry 36, receive circuitry 38, multiple antennas 40, and a network interface 42." *Id.*, [0077]. "The receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14." *Id.* "Downconversion and digitization circuitry" are used to "downconvert the filtered, received signal to an intermediate or baseband frequency signal." *Id.*

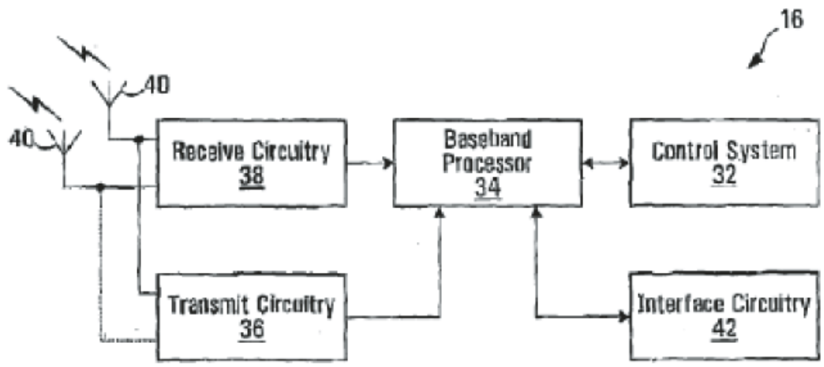


FIG. 3

Id., FIG. 3.

Figure 43 shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066]. A "receiver" receives signals using its "receive antennas 324" and performs a "channel measurement" at 326, which produces channel matrix H. *Id.*, [0223]. An SVD is performed on the channel matrix H at 328 to obtain the V matrix. *Id.* "[T]he V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which can be "uniquely represented by two parameters Θ and C." *Id.* This data is "fed back [to a transmitter] over the MIMO feedback channel 336." *Id.*, [0224].

Advantageously, "[b]y decomposing the SVD-based unitary V matrix into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters." *Id.*, [0227].

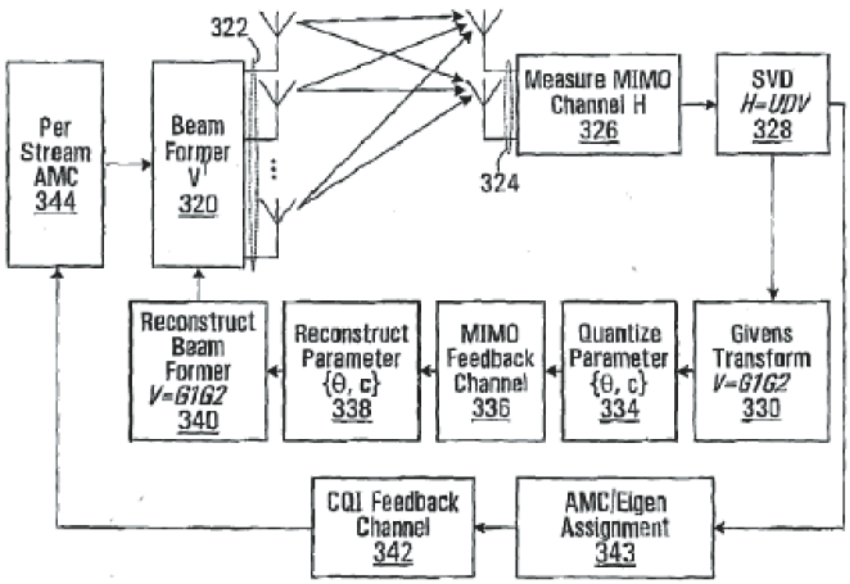
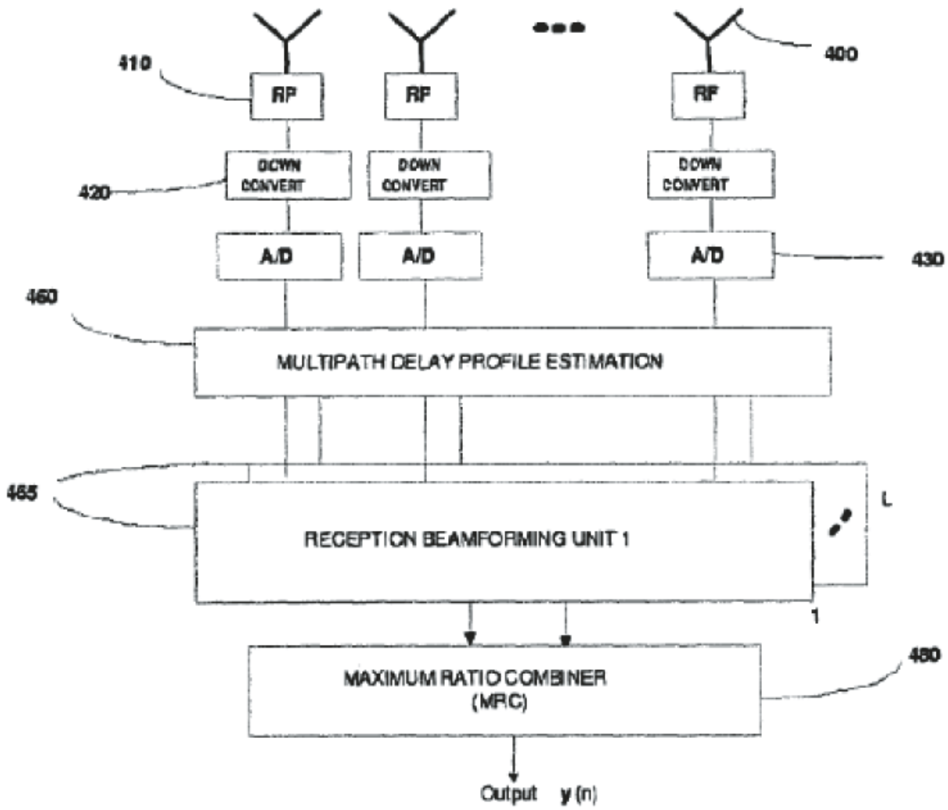


FIG. 43

Id., FIG. 43.

C. Mao Overview

Mao (EX1006), filed March 4, 2005 and issued December 25, 2007, is prior art under, *e.g.*, §102(e). EX1006, cover. Mao discloses an "adaptive beam-forming system" in "wireless communication systems." *Id.*, Abstract. Figure 1 shows "a receiver beam-forming system" with "antenna elements 400" that"feed[] into a plurality of RF units 410 and down converters 420." *Id.*, 7:34-42. The system includes A/D units 430, a multipath delay profile estimation unit 460, and beamforming units 465. *Id.*, 7:42-57.



Id., FIG. 1.

Mao's wireless communication system includes "antenna elements that receive and transmit radio-frequency signals, one or more radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals and transform analog transmit baseband signals into a transmit RF signals." *Id.*, 3:28-36.

D. Obviousness in view of Li-748, Tong, and Mao

Li-748's wireless station operates in a wireless network and sends and receives data. EX1004, 9:55-10:1. The station evaluates a channel matrix based on training symbols received from a transmitter, performs an SVD on the channel matrix to determine transmit beamforming matrix V, and transmis matrix V back to the transmitter. *Id.*, 2:52-59, 3:19-35. Tong's mobile devices operate within a wireless network that converts RF signals to baseband signals. EX1005, [0074]; §VII.B. Tong discloses a conventional practice: a mobile device (receiver) receives signals, determines channel matrix H, performs an SVD on channel matrix H to determine unitary matrix V, decomposes matrix V using a "Givens transform," then sends data generated from the Givens transform to the transmitter. *Id.*, [0223]-[0224]. Mao suggests using a wireless communication system (receiver beam-forming system) with RF units/frequency converters that transform received RF signals to "base-band signals." EX1006, 3:28-36, 7:34-35; §VII.C.

A POSITA would have been motivated to implement Li-748's wireless station as Tong discloses ("receive an RF signal and[] convert the RF signal into a baseband signal" in Element [9a] and "decompose" unitary matrix V using a traditional "Givens rotation" in Element [9f]) and by Mao ("form a baseband signal" in Element [9g]) to achieve a number of known benefits. EX1003, ¶¶77-79, 94-97.

A POSITA would have been motivated to implement Tong's teachings in Li-748's receiver as Mao suggests ("convert the RF signal to a baseband signal" in Element [9a] and "form a baseband signal" in Element [9g]) to achieve a number of known benefits. EX1003, ¶¶145-146, 161.

1. Claims 1-4

Method claims 1-4 correspond to device claims 9-12. Li-748's "electronic system 400" is a receiving wireless communication device. EX1004, 9:32-46, FIGs. 1, 4. It performs disclosed methods for feeding back transmitter beamforming information to a transmitting wireless device. *Id.*, 8:4-9:46, 10:16-24, Figs. 2-3. Accordingly, the elements of claims 1-4 are rendered obvious for the same reasons as the corresponding portions of claims 9-12. EX1003, ¶¶58, 72.

Claim 1	
Element	**Discussion**
[1.P] A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device, the method comprising:	§VII.D.2 (Element [9P])
[1a] the receiving wireless communication device receiving a preamble sequence from the transmitting wireless device;	§VII.D.2.d (Element [9c])
[1b] the receiving wireless device estimating a channel response based upon the preamble sequence;	§VII.D.2.e (Element [9d])
[1c] the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);	§VII.D.2.f (Element [9e])
[1d] the receiving wireless device decomposing the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and	§VII.D.2.g (Element [9f])
[1e] the receiving wireless device wirelessly sending the transmitter beamforming information to the transmitting wireless device.	§VII.D.2.h (Element [9g])
Claim 2	
The method of claim 1 wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises: the receiving	§VII.D.3 (Element [10])

wireless device producing the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and the receiving wireless device converting the estimated transmitter beamforming unitary matrix (V) to polar coordinates.	
Claim 3	
The method of claim 1 wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: $H=UDV^*$ where, D is a diagonal matrix.	§VII.D.4 (Element [11])
Claim 4	
The method of claim 3, wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises performing a Singular Value Decomposition (SVD) operation.	§VII.D.5 (Element [12])

2. Claim 9

a. [1p] and [9p]

Claim	Claim Language
1P	A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device, the method comprising:
9P	A wireless communication device, comprising:

Li-748 discloses this element. EX1003, ¶73. Referencing Figures 1 and 4, Li-748 discloses "***electronic system*** 400" which "may be utilized in a ***wireless*** network as ***station*** 102 or ***station*** 104." EX1004, 9:32-46, FIGs. 1, 4. Li-748 discloses the method of Figures 2-3 is "performed by a ***wireless communications device***." *Id.*, 7:57-60, 8:60-64.

b. [9a]

Claim	Claim Language
9a	a plurality of Radio Frequency (RF) components operable to receive an RF signal and to convert the RF signal to a baseband signal; and

The Li-748 in view of Tong renders obvious this element. EX1003, ¶¶74-79. Li-748 includes antennas 410 for sending and receiving signals and "[p]hysical layer (PHY) 430 [that] is coupled to antennas 410 to interact with a wireless network." EX1004, 9:55-63, FIG. 4. "PHY 430 includes an *RF receiver to receive signals and perform 'front end' processing* such as low noise amplification (LNA), filtering, [and] frequency conversion," "transform mechanisms and beam forming circuitry to support MIMO signal processing," "*circuits to support frequency up-conversion*, and an RF transmitter." *Id.*, 9:66-10:6. A POSITA would have understood Li-748's antennas and RF receiver are a plurality of RF components operable to receive an RF signal (consistent with well-known and widely used practices) and Li-748's "front end" processing performed by the RF receiver included the commonly known technique of converting of the RF signal to a baseband signal for further processing by the base station. EX1003, ¶76. Thus, Li-748 teaches the well-known components recited by this element.

Even if Li-748 did not expressly state RF components operate "to receive an RF signal and to convert the RF signal to a baseband signal," this feature was well-known, as Tong demonstrates. EX1003, ¶77. In Figure 3, Tong's mobile device includes "a control system 32, a baseband processor 34, transmit circuitry 36, *receive circuitry 38*, multiple antennas 40, and a network interface 42," where the "*receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14*." EX1005, [0077]; *see also id.*, [0074], [0088], [0094]-[0095], FIGS. 2-5. "*Downconversion and digitization circuitry*" is used to "*downconvert the filtered, received signal to* an intermediate or *baseband frequency signal*, which is then digitized into one or more digital streams." *Id.* Thus, a POSITA would have recognized this was a common and known practice for such wireless communication devices at the time. EX1003, ¶¶77-78.

Multiple reasons existed to motivate a POSITA to implement Li-748's device to receive an RF signal and convert the signal into baseband signals, as Tong discloses.

First, such an implementation of Li-748 in view of Tong would have predictably provided a mobile device to convert the received RF signals to baseband signals so as to advantageously and properly prepare for a digital conversion (to a digital signal) for processing by the digital electronics of the mobile device. EX1003, ¶78. At the time, such mobile devices included components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the widely known practice of converting the received RF signals to baseband signals for purposes of then converting to digital signals (for use internal to the mobile device). EX1003, ¶78.

Second, this implementation of Li-748 would have been merely the application of a known technique (*e.g.*, receiving and converting RF signals to baseband signals, as Tong discloses) to a known system (Li-748) yielding predictable results. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized applying Tong's suggestion of receiving and converting RF signals to Li-748 would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶79.

Third, it would have been obvious to try Tong's conversion techniques in Li-748 at least because it was one of a finite number of identified solutions for receiving and processing signals Li-748 teaches. Ex1003, ¶79. A POSITA would have understood the combination to be a predictable solution with a reasonable expectation of success, at least because Tong's RF conversion techniques were known and already used in wireless devices, including Li-748's devices. *Id.*

c. [9b][2]

Claim	Claim Language
9b	a baseband processing module operable to:

Li-748 alone or in view of the knowledge of a POSITA renders obvious this element. EX1003, ¶¶80-81. Li-748 discloses its wireless device (*e.g.*, station) includes antennas 410, physical layer (PHY) 430, *processor* 460, and *memory* 470. EX1004, 9:33-36. The "processor 460 reads instructions and data from memory 470 and performs actions in response thereto," and, for example, "processor 460 may access instructions from memory 470 and perform method embodiments of the present invention, such as method 200 (FIG. 2)." *Id.*, 10:16-22. Based upon Li-748's teaching, a POSITA would have recognized Li-748's above-described structures provided a baseband processing module, as was widely used in wireless communication devices like Li-748, and the processor was operable to perform the steps below. EX1003, ¶81.

[2] Patent Owner conceded that this element was well known; the court similarly acknowledged a "baseband processing module" was "well known in the art and its actual operation was well known." EX1020, 111:4-10; 117:18-22.

d. [1a] and [9c]

Claim	Claim Language
1a	the receiving wireless communication device receiving a preamble sequence from the transmitting wireless device;
9c	receive a preamble sequence carried by the baseband signal;

Li-748 in view of the knowledge of a POSITA renders obvious this element. EX1003, ¶¶82-83. Li-748 discloses "[t]o obtain V at the transmitter, the transmitter may send *training symbols* to the receiver; the receiver may evaluate H, compute the matrix V'; and the receiver may feedback parameters representing V to the transmitter." EX1004, 3:31-34. Li-748 explains "channel state information is estimated from *received signals*." *Id.*, 8:4-7 (emphasis added), Fig. 2.

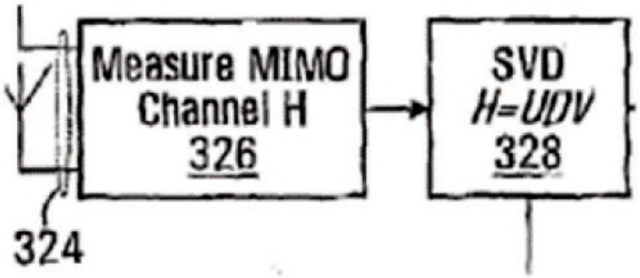
A POSITA would have recognized Li-748 uses "training symbols" to determine a channel response H and beamforming matrix V, just like the preamble of the '862 patent. EX1003, ¶83 (citing 13:37-47). The '862 patent confirms the wireless communication device "receiv[es] a preamble sequence from the transmitting wireless device and estimat[es] a channel response (H) from the preamble sequence." EX1001, 14:21-24. This "preamble" mentioned in the '862 patent also used the traditional "training symbols" (13:40-44), as was customary at the time for purposes of estimating a channel response (H) and using the channel response to calculate the beamforming matrix V. EX1003, ¶83.

e. [1b] and [9d]

Claim	Claim Language
1b	the receiving wireless device estimating a channel response based upon the preamble sequence;
9d	estimate a channel response based upon the preamble sequence;

Li-748 in view of Tong, renders obvious this element. EX1003, ¶¶84-85. Li-748 discloses "*channel state information is estimated from received signals*," where the "channel state information may include the *channel state matrix H*." EX1004, 8:4-7; FIG. 2 (210).

To the extent it Li-748 does not disclose or render obvious this limitation, it would have been obvious to a POSITA at the time to implement Tong's teachings in the Li-748's device. EX1003, ¶¶85, 115-116. Tong discloses "*pilot symbols*" are received by a receiver from a transmitter, and the "MIMO *channel H is measured*," or estimated, by the receiver based on the pilot symbols. EX1005, [0211], [0087], [0090] ("actual and interpolated channel responses are used to estimate an overall channel response"). Referencing Figure 43, Tong discloses "[a]t the receiver, receive antennas 324 receive signals, and the channel measurement is performed at 326," which "***produces the channel matrix***," matrix H is then "SVD decomposed at 328":



Id., [0223], FIG. 43 (excerpted).

f. [1c] and [9e]

Claim	Claim Language
1c	the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
9e	determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);

Li-748 discloses this element. EX1003, ¶¶86-87. Li-748 discloses "transmit beamforming matrix" referred to as V may be found by using SVD as follows:

H=UDV'

X=Vd

where d is the n-vector of code bits for n data streams; x is the transmitted signal vector on the antennas; *H is the channel matrix*; H's singular value decomposition is H=UDV'; U and V are unitary; D is a diagonal matrix with H's eigenvalues; V is n by n, and n is the number of spatial channels. EX1004, 3:19-32; FIG. 2 (22). Based upon Li-748's teaching, a POSITA would have recognized, in this widely known

SVD equation (H=UDV'), channel matrix "H" was the ordinary symbol for the channel response, matrix "V" was the ordinary symbol for the transmit beamforming matrix, and matrix "U" was the ordinary symbol for the receiver beamforming unitary matrix. EX1003, ¶87.

g. [1d] and [9f]

Claim	Claim Language
1d	the receiving wireless device decomposing the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
9f	decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and

Li-748 in view of Tong renders obvious this element. EX1003, ¶¶88-91. As an initial matter, Li-748 discloses in some embodiments, "the beamforming matrix V is represented by n^2-1 real numbers instead of $2n^2$ real numbers," and "[b]y sending n^2-1 real numbers instead of $2n^2$ real numbers, the feedback bandwidth *may be reduced*." EX1004, 2:63-67; *see* 3:35-39. Notably, this teaching is similar to the '862 patent, which explains "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device ***are reduced***." EX1001, 13:67-14:3. A POSITA would have recognized Li-748 similarly disclosed a reduction, or decomposition, of the transmit beamforming matrix. EX1003, ¶89. Thus, Li-748 discloses this element.

To the extent Li-748 does not disclose this limitation, a POSITA would have recognized that feature was widely known and used in similar wireless communication devices, as Tong demonstrates. EX1003, ¶90. Tong discloses "[b]y ***decomposing the SVD-based unitary V matrix*** into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters." EX1005, [0227] (emphasis added). Tong's Figure 43 (above) shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066]; FIG. 43. Tong discloses an SVD is performed on the channel matrix H at 328, and the "***the V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which "can then be uniquely represented by two parameters Θ and C***." *Id.*, [0223] (emphasis added). A POSITA viewing Li-748 would have recognized this limitation was known and used in similar devices and systems. EX1003, ¶¶90-91.

It would have been obvious to a POSITA to implement Tong's Givens-rotation-based decomposition techniques in Li-748's device. Multiple reasons would have motivated a POSITA to combine these references.

First, this predictable implementation would have advantageously resulted in a device that can reduce the feedback bandwidth by reducing the amount of data fed back to the transmitter. EX1003, ¶91. Tong confirms this known benefit by explaining this solution would "reduce the amount of feedback required." EX1005, [0222]. Thus, a POSITA would have been motivated to implement the Li-748's device to perform Tong's Givens rotation to decompose matrix V to achieve the goal of reducing feedback as disclosed in Li-748. EX1003, ¶91.

Second, a POSITA would have been motivated to combine Li-748 and Tong (e.g., for performing a Givens rotation) to verify received data. *Id*. The combination would have advantageously allowed a transmitter receiving the transmitter beamforming information from Li-748's device "to verify the integrity of the received matrix V." EX1005, [0226]; EX1003, ¶91.

Third, this predictable implementation of Li-748's device would have been merely the application of a known technique (*e.g.*, performing a Givens rotation-based decomposition on matrix V, as Tong teaches) to a known system (Li-748's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized applying Tong's suggestion of decomposing matrix V using a conventional "Givens rotation" to Li-748's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶91. Thus, it would have been obvious to a POSITA to implement Li-748's device in light of Tong's suggestion for decomposing matrix V with a conventional "Givens rotation." EX1003, ¶91.

h. [1e] and [9g]

Claim	Claim Language
1e	the receiving wireless device wirelessly sending the transmitter beamforming information to the transmitting wireless device.

9g	form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device.

Li-748 in view of Tong, Mao renders obvious this element. EX1003, ¶¶92-97. As an initial matter, Li-748 discloses this element, explaining "the receiver may evaluate H, compute the matrix V; and the receiver may feedback parameters representing V to the transmitter," and "the number of feedback parameters used to represent V may be reduced." EX1004, 3:31-39; FIG. 2 (element 240). Additionally, based upon Li-748's teachings regarding the receiver providing feedback to the transmitter, a POSITA would have recognized the wireless device "formed a baseband signal employed by the plurality of RF components to wirelessly send ... beamforming information" as was known and used in such wireless devices at the time. EX1003, ¶¶92-93.

To the extent Li-748 alone does not to disclose or render obvious this limitation, it would have been obvious to a POSITA to implement this feature in the Li-748 device at least because the technique was widely used in similar wireless devices, as evidence by each of Tong and Mao. EX1003, ¶¶94-96.

For example, it would have been obvious to implement Tong's teachings in Li-748's device to practice this limitation. Tong discloses "the baseband processor 34 receives digitized data … from the control system 32, which it encodes for transmission." EX1005, [0079]; *see also id.*, [0076], [0087], [0094]-[0095], FIGS. 2-5. Tong explains "*encoded data*" should be "output to the transmit circuitry 36, where it is used by a modulator to modulate a carrier signal that is at a desired transmit frequency or frequencies." *Id.* Tong discloses for providing output streams of data, each of the "signals is *up-converted* in the digital domain to an intermediate frequency and converted to an analog signal via the corresponding digital up-conversion (DUC) and digital-to-analog (D/A) conversion circuitry 66. The *resultant (analog) signals are then simultaneously modulated at the desired RF frequency*, amplified, and *transmitted via the RF circuitry 68 and antennas 28*." *Id.*, [0087]. A POSITA would have recognized these "resultant signals" were conventional baseband signals generated by Tong's baseband processor. EX1003, ¶¶94-95. Tong discloses baseband signals are employed by a plurality of RF components (RF circuitry including up-conversion and digital-to-analog conversion circuitry, amplifiers, antennas, etc.) to wirelessly send the transmitter beamforming information to the transmitting wireless device. Accordingly, the combination of Li-748 and Tong renders obvious this element. Ex1003, ¶95. For the same reasons articulated above (*supra* §VII.D.2.b (Element [9a])), a POSITA would have implemented the Tong's teachings (forming baseband signals for wireless transmission by RF components) in Li-748's device to achieve predictable and known benefits—including conversion between digital signals and RF signals and vice versa. EX1003, ¶95.

Additionally, it would have been obvious to implement Mao's teachings in the combination of Li-748 and Tong. Mao discloses mobile devices using "a plurality of *antenna elements* that receive and *transmit radio-frequency signals*, *one or more radio-frequency units and frequency converters configured to … transform analog transmit base-band signals into a transmit RF signals*." EX1006, 3:28-36; *see also id.*, 1:62-2:4, 3:29-53, 4:57-67, 5:40-47, 7:40-44, 11:58-63, 12:4-9, FIGS. 1, 8, 9-10. Mao discloses "*a plurality of up-converters which transform base-band signals into RF signals*." *Id.*, 6:34-35; *see also id.*, 6:29-38, 12:26-39, 12:51-59, FIGS. 6, 9-10. Thus, if Tong's "resultant (analog) signals" do not constitute "baseband signals" as recited in Element [9g], Mao teaches forming "base-band signals" for transmission via RF components as recited in this element.

A POSITA would have been motivated to modify Li-748's device in light of Tong and Mao (to form a baseband signal employed by the plurality of RF components at least related to element 9[a] and 9[g]) for multiple reasons.

First, such an implementation of Li-748 with Tong and Mao would have predictably provided a wireless device that would convert the digital baseband signal (processed by Li-748's device) via a plurality of RF components so as to advantageously prepare for wireless transmission. EX1003, ¶97. Mao teaches employing baseband signals with a plurality of RF components for purposes of "transform[ing] the base-band signals into RF signals" for wireless transmission. *Id.* (citing 6:34-35).

Second, this ordinary implementation of Li-748 would have been merely the application of a known technique (*e.g.*, forming a baseband signal employed by the plurality of RF components) to a known system (Li-748's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized applying Tong and Mao's teachings of forming baseband signals employed by RF components for wireless transmission to Li-748's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶97.

3. Claims 2 and 10

Claim	Claim Language
2	The method of claim 1 wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises: the receiving wireless device producing the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and the receiving wireless device converting the estimated transmitter beamforming unitary matrix (V) to polar coordinates.
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.

Li-748 in combination with Tong and Mao, renders obvious this claim. EX1003, ¶¶98-101.

As an initial matter, Li-748 discloses determining an estimated "transmit beamforming matrix" (V) using single-value decomposition" with the equation "H=UDV'" produces matrix V in Cartesian coordinates. EX1004, 3:19-23. Li-748 also discloses "the beamforming matrix V is represented by n^2-1 real numbers instead of $2n^2$ real numbers." *Id.*, 2:63-65. Li-748 also describes "hermitian generator matrices ... utilized to represent the beamforming matrix" where the numbers are "angles from –π to π of an (n2-1)-dimension polar coordinate...." *Id.*, 3:5-11. A POSITA would have understood these disclosures to refer to producing a beamforming matrix V in cartesian coordinates before converting it to polar coordinates. EX1003, ¶98.

To the extent Li-748 alone or in view of the knowledge of a POSITA does not disclose this limitation, it would have been obvious to implement Tong's teachings in Li-748's device. EX1003, ¶99. Tong discloses "employing an SVD based Givens transform feedback" and "*the V matrix is decomposed* by the Givens transform 330 to produce a series of matrices," which "can then be uniquely represented by *two parameters Θ and C*." EX1005, [0066], [0223]. Tong additionally discloses a "V matrix can be decomposed into Givens matrices containing n^2-2 *complex* *parameters*." *Id.*, [0222]. A POSITA would have understood "parameters Θ and C" are traditional polar coordinate representations of the angle and distance, respectively, and would have recognized Tong's reference to "complex parameters" indicate Givens matrices would have been produced in polar coordinates, in accordance with normal practice at the time. EX1003, ¶99. A POSITA would have understood to perform Tong's suggested Givens rotation on matrix V and "produce a series of matrices" represented by "two parameters Θ and C," one would necessarily first need to convert matrix V from Cartesian to polar coordinates. EX1003, ¶99.

A POSITA would have understood these references (Li-748 and Tong) to disclose producing a beamforming matrix V in cartesian coordinates before converting it to polar coordinates. EX1003, ¶100. Yang (EX1008) demonstrates converting Cartesian coordinates to polar coordinates was well-known for in similar beam-forming systems, and a POSITA at the time would have understood these concepts and their application to same technology and field of use described by Li-748 and Tong. Yang is directed to a "method for computing two-sided rotations involved in singular value decomposition (SVD)" that "leads to significantly reduced computations." EX1008, Abstract.

Yang explains there was "massive interest in parallel architectures for computing SVD," and discloses the use of "coordinate rotation digital computer

(CORDIC) processors" to avoid the "computational overhead" of previous computational methods. EX1008, 1, Abstract. Yang discloses a "CORDIC algorithm" for computing "Cartesian-to-polar coordinates conversions." *Id.*, 4. Yang explains SVD, which arises in beam-forming, has a "high computational complexity," but the CORDIC algorithm reduces the complexity, including the step of Cartesian-to-polar coordinates conversions. *Id.*, 1, 5, Abstract. Using this algorithm, Yang explains "the Cartesian coordinate (x0, y0) of a plane vector is converted to its polar representation." *Id.*, 6. Thus, as Yang shows, a POSITA would have understood the uses and applications for first producing beamforming matrix V in Cartesian coordinates and then converting V to polar coordinates and would have understood Li-748 and Tong discloses these claimed uses.

As discussed with respect to claim [9f], multiple reasons existed to prompt a POSITA to implement Li-748's wireless device to include Tong's Givens rotation-based decomposition. This predictable combination would have also included a baseband module that converts matrix V from Cartesian to polar coordinates so matrix V would then be decomposed using a Givens rotation, as Tong discloses and as was known to a POSITA. EX1003, ¶100.

4. Claims 3 and 11

Claim	Claim Language
3	The method of claim 1 wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver

	beamforming unitary matrix (U) are related by the equation: H=UDV* where, D is a diagonal matrix.
11	The wireless communication device of claim 9, wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: H=UDV* where, D is a diagonal matrix.

Li-748 discloses this claim. EX1003, ¶¶102-104. In particular, Li-748 discloses transmit beamforming matrix V may be found by "using SVD as follows:

H=UDV'

where … *H is the channel matrix*; H's singular value decomposition is H=UDV'; *U and V are unitary [matrices]*; *D is a diagonal matrix* with H's eigenvalues." EX1004, 3:19-32, 8:7-11, FIG. 2; *supra* §§VII.D.2.f-2.g (Elements [9e]-[9f]).

5. Claims 4 and 12

Claim	Claim Language
4	The method of claim 3, wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises performing a Singular Value Decomposition (SVD) operation.
12	The wireless communication device of claim 9, wherein in determining the estimated transmitter beamforming unitary matrix (V) based upon the channel response and the receiver beamforming unitary matrix (U), the baseband processing module performs Singular Value Decomposition (SVD) operations.

As discussed above (claim 11), Li-748 discloses this claim. EX1003, ¶¶105-106; EX1004, 3:19-32; *supra* §§VII.D.2.c, VII.D.2.f-2.g, VII.D.4 (Elements [9b], [9e]-[9f], [11]).

VIII. GROUND 2: CLAIMS 1-4 and 9-12 ARE OBVIOUS OVER TONG AND MAO

As explained, Tong describes a wireless communication device and conventional practice where a device (receiver) receives signals, produces channel matrix H, performs an SVD on channel matrix H to determine beam-forming matrix V, and decomposes matrix V by the "Givens transform" to produce reduced feedback information to send to a transmitter. EX1005, [0073], [0223]; §VII.B. These disclosures match the alleged solution of the '862 patent. EX1001, 13:58-67 ("Givens Rotation").

Mao demonstrates traditional practices of receiver beam-forming systems: antennas receive RF signals and RF units/frequency converters then transform the RF signals to baseband signals. EX1006, 3:28-36, 7:34-35; §VII.C. A POSITA would have implemented Tong's device as Mao suggests (including "forming a baseband signal" in Element [9g]) to achieve a number of known benefits discussed below. EX1003, ¶¶123-125.

1. Claims 1-4

Method claims 1 and 3-4 correspond to device claims 9 and 11-12. Tong's mobile device (mobile terminal 16) is a receiving wireless communication device. Ex1005, ¶[0073], FIGS. 1-3. It performs disclosed methods for feeding back transmitter beamforming information to a transmitting wireless. Ex1005, ¶¶[0073]-[0077], FIGs. 1-3. Accordingly, the elements of claims 1-4 are rendered obvious for the same reasons as the corresponding portions of claims 9-12. EX1003, ¶107.

Claim 1	
Element	**Discussion**
[1p]	§VIII.2.a (Element [9P])
[1a]	§VIII.2.d (Element [9c])
[1b]	§VIII.2.e (Element [9d])
[1c]	§VIII.2.f (Element [9e])
[1d]	§VIII.2.g (Element [9f])
[1e]	§VIII.2.h (Element [9g])
Claim 2	
[2]	§VIII.3 (Element [10])
Claim 3	
[3]	§VIII.4 (Element [11])
Claim 4	
[4]	§VIII.5 (Element [12])

2. Claim 9

a. [1p] and [9p][3]

Tong discloses the preamble. EX1003, ¶¶109. Tong discloses "a base station controller (BSC) 10 which controls *wireless communications* within multiple cells 12, which cells are served by corresponding *base stations (BS) 14*." EX1005, [0073], FIG. 1. The "*base stations 14 and mobile terminals 16* may include *multiple antennas to provide spatial diversity for communications*." *Id.*

b. [9a]

Tong discloses this element. EX1003, ¶¶110-111. Tong's mobile device includes "a baseband processor 34, transmit circuitry 36, *receive circuitry 38*, multiple antennas 40, and a network interface 42," where the "*receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14*." EX1005, [0077]; *see also id.*, [0074], [0088], [0094]-[0095], FIGS. 2-5. "*Downconversion and digitization circuitry*" is used to "*downconvert the filtered, received signal to* an intermediate or *baseband frequency signal*, which is then digitized into one or more digital streams." *Id.*

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[3] For Grounds 2-5, Elements are defined as in Ground 1.

c. [9b][4]

Tong discloses this element. EX1003, ¶112. Tong's mobile device includes "*a baseband processor 34*." EX1005, [0077], FIG. 3. "The baseband processor 34 processes the digitized received signal to extract the information or data bits conveyed in the received signal," including "demodulation, decoding, and error correction operations." *Id.*, [0078]. It is "generally implemented in one or more digital signal processors (DSPs) or application-specific integrated circuits (ASICs)." *Id.*

d. 1[a] and [9c]

Tong renders obvious this element. EX1003, ¶¶113-114. Tong's "*pilot symbols*" are received by a receiver from a transmitter, and the "MIMO channel H is measured" by the receiver based on the pilot symbols, and beamforming matrix V is subsequently determined. EX1005, [0211], [0087]. A POSITA would have recognized Tong's "pilot symbols" operated like a conventional preamble to determine a channel response H and beamforming matrix V, much like the preamble of the '862 patent. EX1003, ¶114 (citing 13:37-47); EX1005, [0211], [0223]; *see also* EX1001, 14:21-24.

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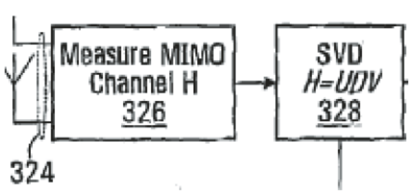
[4] *Supra* footnote 3.

Like Tong's "pilot symbols," the '862 patent's "preamble" comprises known data received from a transmitter for the purpose of estimating a channel response (H) and determining a beamforming matrix V. EX1003, ¶114 (citing to [0090], [0211]); *see* EX1001, 13:37-44.

e. 1[b] and [9d]

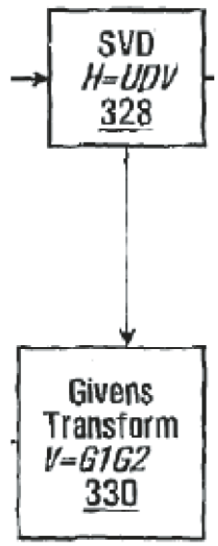
Tong discloses this element. EX1003, ¶¶115-116. Tong discloses "*pilot symbols*" are received by a receiver from a transmitter, and the "MIMO *channel H is measured*," or estimated, by the receiver based on the pilot symbols. EX1005, [0211], [0087], [0090] ("actual and interpolated channel responses are used to estimate an overall channel response"). Referencing, Tong discloses "[a]t the receiver, receive antennas 324 receive signals, and the channel measurement is performed at 326," which "***produces the channel matrix***," matrix H is then "SVD decomposed at 328":



Id., [0223], FIG. 43 (excerpted).

f. 1[c] and [9e]

Tong discloses this element. EX1003, ¶¶117-118. Tong discloses "SVD is performed on the channel matrix H at 328" used to determine the transmit beamforming matrix V:



EX1005, [0223], FIG. 43 (excerpted).

Based upon Tong's teaching, a POSITA would have recognized, in the commonly known SVD equation (H=UDV′), channel matrix "H" was the ordinary symbol for the channel response, "V" was the ordinary symbol for the transmit beamforming matrix, and "U" was the ordinary symbol for the receiver beamforming unitary matrix. EX1003, ¶118.

g. 1[d] and [9f]

Tong discloses this element. EX1003, ¶¶119-120. Tong discloses "[b]y *decomposing the SVD-based unitary V matrix* into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters," thereby reducing the required feedback. EX1005, [0227], [0222]. In particular, discussing Figure 43 (above at 9[e]), Tong shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066], FIG. 43. Tong discloses an SVD is performed on the channel matrix H at 328, and the "*the V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which "can then be uniquely represented by two parameters Θ and C.*" *Id.*, [0223]. Tong's teachings mirror the '862 patent's examples. EX1001, 13:58-67 ("Givens Rotation").

h. 1[e] and [9g]

Tong in view of Mao renders obvious this element. EX1003, ¶¶121-125. Tong discloses "the baseband processor 34 receives digitized data … from the control system 32, which it encodes for transmission." EX1005, [0079]; *see also id.*, [0076], [0087], [0094]-[0095], FIGS. 2-5. Tong teaches "*encoded data*" should be "output to the transmit circuitry 36, where it is used by a modulator to modulate a carrier signal that is at a desired transmit frequency or frequencies." *Id.* Tong discloses:

> Each of the resultant signals is *up-converted* in the digital domain to an intermediate frequency and converted to an analog signal via the corresponding digital up-conversion (DUC) and digital-to-analog (D/A)

> conversion circuitry 66. The *resultant (analog) signals are then simultaneously modulated at the desired RF frequency*, amplified, and *transmitted via the RF circuitry 68 and antennas 28*.

Id., [0087]. A POSITA would have recognized these "resultant signals" were conventional baseband signals generated by Tong's baseband processor Tong's RF components employed to wirelessly send beamforming information. EX1003, ¶122. Accordingly, Tong discloses this element. EX1003, ¶122.

To the extent Tong does not disclose or render obvious this limitation, it would have been obvious to implement Mao's teachings in Tong's system. EX1003, ¶123. Mao explains it was widely known in wireless communications devices to use "a plurality of *antenna elements* that receive and *transmit radio-frequency signals*, *one or more radio-frequency units and frequency converters configured to … transform analog transmit base-band signals into a transmit RF signals*." EX1006, 3:28-36; *see also id.*, 1:62-2:4, 3:29-53, 4:57-67, 5:40-47, 7:40-44, 11:58-63, 12:4-9, FIGS. 1, 8, 9-10. Mao discloses "*a plurality of up-converters which transform base-band signals into RF signals*." *Id.*, 6:34-35 *see also id.*, 6:29-38, 12:26-39, 12:51-59, FIGS. 6, 9-1. Thus, even if Tong does not expressly state its "resultant signals or "resultant (analog) signals" were "baseband signals" as recited in Element [9g], Mao plainly teaches the well-known practice of forming "base-band signals" as recited in this element. EX1003, ¶124.

A POSITA would have been motivated to implement Mao's teachings in Tong's device for a number of reasons.

First, combination would have predictably provided a mobile device that would convert the digital signal (processed by Tong's device) to a baseband signal so as to advantageously prepare for RF wireless transmission to the remote device. EX1003, ¶125. As Mao explains, it was a known benefit to form such baseband signals for purposes of "transform[ing] the base-band signals into RF signals" for transmission. *Id.* (citing 6:34-35).

Second, this ordinary implementation of Tong would have been merely the application of a known technique (forming a baseband signal employed by the plurality of RF components) to a known system (Tong's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized applying Mao's suggestion of receiving and converting RF signals to Tong's device would have led to predictable results without significantly altering or hindering the functions performed by the receiving station. EX1003, ¶125.

3. Claims 2 and 10

Tong in view of Mao renders obvious this limitation. EX1003, ¶¶126-128. Tong discloses "employing an SVD based Givens transform feedback" and "*the V matrix is decomposed* by the Givens transform 330 to produce a series of matrices," which "can then be uniquely represented by *two parameters Θ and C*." EX1005,

[0066], [0223]. Tong additionally discloses "V matrix can be decomposed into Givens matrices containing n^2-2 *complex parameters*." *Id.*, [0222].

A POSITA would have understood "parameters Θ and C" are polar coordinates representing the angle and distance, respectively, and recognized Tong's reference to "complex parameters" disclosed or suggested the Givens matrices were produced in polar coordinates, in accordance with the normal practice at the time. EX1003, ¶127. A POSITA would also have understood to perform Tong's suggested Givens rotation on matrix V and "produce a series of matrices" represented by "two parameters Θ and C," one would necessarily first need to convert matrix V from Cartesian to polar coordinates. *Id*.

Yang (EX1008) demonstrates converting Cartesian coordinates to polar coordinates was well-known and used in similar beam-forming systems, and a POSITA at the time would have understood these concepts and their application to Tong's technology and field of use. Ex1003, ¶128. Yang is directed to a "method for computing two-sided rotations involved in singular value decomposition (SVD)" "lead[ing] to significantly reduced computations." EX1008, Abstract. Yang explains there was "massive interest in parallel architectures for computing SVD" and discloses the use of "coordinate rotation digital computer (CORDIC) processors" to avoid the "computational overhead" of previous computational methods. EX1008, 1, Abstract. Yang discloses a "CORDIC algorithm" for computing "Cartesian-to-polar coordinates conversions." *Id.*, 4. Yang explains SVD, which arises in beam-forming, has a "high computational complexity," but the CORDIC algorithm reduces the complexity in part because of its Cartesian-to-polar coordinates conversions *Id.*, 1, 5, Abstract. Using this algorithm, Yang explains "the Cartesian coordinate (x0, y0) of a plane vector is converted to its polar representation." *Id.*, 6. Thus, as Yang demonstrates, a POSITA would have known applications for first producing beamforming matrix V in Cartesian coordinates and then converting V to polar coordinates and would have understood Tong discloses these claimed uses.

4. Claims 3 and 11

Tong in view of Mao renders obvious this claim. EX1003, ¶¶129-130. Tong discloses an "SVD is performed on the channel matrix H at 328":

EX1005, [0223], FIG. 43 (excerpted); *supra* §§VIII.2.f-2.g (Elements [9e]-[9f]).

5. Claims 4 and 12

As discussed above, Tong discloses this claim element, including performing a Singular Value Decomposition (SVD) operation. EX1003, ¶¶131-132; EX1005, [0223] ("produces the channel matrix which is then SVD decomposed"), FIG. 43; *supra* §§VIII.2.f-2.g, VIII.4 (Elements [9e]-[9f], [11]).

IX. GROUND 3: CLAIMS 1, 3, 4, 9, 11, AND 12 ARE OBVIOUS OVER LI-054 AND MAO

A. Li-054 Overview

Li-054 (EX1007), filed September 8, 2004 and published May 4, 2006, is prior art under, *e.g.*, §102(e). EX1007, cover. Li-054 teaches a "closed loop MIMO system" reduces "feedback bandwidth" by using "Householder transformations and vector quantization using codebooks." *Id.*, Abstract. Li-054 discloses wireless stations 102 and 104 in a wireless local area network:

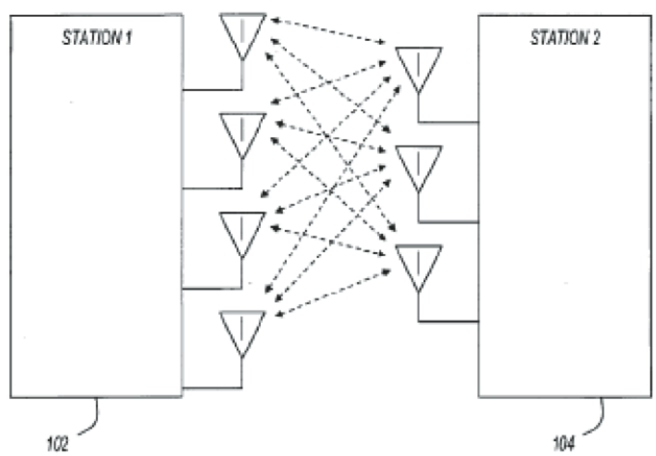


FIG. 1

Id., [0011], FIG. 1.

Figure 5 shows a diagram of a system "includ[ing] antennas 510, physical layer (PHY) 530, … processor 560, and memory 570" and can perform various operations. *Id.*, [0101]. Li-054 discloses "receiver receives training symbols and computes the beamforming matrix, V." *Id.*, [0022]. The "beamforming matrix V is fed back from the receiver to the transmitter." *Id.*, [0019].

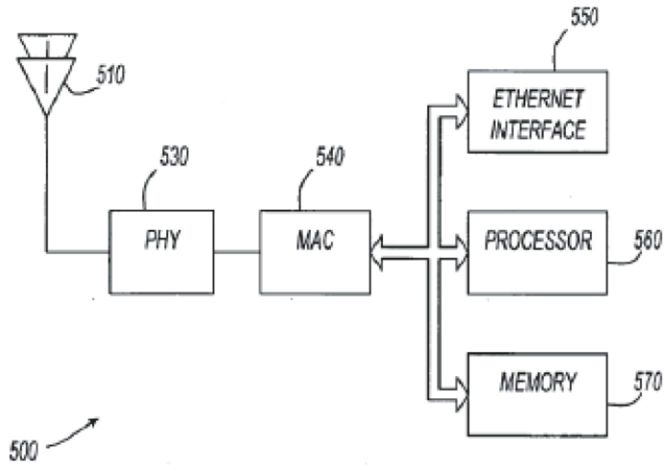


FIG. 5

Id., FIG. 5.

Li-054 describes this process in detail (Figure 3). At 310, "channel state information is estimated from received signals," where the "channel state information may include the channel state matrix H." *Id.*, [0093], FIG. 3. "At 320, a beamforming matrix is determined from the channel state information," which, may "correspond[] to performing singular value decomposition (SVD)" using the equation: $H_{mxn} = U_{mxm}D_{mxn}V'_{nxn}$. *Id.*, [0093], [0018]. "At 330, a column of a beamforming matrix is quantized using a codebook," and at 340, "a householder reflection is performed on the beamforming matrix to reduce the dimensionality of the beamforming matrix." *Id.*, [0094]-[0095]. At 360, "the quantized column vectors are transmitted." *Id.*, [0096], FIG. 3.

B. Obviousness in view of Li-054 and Mao

Li-054 is directed to a conventional wireless system (*e.g.*, receiver) estimates channel state information from received signals, determines a beamforming matrix from the estimated channel state information, and reduces the beamforming matrix before sending it to a transmitter. EX1008, [0018], [0093]-[0095]. As described above (§VII), Mao teaches a wireless communication system (*e.g.*, receiver beam-forming system) receives RF signals and RF units/frequency converters transform the RF signals to base-band signals. EX1006, 3:28-36, 7:34-35; §VII.C.

A POSITA would have been motivated to implement Li-054's receiver as Mao suggests ("convert the RF signal to a baseband signal" in Element [9a] and "form a baseband signal" in Element [9g]) to achieve a number of known benefits. EX1003, ¶¶145-146, 161.

1. Claims 1, 3, and 4

Method claims 1 and 3-4 correspond to device claims 9 and 11-12. Li-054's "wireless stations" are receiving wireless communication devices performing methods for feeding back transmitter beamforming information to transmitting wireless devices. Ex1007, ¶¶[0011]-[0014], Fig. 1. Accordingly, the elements of claims 1 and 3-4 are rendered obvious for the same reasons as the corresponding portions of claims 9 and 11-12. EX1003, ¶133.

Claim 1	
Element	**Discussion**

[1.P]	§**Error! Reference source not found.** (Element [9P])
[1a]	§**Error! Reference source not found.** (Element [9c])
[1b]	§IX.B.2.e (Element [9d])
[1c]	§IX.B.2.f (Element [9e])
[1d]	§IX.B.2.g (Element [9f])
[1e]	§IX.B.2.h (Element [9g])
Claim 3	
[3]	§IX.B.3 (Element [11])
Claim 4	
[4]	§IX.B.4 (Element [12])

2. Claim 9

a. [1p] and [9p]

To the extent the preamble is limiting, Li-054 discloses the preamble. EX1003, ¶140. Li-054 discloses "two ***wireless stations***, station 102, and station 104," which may be part of a wireless local area network:

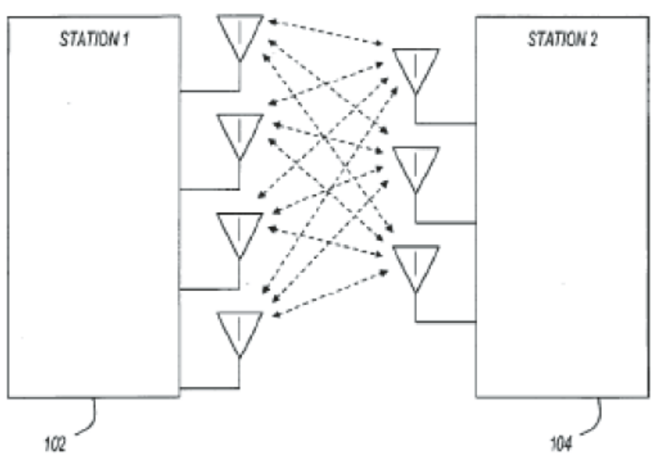


FIG. 1

EX1007, [0011], FIG. 1. Li-054 discloses the stations include antennas and "*may communicate* using Multiple-Input-Multiple-Output (MIMO) techniques." *Id.*,

[0013]. Li-054 discloses "electronic system 500 may be utilized in a *wireless network as station 102 or station 104*." *Id.*, [0101], FIG. 5.

b. [9a]

The combination of Li-054 and Mao renders obvious this element. EX1003, ¶¶141-146. As an initial matter, Li-054's electronic system 500 (*e.g.*, station) "sends and *receives signals using antennas 510*." EX1007, [0103]. The system 500 includes a "[p]hysical layer (PHY) coupled to antennas 510 to interact with a wireless network" and "*circuitry to support the transmission and reception of radio frequency (RF) signals*." *Id.*, [0104]. "PHY 530 includes an *RF receiver to receive signals* and perform 'front end' processing such as … *frequency conversion* or the like." *Id.*

A POSITA would have recognized Li-054's conventional "antennas," "circuitry," and "RF receiver" provided a plurality of RF components operable to receive an RF signal. EX1003, ¶143. A POSITA would also have understood Li-054's description of its RF receiver as disclosing frequency conversion circuitry that converts the RF signal to a baseband signal for processing, a well-known technique at the time. *Id*.

To the extent Li-054 does not disclose or render obvious this limitation, it would have been obvious to implement Mao's teachings in Li-054's device to practice this limitation, including "to convert the RF signal to a baseband signal." *Id.*, ¶144. Mao discloses a wireless communication system includes "a plurality of *antenna elements* that *receive … radio-frequency signals, ... radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals*." EX1006, 3:28-36; *see also id.*, 1:62-2:4, 3:29-53, 4:57-67, 5:40-47, 7:40-44, 11:58-63, 12:4-9, FIGS. 1, 8, 9-10.

A POSITA would have been motivated to combine Li-054's teachings and Mao for multiple reasons.

First, an implementation of the Mao's teachings in Li-054's station would have predictably provided a station that can receive RF signals and then convert them to baseband signals so as to advantageously achieve a digital conversion (to a digital signal) for processing by the electronics of the station. EX1003, ¶145. At the time, such stations included components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the widely well-known practice of converting the received RF signals to baseband signals for the purposes of then converting to digital signals (for use internal to the station). *Id*.

Second, this ordinary implementation of Li-054 would have been merely the application of a known technique (*e.g.*, converting RF signals to baseband signals, as Mao suggests) to a known system (Li-054's station) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized applying Mao's suggestion of receiving and converting RF signals to Li-054's station would have led to predictable results without significantly altering or hindering the functions performed by the station. EX1003, ¶146.

c. [9b][5]

Li-054 discloses this element. EX1003, ¶¶147-149. In particular, Li-054 discloses its station includes "antennas 510, physical layer (PHY) 530, media access control (MAC) layer 540, Ethernet interface 550, *processor* 560, and *memory* 570." EX1007, [0101], FIG. 5. "[P]rocessor 560 reads instructions and data from memory 570 and performs actions in response thereto," and "processor 560 may access instructions from memory 570 and perform method embodiments of the present invention, such as method 300 (FIG. 3) or method 400 (FIG. 4)." *Id.*, [0106]. Based upon Li-054's teaching, a POSITA would have recognized Li-054's above-described structures provided a baseband processing module. EX1003, ¶149.

d. [1a] and [9c]

Li-054 discloses this element. EX1003, ¶¶150-151. In particular, Li-054 discloses "the receiver receives *training symbols* and computes the beamforming matrix, V" using the equation H=UDV′. EX1007, [0022], [0018]-[0019]. Additionally, a POSITA would have recognized Li-054's "training symbols" are

[5] *Supra* footnote 3.

used to determine a channel response H and beamforming matrix V, just like the preamble of the ’862 patent. EX1003, ¶151 (citing 13:37-47).

Indeed, the ’862 patent confirms the wireless communication device “receiv[es] a preamble sequence from the transmitting wireless device and estimate[es] a channel response (H) from the preamble sequence.” EX1001, 14:21-24. This “preamble” mentioned in the ’862 patent used the same type of “training symbols” (13:40-44), which was traditional for purposes of estimating a channel response (H) used to calculate the beamforming matrix V. EX1003, ¶151.

e. [1b] and [9d]

Li-054 discloses this element. EX1003, ¶¶152-153. In particular, Li-054 discloses estimating “*channel state information … from received signals*” at 310, where the “channel state information may include the *channel state matrix H*.” EX1007, [0093], FIG. 3 (element 310). Li-054 discloses the “receiver receives training symbols and computes the beamforming matrix, V as shown” in the equation $H_{m\times n} = U_{m\times m} D_{m\times n} V'_{n\times n}$. *Id.*, [0018]-[0019].

f. [1c] and [9e]

Li-054 discloses this element. EX1003, ¶¶154-155. In particular, Li-054 discloses, after the “channel state matrix H” is estimated from the received signals, “a *beamforming matrix is determined from the channel state information*,” where the beamforming matrix is V. EX1007, [0093], FIG. 3 (element 320). Li-054 also discloses "performing singular value decomposition (SVD)" according to the equation: $H_{m\times n} = U_{m\times m} D_{m\times n} V'_{n\times n}$ where "H is the channel matrix, H's singular value decomposition is H=UDV′; U and V are unitary; [and] D is a diagonal matrix." *Id.*, [0018]-[0019], [0093].

g. 1[d] and [9f]

Li-054 discloses this element. EX1003, ¶¶156-157. It describes quantizing and performing a "householder reflection" on "the beamforming matrix to *reduce the dimensionality of the beamforming matrix*." EX1007, [0094]-[0095].

This teaching matches the '862 patent, which explains "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device ***are reduced***." EX1001, 13:67-14:3. A POSITA would have recognized Li-054 and the '862 patent similarly disclosed a reduction (or "decomposition") of the transmit beamforming matrix. EX1003, ¶157.

h. 1[e] and [9g]

The combination of Li-054 and Mao renders obvious this element. EX1003, ¶¶158-161. As an initial matter, Li-054 discloses after quantizing and performing householder reflection on the beamforming matrix V, the data is fed back to the transmitter. EX1007, [0019], [0096], FIG. 3. Li-054's device includes a "[p]hysical layer (PHY) coupled to antennas 510 to interact with a wireless network" and "circuitry to support the transmission and reception of radio frequency (RF) signals" and "circuits to support *frequency up-conversion*, and an *RF transmitter*." *Id.*, [0104], FIG. 5. A POSITA would have recognized Li-054's "frequency up-conversion" circuitry would have converted a baseband signal into an RF signal for transmission, as was common at the time. EX1003, ¶159.

Even if Li-054 did not expressly state the device would "form a base-band signal," this feature was widely used in similar devices, as Mao demonstrates. EX1003, ¶160. Mao confirms it was widely known to use "a plurality of *antenna elements* that receive and *transmit radio-frequency signals*, *one or more radio-frequency units and frequency converters configured to* transform received RF signals to receive analog base-band signals and *transform analog transmit base-band signals into a transmit RF signals*." EX1006, 3:28-36. Like Li-054, Mao discloses "*a plurality of up-converters which transform base-band signals into RF signals*." *Id.*, 6:29-38, 6:29-38, 12:26-39, 12:51-59, FIGS. 6, 9-10. For the same reasons articulated above (*supra* §**Error! Reference source not found.** (Element [9a])), a POSITA would have implemented Li-054's device in a manner Mao discloses (to form baseband signals) to achieve known benefits—including the advantageous and customary conversion between digital and RF signals and vice versa. EX1003, ¶161.

3. 3 and 11

Li-054 in view of Mao renders obvious this claim. EX1003, ¶¶162-163. In particular, Li-054 discloses "a beamforming matrix is determined from the channel state information" by "performing singular value decomposition (SVD)" using the equation: $H_{m \times n} = U_{m \times m} D_{m \times n} V'_{n \times n}$. EX1007, [0093], [0018].

4. 4 and 12

As explained, Li-054 in view of Mao discloses this claim. EX1003, ¶¶164-165; EX1007, [0093], [0018]; *supra* §§IX.B.2.f-2.g, IX.B.3 (Elements [9e]-[9f], [11]).

X. GROUND 4: CLAIMS 2 and 10 ARE OBVIOUS IN VIEW OF LI-054, MAO, AND YANG

A. Yang Overview

Yang (EX1008) was published in 1991 in a well-recognized publication— the JOURNAL ON MATRIX ANALYSIS AND APPLICATIONS (a scholarly publication by the Society for Industrial and Applied Mathematics). EX1008, 1. Yang was publicly accessible to skilled artisans at the time, and thus qualifies as §102(b) prior art. EX1021, §§ 3-5 (comprising ¶¶ 10-44).

Yang describes a "method for computing two-sided rotations involved in singular value decomposition (SVD)" "lead[ing] to significantly reduced computations." EX1008, Abstract. Yang states a typical application of SVD arises in beam-forming, and because of the "high computational complexity of SVD," there was "massive interest in parallel architectures for computing SVD." *Id.*, 1. Thus, Yang teaches using "coordinate rotation digital computer (CORDIC) processors" to avoid the "computational overhead" of previous methods. *Id.*, Abstract.

Yang explains the "CORDIC algorithm" is "an iterative procedure for computing plane rotations and Cartesian-to-polar coordinates conversions." *Id.*, 4. Using this algorithm, Yang explains "the Cartesian coordinate (x_0, y_0) of a plane vector is converted to its polar representation." *Id.*, 6.

B. Obviousness in view of Li-054, Mao, and Yang

As discussed in Ground 3, the combination of Li-054 and Mao renders claims 1 and 9 obvious. Regarding claims 2 and 10, even if Li-054 and Mao do not expressly disclose the common Cartesian-to-polar conversion, this feature was well-known and often used in similar beam-forming systems, as Yang demonstrates. EX1008, 4, 6; §X.A. To achieve a number of known benefits, a POSITA would have implemented Li-054's receiver as Yang describes. EX1003, ¶170.

1. Claim 2

The combination of Li-054, Mao, and Yang renders obvious Claim 2, as explained for Claim 10. EX1003, ¶168; *supra* §X.B.2 (Element [10]).

2. Claim 10

The combination of Li-054, Mao, and Yang renders obvious this claim. As discussed in Section IX.B (claim [9e]), Li-054 determines matrix V based on channel response H and matrix U by "performing singular value decomposition (SVD)." EX1003, ¶¶169-171; EX1007, [0018]-[0019], [0093]. Yang discloses a "CORDIC algorithm" for computing "Cartesian-to-polar coordinates conversions." EX1008, 4. Yang explains that singular value decomposition, which arises in beam-forming, has a "high computational complexity," but that the CORDIC algorithm reduces complexity in part because it converts Cartesian to polar. *Id.*, 1, 5, Abstract.

Multiple reasons would have prompted a POSITA to modify Li-054's wireless station (*e.g.*, receiver) to use the CORDIC algorithm (with Cartesian-to-polar conversion of matrix V) as Yang suggests, resulting in a station that can determine matrix V using an SVD with less computational complexity.

First, the combination would have advantageously resulted in a station using less processor bandwidth to determine matrix V. EX1003, ¶170. Thus, a POSITA would have been motivated to implement Li-054's station to reduce computational complexity. *Id.*

Second, this predictable implementation of Li-054's station would have been merely the application of a known technique (converting Cartesian to polar coordinates when performing an SVD, as Yang discloses) to a known system (Li-

054's wireless station) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Yang's suggestion of using the CORDIC algorithm for an SVD (converting the Cartesian coordinates of V to polar coordinates) to Li-054's station would have led to predictable results without significantly altering or hindering the functions performed by the station. EX1003, ¶170.

XI. GROUND 5: CLAIMS 1, 3-4, 9 AND 11-12 ARE OBVIOUS IN VIEW OF POON AND MAO

A. Poon Overview

Poon (EX1009), filed June 23, 2004 and issued May 4, 2010, is prior art under, *e.g.*, §102(e). EX1009, cover. Poon discloses a "receiving station determines channel state information for N spatial channels and feeds back to the transmitting station channel state information," where the "channel state information may include a beamforming matrix to cause the transmitting station to utilize N-1 spatial channels." *Id.*, Abstract, 1:56-58, 2:5-7, FIG. 1 ("wireless stations" 102).

Poon teaches the receiving device performs a traditional SVD operation. *Id.*, FIG. 2, 3:7-8, 3:20-58. After steps 210-230, Poon explains at 240 "receiving stations transmits back the channel state information describing the N-l spatial channels." *Id.*, 3:28-31. Channel state information may be "in the form of a transmit beamforming matrix," in which case "the receiver computes a transmit beamforming matrix from the current channel matrix and then sends the beam-forming matrix back to the transmitter." *Id.*, 3:31-36. Poon expressly teaches "[u]pon singular value decomposition (SVD), we have

$H=U\Sigma V^{y}$

where U and V are N×N unitary matrices, and Σ is a diagonal matrix with positive entries"; and "[m]atrix V is the transmit beamforming matrix." *Id.*, 3:53-58, FIG. 2.

Poon also details a receiver "capable of performing channel estimation." *Id.*, FIG. 7, 6:5-17. The system "sends and receives signals using antennas 710, and the signals are processed by the various elements shown in FIG. 7." *Id.*, 6:26-28. It includes physical layer (730) "coupled to antennas 710 to interact with a wireless network" and "may include circuitry to support the transmission and reception of radio frequency (RF) signals," such as "an RF receiver to receive signals and perform 'front end' processing." *Id.*, 6:33-39. The system includes media access control (MAC) layer 740 and processor 760 "reads instructions and data from memory 770 and performs actions in response thereto." *Id.*, 6:45-54, FIG. 7.

B. Obviousness in view of Poon and Mao

Poon discloses performing an SVD using the equation $H=U\Sigma V^{y}$ to determine matrix V, the transmit beamforming matrix. EX1009, 3:53-58. Similar to Poon, Mao discloses a wireless communication system (*e.g.*, receiver beam-forming system). EX1007, 3:28-30, 7:34-35; *supra* §VII.A. Mao explicitly discloses antennas receive RF signals and RF units/frequency converters transform the received RF signals to baseband signals (and processed baseband signals back to RF for transmission). *Id.*, 3:28-36. A POSITA would have been motivated to combine Poon's receiver station with Mao's RF components to achieve known benefits. EX1003, ¶¶186-187, 201.

1. Claims 1, 3, and 4

Method claims 1 and 3-4 correspond to device claims 9 and 11-12. Poon "wireless stations" are receiving wireless communication devices that performs methods for feeding back transmitter beamforming information to transmitting wireless devices. EX1009, 1:56-2:36, 3:7-4:36, FIGs. 1-2. Accordingly, the elements of claims 1 and 3-4 are obvious for the same reasons as the corresponding portions of claims 9 and 11-12. EX1003, ¶179.

Claim 1	
Element	**Discussion**
[1.P]	§XI.B.2.a (Element [9P])
[1a]	§XI.B.2.d (Element [9c])
[1b]	§XI.B.2.e (Element [9d])
[1c]	§XI.B.2.f (Element [9e])
[1d]	§XI.B.2.g (Element [9f])
[1e]	§XI.B.2.h (Element [9g])
Claim 3	
[3]	§XI.B.3 (Element [11])
Claim 4	
[4]	§XI.B.4 (Element [12])

2. Claim 9

a. [1p] and [9p]

To the extent limiting, Poon discloses the preamble. EX1003, ¶180. Poon discloses "two *wireless stations*" 102 and 104 in a wireless local area network, each including multiple antennas. EX1009, 1:56-58, 2:5-7, FIG. 1. Poon discloses a "wireless communication device performs" Figure 2's method. *Id.*, 3:13-14, FIG. 2.

b. [9a]

Poon in view of Mao renders obvious this element. EX1003, ¶¶181-187. Poon discloses "a receiving station receives a training pattern from a transmitting station" and has a number of "*receiving antennas*." *Id.*, 3:20-25, 4:49-63, 5:6-11, 5:60-65, 6:33-44, FIGS. 4, 7. Poon's "wireless communications device [has] a combination of hardware and software components… to transmit N-1 beamforming vectors to a transmitter for use in antenna beamforming" and includes "*baseband data circuits* to source data to a beamforming network." *Id.*, claims 10-11.

A POSITA would have understood Poon's "receiving antennas" are a plurality of RF components operable to receive an RF signal (well-known at the time) and Poon's receiving station included circuitry, such as "baseband data circuits," that converted RF signals to baseband signals for further processing. EX1003, ¶¶182-184. Thus, Poon discloses [9a].

If Poon is deemed insufficient, it would have been obvious to combine Poon with Mao. EX1003, ¶185. Mao's wireless communication system includes "a plurality of *antenna elements* that *receive* and transmit *radio-frequency signals*, *one or more radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals* and transform analog transmit base-band signals into a transmit RF signals." *Id.*, 3:28-36. A POSITA would have recognized this common practice for such wireless devices. EX1003, ¶185.

Multiple reasons would have prompted a POSITA to implement Poon's device as Mao discloses to receive RF signals and convert them into baseband signals.

First, this combination would have predictably provided a device to receive RF signals and convert them to baseband signals to advantageously enable conversion to digital signals for processing by device. EX1003, ¶186. At the time, such devices included components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the common practice of converting received RF signals to baseband signals, then converting to digital signals for use on the device. *Id*.

Second, this combination would have merely applied a known technique (receiving and converting RF signals to baseband signals) to a known system

(Poon's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized the combination would have led to predictable results without hindering device performance. EX1003, ¶187.

c. [9b][6]

Poon discloses or at least renders obvious this element. EX1003, ¶¶188-189. Poon's wireless device (receiving station) includes "*processor* 760, and *memory* 770." EX1009, 6:5-9. Poon states "processor 760 reads instructions and data from memory 770 and performs actions in response," and, for example, "processor 760 may access instructions from memory 770 and perform method embodiments of the present invention, such as method 200 (FIG. 2)." *Id.*, 6:53-57. A POSITA would have recognized Poon's above-described structure provided a baseband processing module. EX1003, ¶189.

d. [1a] and [9c]

Poon discloses or at least renders obvious this element. EX1003, ¶¶190-191. In particular, Poon teaches the "receiving station receives a *training pattern*" to determine channel response H and beamforming matrix V. EX1009, 3:20-60.

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[6] *Supra* n.3.

A POSITA would have recognized Poon's training pattern is used to determine the channel response and beamforming matrix V of the '862 patent. EX1003, ¶191 (citing 13:37-47). Indeed, the '862 patent confirms the wireless communication device "receiv[es] a preamble sequence from the transmitting wireless device and estimat[es] a channel response (H) from the preamble sequence." EX1001, 14:21-24. This "preamble" used "training symbols" (13:40-44), as was common at the time for estimating channel response (H) and calculating beamforming matrix V. EX1003, ¶191.

e. [1b] and [9d]

Poon discloses or at least renders obvious this element. EX1003, ¶¶192-193. In Poon, "the receiving station *estimates N spatial channels*, where N is equal to a number of receiving antennas." EX1009, 3:23-25. "In some embodiments, this may correspond to station 104 computing a current *channel matrix* describing the current state of the N spatial channels." *Id.*, 3:25-28; *see id.*, FIG. 2. In Poon, the "receiving station receives a *training pattern*" used to determine channel response H and beamforming matrix V. *Id.*, 3:20-60. A POSITA would have recognized Poon's estimates of the channel or channel matrix are estimated channel responses. EX1003, ¶193.

f. [1c] and [9e]

Poon discloses or renders obvious this element. EX1003, ¶¶194-195. In particular, Poon discloses "the receiver computes a transmit beamforming matrix from the current channel matrix." EX1009, 3:31-36. Poon discloses "singular value decomposition (SVD)" using the equation "$H=U\Sigma V^y$ where U and V are N×N unitary matrices, and Σ is a diagonal matrix," and "[m]atrix V is the transmit beamforming matrix." *Id.*, 3:53-58.

A POSITA would have recognized the widely known SVD equation $H=U\Sigma V^y$ is used by the receiver to "compute[] a transmit beamforming matrix [V] from the current channel matrix [H]" and the receiver beamforming unitary matrix [U]. EX1003, ¶195.

g. [1d] and [9f]

Poon discloses or renders obvious this element. EX1003, ¶¶196-197. In some embodiments, "one spatial channel is always punctured, and the transmit beamforming matrix is reduced in size, thereby reducing the feedback bandwidth." EX1009, 3:36-39.

A POSITA would have recognized Poon and the '862 patent similarly disclosed a reduction, or decomposition, of the transmit beamforming matrix. EX1003, ¶197. The '862 patent explains "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device are reduced," which is similar to Poon. EX1001, 13:67-14:3.

h. [1e] and [9g]

Poon in view of Mao discloses or at least renders obvious this element. EX1003, ¶¶198-201. Poon discloses "at 240, the receiving station[] transmits back the channel state information describing the N-1 spatial channels," and "the channel state information is in the form of a transmit beamforming matrix." EX1009, 3:29-33, 4:49-63, 5:6-11, 5:60-65, 6:33-44, FIGS. 4, 7.

To the extent Poon does not disclose or render obvious this limitation, it would have been obvious to combine Poon with Mao. EX1003, ¶¶200-201. Mao confirms it was widely known for a wireless communication system to include "*antenna elements* that receive and *transmit radio-frequency signals*, ... *radio-frequency units and frequency converters configured to … transform analog transmit base-band signals into a transmit RF signals*." *Id.*, 3:28-36. Mao discloses a "transmission beam-forming system" including "an antenna array system and a plurality of RF units which may be shared with the receiver beamforming system, [and] *a plurality of up-converters which transform baseband signals into RF signals*." *Id.*, 6:29-35.

3. Claims 3 and 11

Poon in view of Mao renders obvious this claim. EX1003, ¶¶202-203. In particular, Poon discloses "[u]pon singular value decomposition (SVD), we have

H=UΣV[y]

where *U and V are N×N unitary matrices*, and *Σ*[7] *is a diagonal matrix*"; and "[m]atrix V is the transmit beamforming matrix." EX1009, 3:53-58.

4. Claims 4 and 12

For the reasons explained in Section XI.B (claim [11]), the combination of Poon and Mao renders obvious this claim. EX1003, ¶¶204-205; *Id.*, 3:53-58.

XII. TRIAL SHOULD BE INSTITUTED

The related matters (§II.B) do not warrant discretionary denial under §314(a). As a preliminary matter, ITC 337-TA-1367 does not warrant denial because the Board will not discretionally deny based on a parallel ITC proceeding. Director Vidal, *Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation* (June 21, 2022). Case 8-23-cv-01065 in the Central District of California (the "CDCA case") does not warrant discretionary denial either. *See Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11, 56 (P.T.A.B. Mar. 20, 2020). And Case 1-23-cv-00633 in the Western District of Texas (the "WDTX case") does not warrant discretionary denial either. *See Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11, 56 (P.T.A.B. Mar. 20, 2020). All other related matters listed above have terminated.

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[7] *Supra* footnote 1.

The first *Fintiv* factor favors institution. The CDCA and WDTX cases have been stayed pending resolution of ITC 337-TA-1367. Ex1024; Ex1025.

The second *Fintiv* factor also favors institution. The trials in the CDCA and WDTX cases have not been scheduled.

The third *Fintiv* factor favors institution because the parties expended few resources in the CDCA, WDTX, and ITC cases, where no discovery or claim construction proceedings have occurred.

The fourth *Fintiv* factor is neutral. This Petition challenges all ’862 patent claims and a Final Written Decision would streamline at least the CDCA and WDTX cases. *Integrated Sensing*, 2019 WL 3776947, *3.

The fifth *Fintiv* factor is neutral because “[a]ll parties to this proceeding are included in the related [] proceeding[s].” *Cast Lighting, LLC v. Wangs Alliance Corp.*, PGR2021-00012, Paper 12, 36 (P.T.A.B. June 7, 2021).

The sixth *Fintiv* factor favors institution because the merits are exceptionally strong.

The Board should not deny institution under 35 U.S.C. §325(d). The grounds presented here are not cumulative—the Board has not issued a Final Written Decision in any IPR proceeding involving the ’862 patent. Although *LG* was instituted on the same grounds presented here, it terminated just two months later and did not proceed to trial. IPR2020-00108, Paper 14 (Institution), Paper 22

(Termination due to settlement). In addition, four other petitions settled and terminated prior to an institution decision. IPR2021-00048, Paper 10 (P.T.A.B. Jan. 28, 2022) (challenging claims 1-4 and 9-12 on the same grounds as IPR2020-00108, but settled prior to institution); IPR2021-01590, Paper 8 (P.T.A.B. Jan. 28, 2022) (same); IPR2019-01439, Paper 9 (P.T.A.B. Dec. 13, 2019); IPR2019-01438, Paper 10 (P.T.A.B. Dec. 17, 2019). Finally, two petitions presented different grounds with different references from those presented here and were denied institution for failure to demonstrate a reference used in all grounds was publicly accessible prior to the critical date. IPR2020-00611, Paper 14 (P.T.A.B. Oct. 27, 2020); IPR2020-00613, Paper 10 (P.T.A.B. Aug. 24, 2020).

XIII. CONCLUSION

Accordingly, Petitioners requests IPR of the Challenged Claims based upon the Grounds 1-5.

Respectfully submitted,

Date: June 5, 2024

/s/ Brian Erickson
Brian Erickson
Reg. No. 48,895
DLA Piper LLP (US)
303 Colorado Street, Suite 3000
Austin, TX 78701
Phone: 512-457-7059
Fax: 512-721-2263
Brian.Erickson@us.dlapiper.com

Counsel for Petitioner NXP

CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing **AMENDED PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT 8,416,862** was served on June 5, 2024, via email, to counsel of record for Patent Owner at the following:

Jason M. Shapiro
Timothy Devlin
Devlin Law Firm LLC
1526 Gilpine Ave.
Wilmington, DE 19806
jshashipro@devlinlawfirm.com
tdevlin@devlinlawfirm.com
BNR-MEDIATEK-IPR@devlinlawfirm.com

Date: June 5, 2024

/s/ Brian Erickson
Brian Erickson
Reg. No. 48,895
DLA Piper LLP (US)
303 Colorado Street, Suite 3000
Austin, TX 78701
Phone: 512-457-7059
Fax: 512-721-2263
Brian.Erickson@us.dlapiper.com

Counsel for Petitioner NXP