

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Maged F. Barsoum et al.
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Appl. Serial No.: 16/728,384
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Title: RECEIVERS INCORPORATING NON-UNIFORM
CONSTELLATIONS WITH OVERLAPPING CONSTELLATION
POINT LOCATIONS

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 11,019,509 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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EXHIBITS

LGE1001	U.S. Patent No. 11,019,509
LGE1002	Prosecution History for U.S. Patent No. 11,019,509
LGE1003	Expert Declaration of Dr. Bertrand Hochwald
LGE1004	PCT Patent Publication No. WO 2006089569A1 (“Bauch”)
LGE1005	U.S. Patent Pub. No. 2004/0054960 to Eroz et al. (“Eroz”)
LGE1006	RESERVED
LGE1007	U.S. Patent Application No. 2007/0118787 (“Schmidt”)
LGE1008	RESERVED
LGE1009	Digital Video Broadcasting (DVB) ETSI EN 300 744 V1.2.1 (1999-07) (“DVB-T”)
LGE1010	RESERVED
LGE1011	RESERVED
LGE1012	RESERVED
LGE1013	RESERVED
LGE1014	De Gaudenzi et al., <i>Turbo-coded APSK modulations design for satellite broadband communications</i> , Int. J. Satell. Commun. Network. 2006; 24:261–281, Published online 19 May 2006 in Wiley InterScience (“DeGaudenzi”)
LGE1015	U.S. Provisional application No. 60/933,319 (“’319 Provisional”)

LGE1016	ETSI EN 302 307 V1.1.2, Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications, June, 2006 (LGE1016 or “DVB-S2”)
LGE1017	Declaration of Friedhelm Rodermund
LGE1018	Giuseppe Caire, Giorgio Taricco, and Ezio Biglieri, <i>Bit-Interleaved Coded Modulation</i> , IEEE Transactions of Information Theory, vol. 44, no. 3, May 1998 (“Caire”)
LGE1019	Ulrich Reimers et al., <i>DVB The Family of International Standards for Digital Video Broadcasting</i> , Second Edition, 2005 (“Ulrich”)
LGE1020	Declaration of June Munford
LGE1021	Stipulation by Petitioner, LGE, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1022	Complaint, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1023	Complaint Exhibit, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1024	RESERVED
LGE1025	Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (USPTO June 21, 2022) (“Interim Procedure”)
LGE1026	Docket Control Order, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)

LIST OF CHALLENGED CLAIMS

Claim 1	
[1pre]	A communication system, comprising:
[1a]	a receiver capable of receiving signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver comprises:
[1b]	a demodulator capable of demodulating a received signal into a demodulated signal;
[1c-1]	a demapper, coupled to the demodulator, capable of determining likelihoods using the demodulated signal and a symbol constellation that includes constellation points at a plurality of unique point locations, where:
[1c-2]	the plurality of unique point locations are unequally spaced;
[1c-3]	the constellation points each have a location and a different label; and
[1c-4]	the locations of at least two of the constellation points are the same; and

[1d]	a decoder, coupled to the demapper, capable of using the likelihoods determined by the demapper to provide a sequence of received bits based upon a low density parity check (LDPC) code.
Claim 2	
[2a]	The communication system of claim 1, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations;
[2b]	the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a first type that comprise multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations, where unequally spaced symbol constellations of the first type include at least two constellation points having locations that are the same and different labels;

[2c]	the receiver is capable of selecting an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs; and
[2d]	each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs.
Claim 8	
[8a]	The communication system of claim 1, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations; and
[8b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a symbol constellation operating SNR subject to at least one constraint.

Claim 9	
[9pre]	The communication system of claim 1, further comprising a transmitter capable of transmitting signals via the communication channel, where the transmitter comprises:
[9a]	a coder capable of receiving bits and outputting encoded bits using a Low Density Parity Check (LDPC) code;
[9b]	a mapper, coupled to the coder, capable of mapping the encoded bits to symbols in the symbol constellation; and
[9c]	a modulator, coupled to the mapper, capable of generating a signal for transmission via the communication channel based upon symbols selected by the mapper.
Claim 10	
[10a]	The communication system of claim 1, wherein: the symbol constellation is selected from a plurality of symbol constellations each having a same number of constellation points;
[10b]	a first of the plurality of symbol constellations includes constellation points at a first set of unique point locations that are unequally spaced;

[10c]	a second of the plurality of symbol constellations includes constellation points at a second set of unique point locations that are unequally spaced; and
[10d]	the number of unique point locations in the first set of unique point locations is different from the number of unique point locations in the second set of unique point locations.
Claim 11	
[11pre]	A communication system, comprising:
[11a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver comprises:
[11b]	a demodulator that demodulates a received signal into a demodulated signal;
[11c-1]	a demapper that determines likelihoods using the demodulated signal and a symbol constellation that includes constellation points at a plurality of unique point locations, where:
[11c-2]	the plurality of unique point locations are unequally spaced;
[11c-3]	the constellation points each have a location and a different label; and

[11c-4]	the locations of at least two of the constellation points are the same; and
[11d]	a decoder that uses the likelihoods determined by the demapper to provide a sequence of received bits based upon a low density parity check (LDPC) code;
[11e]	wherein the demapper is interposed between the demodulator and the decoder and the demapper receives information from the demodulator and provides information to the decoder.
Claim 12	
[12a]	The communication system of claim 11, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations;

[12b]	the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a first type that comprise multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations, where unequally spaced symbol constellations of the first type include at least two constellation points having locations that are the same and different labels;
[12c]	the receiver selects an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs; and
[12d]	each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs.
Claim 18	
[18a]	The communication system of claim 11, wherein the symbol constellation is selected from a plurality of unequally spaced symbol constellations; and

[18b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a symbol constellation operating SNR subject to at least one constraint.
Claim 19	
[19pre]	The communication system of claim 11, further comprising a transmitter that transmits signals via the communication channel, where the transmitter comprises:
[19a]	a coder that receives bits and outputs encoded bits using a Low Density Parity Check (LDPC) code;
[19b]	a mapper that maps the encoded bits to symbols in the symbol constellation; and
[19c]	a modulator that generates a signal for transmission via the communication channel based upon symbols selected by the mapper;
[19d]	wherein the mapper is interposed between the modulator and the coder and the mapper receives information from the coder and provides information to the modulator.

Claim 20	
[20a]	The communication system of claim 11, wherein: the symbol constellation is selected from a plurality of symbol constellations each having a same number of constellation points;
[20b]	a first of the plurality of symbol constellations includes constellation points at a first set of unique point locations that are unequally spaced;
[20c]	a second of the plurality of symbol constellations includes constellation points at a second set of unique point locations that are unequally spaced; and
[20d]	the number of unique point locations in the first set of unique point locations is different from the number of unique point locations in the second set of unique point locations.
Claim 21	
[21pre]	A communication system, comprising
[21a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR),

[21b]	wherein the receiver uses a symbol constellation to transform the received signals into received bits, and the symbol constellation includes constellation points at a plurality of unique point locations, where:
[21c-1]	the plurality of unique point locations are unequally spaced;
[21c-2]	the constellation points each have a location and a different label; and
[21c-3]	the locations of at least two of the constellation points are the same.
Claim 22	
[22]	The communication system of claim 21, further comprising a transmitter that transmits signals via the communication channel, where the transmitter uses the symbol constellation to transform encoded bits into the transmitted signals.
Claim 23	
[23a]	The communication system of claim 21, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations;

[23b]	the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a first type that comprise multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations, where unequally spaced symbol constellations of the first type include at least two constellation points having identical locations and different labels;
[23c]	the receiver selects an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs; and
[23d]	each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs.
Claim 29	
[29a]	The communication system of claim 22, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations; and

[29b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a symbol constellation operating SNR subject to at least one constraint.
Claim 30	
[30a]	The communication system of claim 22, wherein: the symbol constellation is selected from a plurality of symbol constellations each having a same number of constellation points;
[30b]	a first of the plurality of symbol constellations includes constellation points at a first set of unique point locations that are unequally spaced;
[30c]	a second of the plurality of symbol constellations includes constellation points at a second set of unique point locations that are unequally spaced; and
[30d]	the number of unique point locations in the first set of unique point locations is different from the number of unique point locations in the second set of unique point locations.

LG Electronics, Inc. (“**Petitioner**” or “**LGE**”) petitions for *Inter Partes* Review (“**IPR**”) of claims 1, 2, 8-12, 18-23, and 29-30 (“**the Challenged Claims**”) of U.S. Patent 11,019,509 (“**the ’509 Patent**”). As explained in this Petition, there exists a reasonable likelihood that the Challenged Claims are unpatentable.

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

A. Standing

Petitioner certifies that the ’509 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review. Petitioner was served with a complaint of infringement of the ’509 Patent less than one year ago. LGE1022.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the grounds¹ identified in the table below. Accompanying explanations and support are provided in Dr. Hochwald’s Declaration (LGE1003). LGE1003, [1]-[190].

¹ Petitioner is not conceding that each challenged claim satisfies all statutory requirements, such as 35 U.S.C. § 112. As this is an IPR petition, Petitioner is asserting prior art-based grounds. Petitioner is not waiving any arguments concerning other grounds that can only be raised in district court.

Ground	Claims	35 U.S.C. § 103 Ground
1	1, 9, 11, 19, 21, 22	Eroz in view of Bauch
2	10, 20, 30	Eroz in view of Bauch and DVB-T
3	2, 8, 12, 18, 23, 29	Eroz in view of Bauch, DVB-T, and DeGaudenzi

The '509 Patent was filed on Dec. 27, 2019 and claims priority from U.S. Provisional application No. 60/933,319 (“**319 Provisional**” or LGE1015), which was filed on June 5, 2007. While Petitioner does not concede that the '509 Patent should be afforded a priority date of June 5, 2007, each of the references asserted in this petition (as shown in the table below) qualifies as prior art even if the June 5, 2007 date of the provisional application is used as the priority date of the '509 Patent. The declarations of Friedhelm Rodermund (LGE1017) and June Munford (LGE1020) provide information regarding the public availability of the non-patent literature references listed in the table.

Reference	Publication Date	Section
PCT Patent Publication No. WO 2006/089569A1 (“Bauch” or LGE1004)	August 31, 2006	102(a)/(e)
U.S. Patent Application No.	May 17, 2007	102(a)

Reference	Publication Date	Section
US20070110191A1 (“Eroz” or LGE1005)		
ETSI TS 102 006 V1.2.1, <i>Digital Video Broadcasting (DVB); Specification for System Software Update in DVB System</i> , Oct. 2002 (“DVB-T” or LGE1009)	October, 2002, LGE1017, ¶[19]	102(a)/(b)
De Gaudenzi et al., <i>Turbo-coded APSK modulations design for satellite broadband communications</i> , Int. J. Satell. Commun. Network. 2006; 24:261–281, Wiley InterScience (“DeGaudenzi” or LGE1014)	May 19, 2006, LGE1020, ¶¶[6]-[9]	102(a)/(b)

II. OVERVIEW OF THE ’509 PATENT

A. Background of Related Technology

The ’509 Patent is directed to communication systems that use geometrically-shaped constellations. LGE1001, Abstract. In communication systems, the term “‘constellation’ is used to describe the possible symbols that can be transmitted by a typical digital communication system.” *Id.*, 1:42-44. When a transmitter transmits data symbols, a “receiver attempts to detect the symbols that were transmitted by mapping a received signal to the constellation.” *Id.*, 1:44-46. The ’509 Patent explains that the “minimum distance (d_{min}) between constellation points is indicative of the capacity of a constellation at high signal-to-noise ratios (SNRs),” so

“constellations used in many communication systems are designed to maximize d_{min} .” *Id.*, 1:46-50; LGE1003, ¶[45].

According to the '509 Patent, many communication systems have been designed to increase the capacity of a communication channel, which has a theoretical capacity known as the Shannon limit. LGE1001, 1:42-45. “The Shannon limit can be thought of as being based upon a theoretical constellation known as a Gaussian distribution [constellation], which is an infinite constellation where symbols at the center of the constellation are transmitted more frequently than symbols at the edge of the constellation.” *Id.*, 1:61-67. One method of increasing the capacity is using a coding technique such as turbo codes or LDPC codes. *Id.*, 1:58-62; LGE1003, ¶[46].

The '509 Patent explains that using unequally spaced constellations to increase channel capacity is not new. LGE1001, 2:6-12. One known system “uses unequally spaced constellations that are optimized to minimize the error rate of an uncoded system.” *Id.*, 2:6-12. “Another proposed system uses a constellation with equiprobable but unequally spaced symbols in an attempts[sic] to mimic a Gaussian distribution.” *Id.*, 2:10-12. Yet another known method “increases the dimensionality of a constellation or select a new symbol to be transmitted taking into consideration previously transmitted symbols.” *Id.*, 2:13-15. The '509 Patent alleges, however, that “constellation were still designed based on a minimum

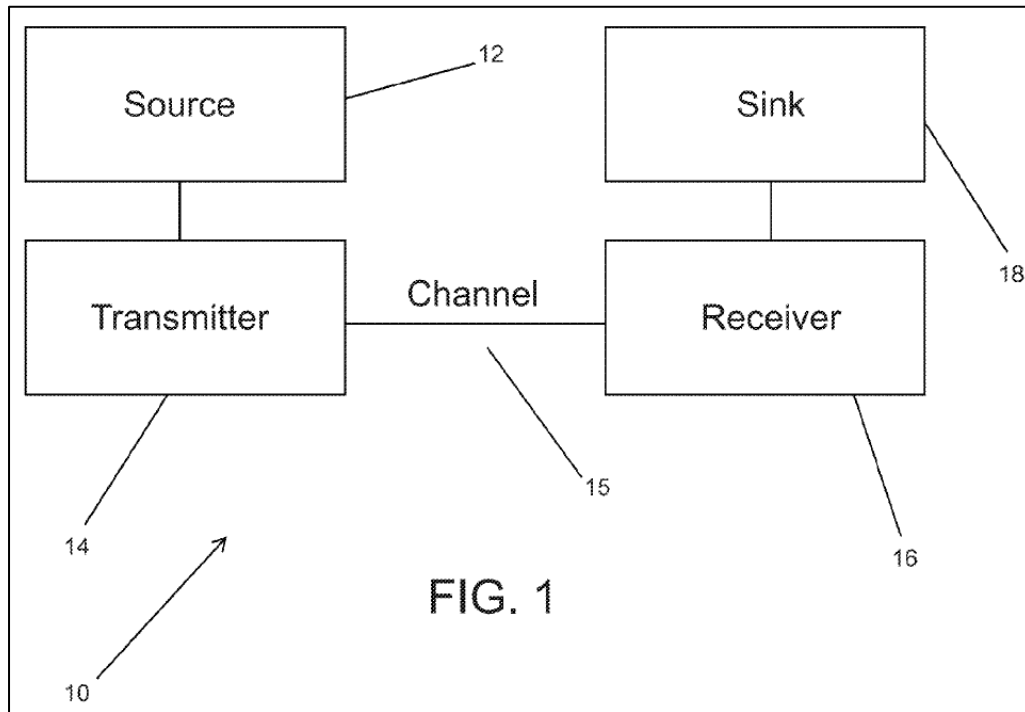
distance criteria.” *Id.*, 2:15-17; LGE1003, ¶[47].

Contrary to the ’509 Patent’s assertions, however, known systems employed unequally spaced constellations without reliance on a minimum distance criteria. LGE1003, ¶[47]; *see infra* Section IV.

B. Brief Description of the ’509 Patent

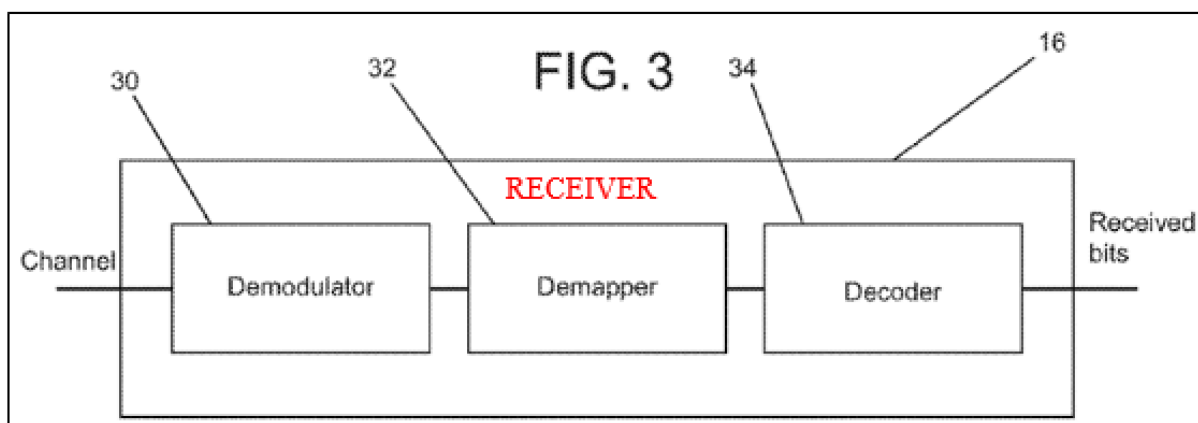
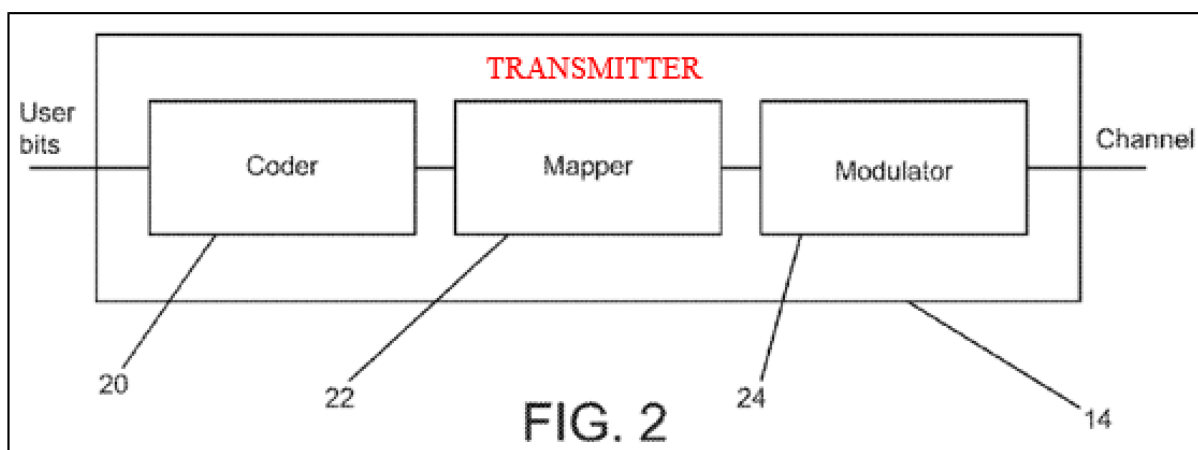
The ’509 Patent discloses “constructing a modulation such that the constrained capacity between a transmitter and a receiver approaches the Gaussian channel limit first described by Shannon.” LGE1001, 2:21-25. The ’509 Patent discloses a method for locating points (in a one or multiple dimensional space) in order to maximize capacity between the input and output of a bit or symbol mapper and demapper respectively.” *Id.*, 2:28-34; LGE1003, ¶[48].

Figure 1 (reproduced below) shows a communication system 10 according to the ’509 Patent, which includes “a source 12 that provides user bits to a transmitter 14,” which in turn “transmits symbols over a channel to a receiver 16 using a predetermined modulation scheme.” LGE1001, 5:30-35. Using knowledge of the modulation scheme, the receiver 16 decodes the signal and provides the decoded bits to a sink device 18 connected to the receiver 16. *Id.*, 5:35-38; LGE1003, ¶[49].



LGE1001, FIG. 1.

FIG. 2 (reproduced below) of the '509 Patent depicts the transmitter 14 and its components, which include a coder 20, a mapper 22, and a modulator 24. LGE1001, 3:45-46, 5:39-51. FIG. 3 (reproduced below) of the '509 Patent depicts the receiver 16 and its components, which include a demodulator 30, a demapper 32, and a decoder 34. LGE1001, 3:47-48, 5:52-60; LGE1003, ¶[50].



LGE1001, FIGS. 2-3.²

The coder 20 of the transmitter 14 “receives user bits from a source and encodes the bits in accordance with a predetermined coding scheme,” such as a capacity approaching code (*e.g.*, turbo code, LDPC code) or other coding schemes that provide a coding gain. LGE1001, 5:39-45. A mapper 22 connected to the coder “maps the bits output by the coder to a symbol within a geometrically distributed

² Annotations to this and other figures in this petition are indicated by colored text and/or marks.

signal constellation stored within the mapper” and “provides the symbols to a modulator 24, which modulates the symbols for transmission via the channel.” *Id.*, 5:46-51. The mapper of the transmitter encodes bits to symbols in a symbol constellation that “is a capacity optimized geometrically spaced symbol constellation that provides a given capacity at a reduced signal-to-noise ratio compared to a signal constellation that maximizes d_{min} .” *Id.*, 2:38-46, 2:51-55, 4:63-5:3. Signal-to-noise ratio (SNR) is “defined as the ratio of the average constellation energy per dimension to the average noise energy per dimension.” *Id.*, 7:53-54. The ’509 Patent explains that “capacity optimized constellation at low SNRs are geometrically shaped constellations that can achieve significantly higher performance gains (measured as reduction in minimum required SNR) than constellations that maximize d_{min} .” *Id.*, 8:24-29; LGE1003, ¶[51].

“Capacity measures that can be used in the selection of the location of constellation points include ... parallel decode (PD) capacity and joint capacity.” LGE1001, 5:6-8. The “PD capacity of a channel can be viewed in terms of the mutual information between the output bits of the encoder (such as an LDPC encoder) at the transmitter and the likelihoods computed by the demapper at the receiver,” and it is “influenced by both the placement of points within the constellation and by the labelling assignment.” *Id.*, 6:66-7:3. Joint capacity describes “the achievable capacity between the input of the mapper on the transmit

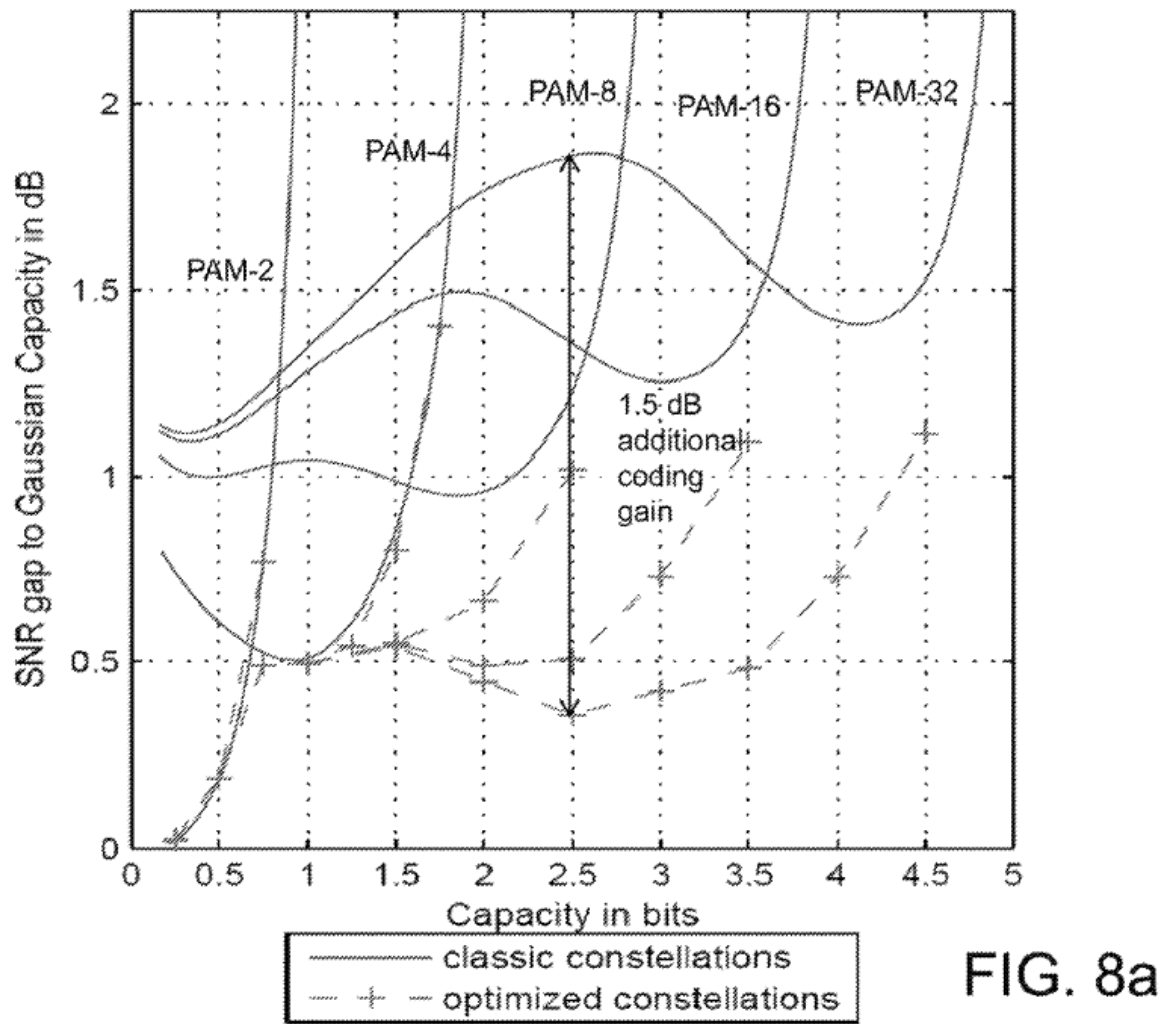
side of the link and the output of the channel (including for example AWGN and Fading channels).” *Id.*, 7:17-21; LGE1003, ¶[52].

Receiver 16 of FIG. 3 “includes a demodulator 30 that demodulates a signal received via the channel to obtain symbol or bit likelihoods” and a demapper 32 that “uses knowledge of the geometrically shaped symbol constellation used by the transmitter to determine these likelihoods.” LGE1001, 5:52-55. The demapper also “provides the likelihoods to a decoder 34 that decodes the encoded bit stream to provide a sequence of received bits to a sink.” *Id.*, 5:55-60; LGE1003, ¶[53].

The ’509 Patent discloses that “[t]ransmitters and receivers ... utilize geometrically shaped symbol constellations” and that a geometrically shaped symbol constellation can be “used that optimizes the capacity of the constellation.” LGE1001, 5:62-6:3. Various factors dictate the selection of a constellation, including whether the code rate is fixed and specific performance requirements (e.g., specified bit rate, a maximum transmit power). *Id.*, 6:5-8, 6:16-20. The ’509 Patent states that in “many embodiments, a geometrically shaped constellation is used to replace a conventional constellation (i.e. a constellation maximized for d_{min}) in the mapper of transmitters and the demapper of receivers within a communication system.” *Id.*, 6:8-12. Moreover, a conventional communication system can easily substitute a conventional constellation with a “geometrically shaped constellation that provides a capacity, which is greater than the capacity of a constellation

maximized for d_{min} ,” by way of firmware or software upgrades of the transmitter/receiver. *Id.*, 6:24-33; LGE1003, ¶[54].

The '509 Patent explains that PAM constellations can be paired with specific code rates to optimize capacity. LGE1001, 10:5-24. For example, FIG. 8a shows the lower SNR required for optimized constellations relative to classic PAM constellations. *Id.* The '509 Patent discloses certain conditions (e.g., bit rate, SNR) at which the PAM constellations can be optimized. For instance, FIGS. 11a-b provide a range of bit rates and SNRs at which PAM-4 constellations can be optimized for joint capacity or parallel decoding capacity. LGE1001, 11:4-11; LGE1003, ¶[55].



LGE1001, FIG. 8a.

PAM-4 constellations optimized for joint capacity at different rates

(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.03	2.71	5.00	7.15	9.24
x_0	-1.41	-1.41	-1.40	-1.37	-1.36
x_1	0.00	0.00	-0.20	-0.33	-0.39
x_2	0.00	0.00	0.20	0.33	0.39
x_3	1.41	1.41	1.40	1.37	1.36

FIG. 11a

LGE1001, FIG. 11a.

PAM-4 constellations optimized for parallel decoding capacity at different

(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39

FIG. 11b

LGE1001, FIG. 11b.

C. Summary of the Prosecution History of the '509 Patent

The '509 Patent issued from US application no. 16/728,384 (“**384 application**”) that was filed as a Track 1 application on December 27, 2019. LGE1001, 1; LGE1002, 1-103. The '509 Patent claims priority to U.S. Patent Nos. 10,567,980, 10,149,179, 9,743,292, 9,385,832, 8,842,761, 8,270,511 and 7,978,777 and the '319 Provisional. LGE1001, 1-2; LGE1003, ¶[56].

During prosecution, Patent Owner (then applicant) filed a final office action response dated March 5, 2021 in which the claims were amended, in part, by replacing some instances of “**non-uniform** symbol constellations” with “**unequally spaced** symbol constellations,” among additional amendments. LGE1002, 3119-3153. Subsequently, the Examiner issued a Notice of Allowance providing a generic reason for allowing the application, namely that the arts of record fail to teach or suggest the claimed language in the independent claims. *Id.*, 3169-3178. LGE1003, ¶¶[57]-[59].

D. Level of Ordinary Skill in the Art

Petitioner submits that a person of ordinary skill in the art at the time of the alleged invention (a “POSITA”) would have had at least a Master’s degree in an academic area emphasizing electrical engineering or a similar discipline, and at least two years of experience in the field working with, teaching, or researching communication systems including the use of constellations in transmitting signals

between devices. LGE1003, ¶¶[21]-[23]. Superior education could compensate for a deficiency in work experience, and *vice-versa*. *Id.*

III. CLAIM CONSTRUCTION

For the purposes of this petition, no claim construction is necessary. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy’” (*quoting Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))). Petitioner reserves the right to respond to any constructions offered/adopted by Patent Owner or the Board.

IV. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

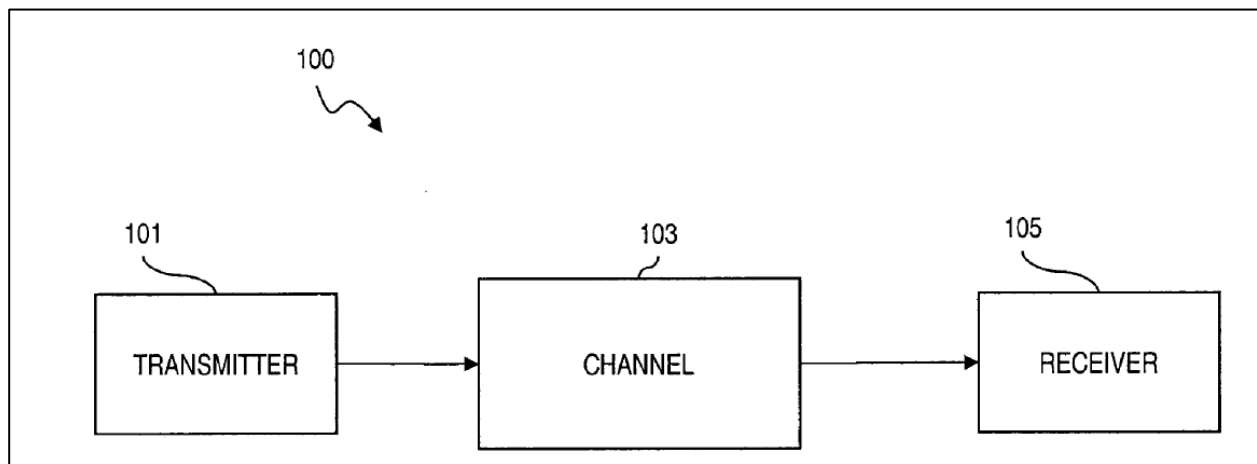
A. Ground 1: Eroz and Bauch render claims 1, 9, 11, 19, 21, and 22 obvious

1. Overview of Eroz³

Eroz is a U.S. Patent Publication entitled “Method and System for providing Low Density Parity Check (LDPC) Encoding.” LGE1005, cover. Like the ’509

³ General descriptions provided for this and other references and combinations thereof are incorporated into each subsection and mapping of the claims that includes citations to these references.

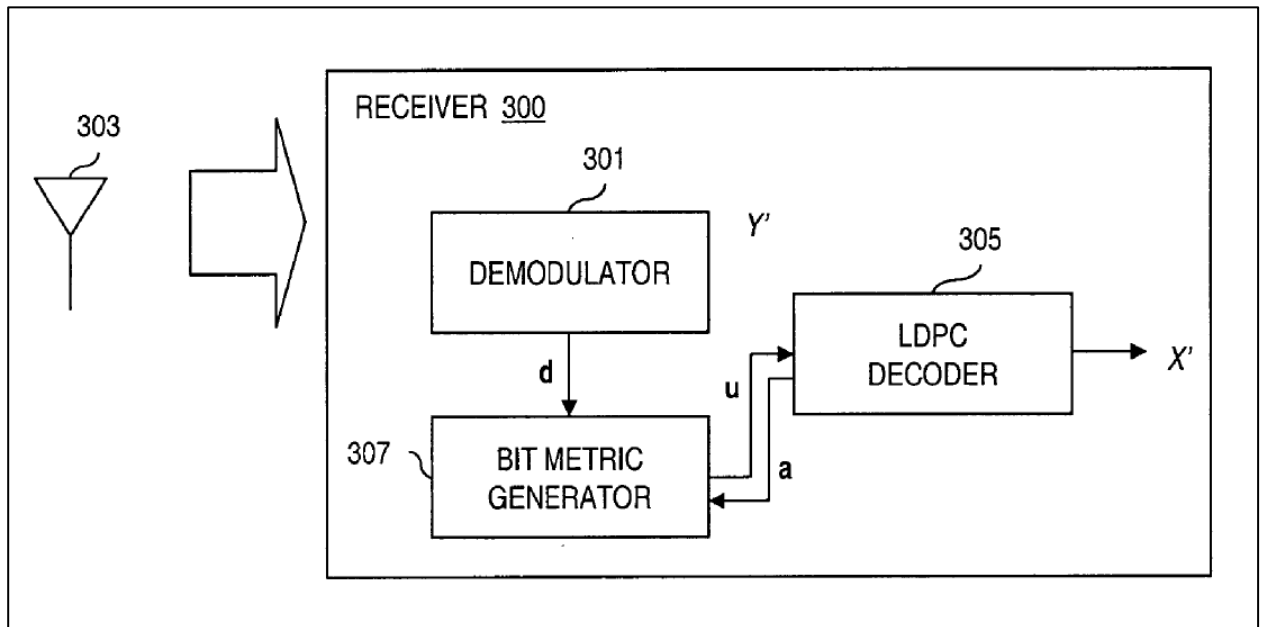
Patent, Eroz discloses “a communications system configured to utilize Low Density Parity Check (LDPC) codes,” which “generates signal waveforms across a communication channel to a receiver.” LGE1005, ¶[0030]; LGE1001, 4:62-5:51. Eroz’s FIG. 1 (reproduced below) depicts an example communication system 100 that “includes a transmitter 101 that generates signal waveforms across a communication channel 103 to a receiver 105.” LGE1005, ¶[0030], FIG. 1. The “signal waveforms are attenuated, or otherwise altered, by communications channel 103. *Id.* Transmitter 101 can include an LDPC encoder 203 and modulator 205 to transmit LDPC codes. LGE1005, ¶¶[0030]-[0058], FIGS. 2A, 2B; LGE1003, ¶[60].



LGE1005, FIG. 1.

Eroz’s FIG. 3 (reproduced below) depicts an example receiver 105/300 receiving signals via antenna 303. LGE1005, FIG. 3. The “receiver 300 includes a demodulator 301 that performs demodulation of received signals from transmitter 200,” “a decoder 305, which attempts to reconstruct the original source messages

by generating messages, X' , in conjunction with a bit metric generator 307" that, in some implementations, is configured to "exchange[] probability information with the decoder 305." LGE1005, ¶[0058]; LGE1003, ¶[61].



LGE1005, FIG. 3.

Eroz discloses that:

At the receiving side, a receiver 300 includes a demodulator 301 that performs demodulation of received signals from transmitter 200. These signals are received at a receive antenna 303 for demodulation. After demodulation, the received signals are forwarded to a decoder 305, which attempts to reconstruct the original source messages by generating messages, X' , in conjunction with a bit metric generator 307. With non-Gray mapping, the bit metric generator 307

exchanges probability information with the decoder 305 back and forth (iteratively) during the decoding process, which is detailed in FIG. 10. Alternatively, if Gray mapping is used (according to one embodiment of the present invention), one pass of the bit metric generator is sufficient, in which further attempts of bit metric generation after each LDPC decoder iteration are likely to yield limited performance improvement.

LGE1005, ¶[0058]; LGE1003, ¶[62]. Eroz explicitly states that “[t]here is also a need for using LDPC codes efficiently to support high data rates, without introducing greater complexity” and includes claims directed to “modulating the LDPC coded signal according to a signal constellation that includes one of 8-PSK (Phase Shift Keying), 16-QAM (Quadrature Amplitude Modulation).” LGE1005, ¶[0006], claim 7; LGE1003, ¶[62]..

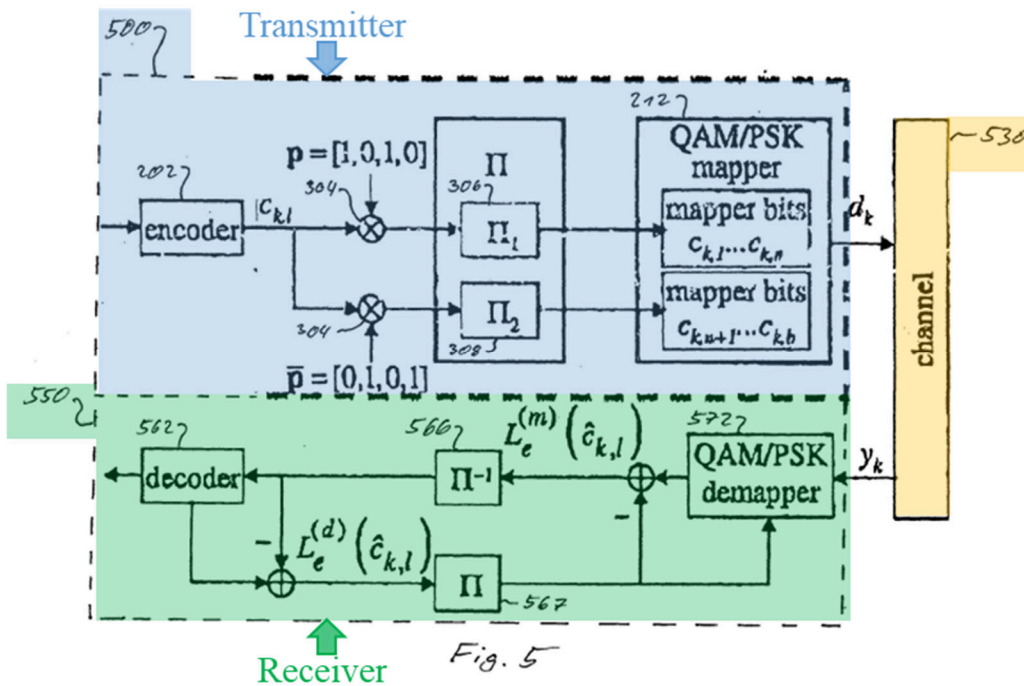
2. Overview of Bauch

Bauch is a WIPO patent publication entitled “Method and apparatus for transmitting and receiving bit interleaved coded modulation signal.” LGE1005, 1. Bauch is directed to “a method for transmitting, a method for receiving and a computer program which allow a digital transmission with an improved performance.” LGE1004, 11:27-30; LGE1003, ¶[63].

To realize the improved performance in its wireless system, Bauch discloses

“a forward error correction encoder for generating a first number of code bits from a second number of information bits, the first number being larger than the second number, a ratio between the second number and the first number defining a code ratio.” LGE1004, 12:4-26. Further, Bauch discloses a mapper that maps code bits to symbols such that “at least two different possible groups of code bits correspond to the same constellation point, and wherein the the [sic] at least two different possible groups of code bits have at least two primary bits at mutual corresponding positions in the code groups, which are identical to each other and at least one secondary bit, at a mutual corresponding position which is different in the two groups of bits.” LGE1004, 12:4-26, 14:32-15:3. A corresponding demapper and forward error correcting decoder are provided in the receiver to decode the turbo-coded data received from the transmitter. LGE1004, 4:28-30, 9:27-35, 12:28-13:37; LGE1003, ¶[64].

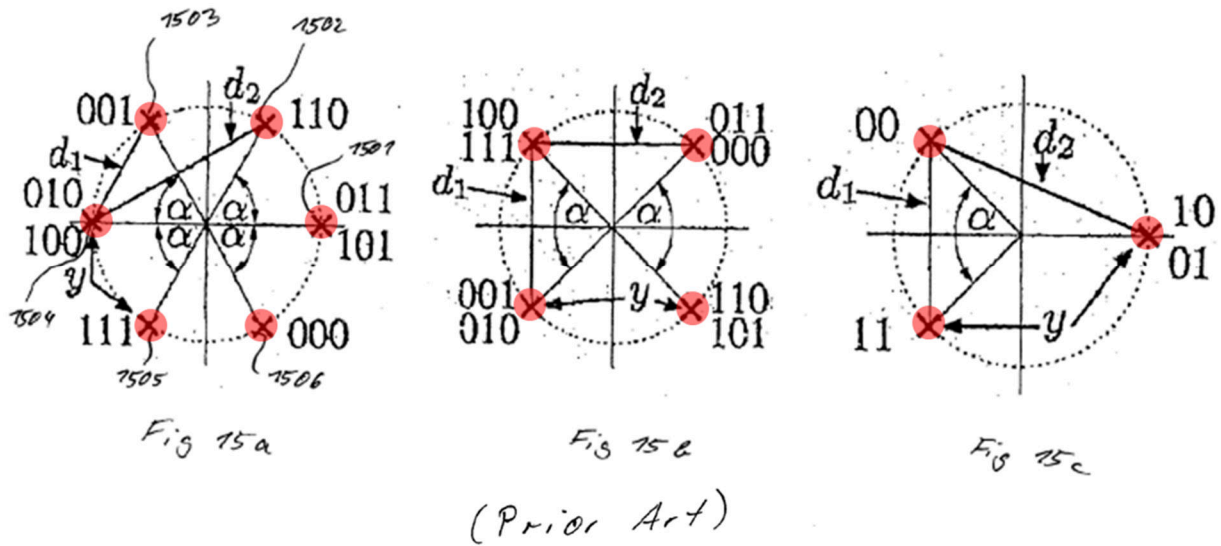
In more detail, Bauch’s communication system, like Eroz’s system, includes a transmitter and a receiver connected through a communication channel. LGE1004, 23:1-37, FIG. 5 (reproduced below); LGE1003, ¶[65].



LGE1004, FIG. 5.

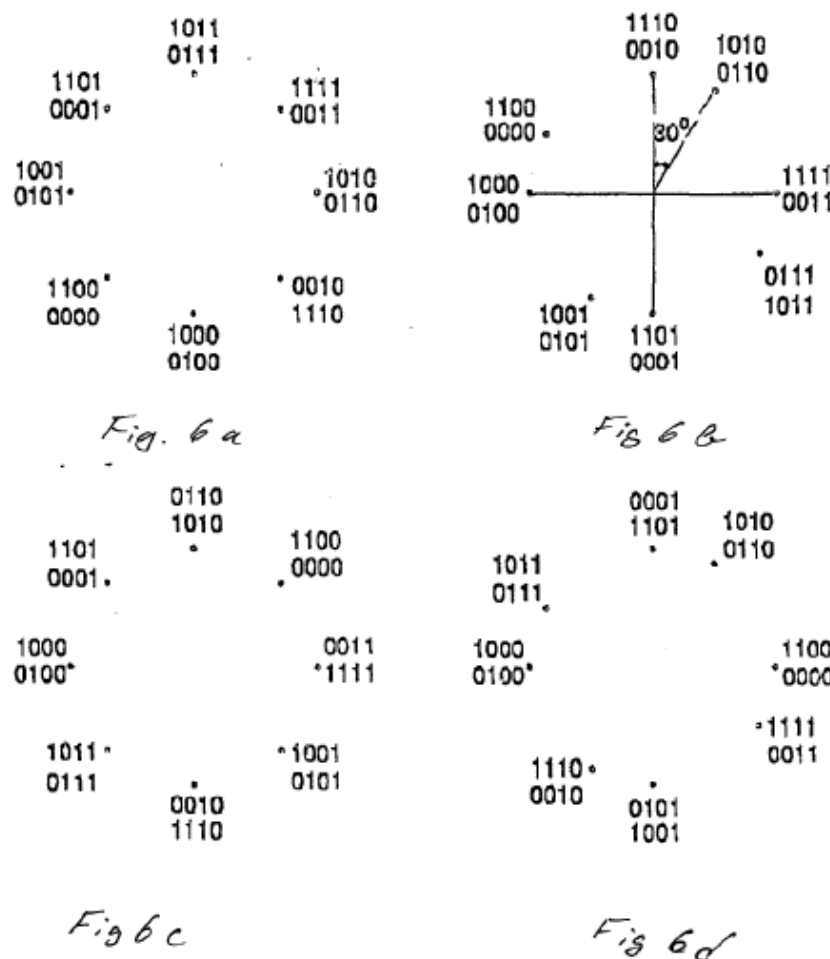
As shown in FIG. 5, Bauch's receiver includes a decoder and "a demapper for demapping a transmit symbol to a group of code bits." LGE1004, 12:27-32. "[T]he demapper is operative to de-map in accordance with a constellation diagram having a plurality of constellation points, each constellation point corresponding to a transmit symbol." LGE1004, 12:35-13:2, 4:24-6:25. Bauch also discloses determining likelihoods using the demodulated signal. For instance, Bauch teaches "comput[ing] soft values for the code bits in the form of log-likelihood ratios (L-values)." LGE1004, 5:1-15; *see also* 2:20-34, 6:1-25, 28:35-29:10; LGE1003, ¶[66].

A description of Bauch's mapping scheme and assignment of labels and spacing of constellation points is described with respect to FIGS. 15A-C and 6A-6D. Bauch explains that various types of constellations, such as 8-PSK constellations, could be implemented by adjusting "the distances between adjacent constellation points ... depending on the value of α ," as shown below in FIGS. 15A-C. LGE1004, 4:8-12. Such mappings "are the basis for" Bauch's teachings. LGE1004, 4:21-22. In particular, FIG. 15a illustrates eight symbol constellation points (000, 001, 010, 011, 100, 101, 110, and 111) at six unique point locations (shown as annotated red dots and labelled as 1501, 1502, 1503, 1504, 1505, and 1506). FIG. 15b illustrates eight symbol constellation points at four unique point locations (annotated in red). Fig. 15c illustrates four symbol constellation points (00, 01, 10, and 11) at three unique point locations (annotated in red). LGE1003, ¶¶[67]-[68]. If $\alpha=90^\circ$ in FIG. 15c (resulting in a perpendicular triangle between points 00, 01, and the origin), then the three unique location points would be unequally spaced as d_2 (the distance between the location of point 00 and the location of points 10 and 01) would be greater than d_1 (the distance between the location of point 00 and the location of point 11). LGE1003, ¶¶[67]-[68].



LGE1004, FIGS. 15a-c.

FIGS. 6a-6d (reproduced below) illustrate examples of a PSK signal constellation that include 16 constellation points at eight unique point locations. LGE1004, 17:30-35, 24:15-26:31; LGE1003, ¶¶[69]-[70]. Bauch describes FIGS. 6a and 6c as symmetric 8-PSKs and FIGS. 6b and 6d as asymmetric 8-PSKs because the unique point locations are not all equally spaced. LGE1004, 24:15-17. Each of these constellations have two constellation points at each unique location point of the constellation. LGE1003, ¶¶[69]-[70].



LGE1004, FIGS. 6a-6d.

In addition, Bauch discloses that asymmetric 8-PSKs, shown in FIGs 6b and 6d, have optimized distances between constellation points:

The mappings shown in Figs. 6a-d are non-unique in the two left-most bits and unique in the two rightmost bits. The mappings have been optimized as follows: First, the two right-most bits are fixed using a Gray mapping, which yield optimum BER performance if no iterations are performed. Given this constraint on the right-most bits, the two left-most bits are optimized using the binary

switching algorithm such that the end point of the EXIT curve is maximized. **Whereas adjacent constellation points in the mappings of Fig. 6a and 6c have the same Euclidean distance, the distance is additionally optimized in the constellations in Figs. 6b and 6d.**

LGE1004, 24:24-37, *see also* 25:1-26:31. Bauch explains that some of the advantages of its mapping scheme are that “ambiguities occur only in certain bit positions for the least important code bits, which enable reasonable performance even without iterations. If no iterations are performed, the receiver sees an effective higher code rate.” LGE1004, 13:20-25. Additional benefits of Bauch’s method include a “lower error floor compared to existing protocols,” “bandwidth-efficient transmission with a reduced size of the modulation alphabet due to non-unique mapping,” and reduced detection complexity and peak to average power ratio, “which relaxes the requirements for linearity of amplifiers.” LGE1004, 13:36-14:30, 16:32-38. Advantageously, and like EroZ, Bauch’s method can be performed with or without iterations and still attain reasonable performance. LGE1004, 14:10-17; LGE1003, ¶[71].

Bauch teaches that its “mapping scheme is not restricted to PSK and QAM constellations, but can be used for any other signal space constellation diagram based, for example, on QPSK, PAM, QAM, PSK, M-QAM, MPSK, wherein M is a number equal to or greater than 1.” LGE1004, 29:18-23. Bauch also discloses that its invention “may be implemented in hardware or in software,” “may be

performed on a digital storage medium,” or “realized as a computer program having a program code for performing the method for encrypting original data when the computer program runs on a computer.” LGE1004, 29:24-30:3; LGE1003, ¶[72].

3. Combination of Eroz and Bauch (“EBC”)

As noted above, Eroz is related to a communication system that uses LDPC codes. LGE1005, Abstract, ¶[0007]. Bauch describes known techniques to configure constellations so that unique constellation locations can have one or more constellation points that are unequally spaced to realize improved performance and benefits, such as bandwidth-efficient transmission with a reduced size of the modulation alphabet due to non-unique mapping, reduced detection complexity and peak to average power ratio, and a lower error floor compared to existing protocols. LGE1004, 13:36-14:30, 16:32-38, FIGS. 6a-6d, 15a-c; LGE1003, ¶[73]. It would have been obvious to a POSITA to combine the teachings of Eroz and Bauch so that the above-noted benefits can be realized in Eroz’s communication system. LGE1003, ¶[74]. Indeed, such benefits are consistent with Eroz’s objectives which include the “need for using LDPC codes efficiently to support high data rates, without introducing greater complexity” and “a need to improve performance of LDPC encoders and decoders.” LGE1005, ¶[0006]. LGE1003, ¶¶[73]-[74].

The combination of Eroz and Bauch is also obvious because a POSITA would have looked at similar systems and coding techniques that would have been predictably incorporated into Eroz's system. LGE1003, ¶[75]. For instance, Eroz and Bauch are both directed to communication systems in which encoded signals are sent from a transmitter to a receiver over a channel. *See supra* §§IV.A.1-IV.A.2; LGE1005, FIGS. 1-3; LGE1004, FIG. 5. Eroz and Bauch both include receivers that can demodulate a received signal, determine likelihoods using the demodulated signal, demap symbols to bits, perform decoding using the likelihoods and demapped data in an iterative or non-iterative manner. LGE1005, ¶¶[0058]-[0093]; LGE1004, 2:20-34, 4:24-6:25, 12:35-13:2, 28:35-29:10. Bauch uses turbo codes, which, like LDPC coding in Eroz, can perform very close to the Shannon limit and also use a message passing algorithm. LGE1004, 4:28-30, 9:27-35, 13:29-37; LGE1003, ¶[75]. Indeed, it would have been obvious for a POSITA to look at similar codes to improve Eroz's communication system. LGE1003, ¶[75]. Eroz and Bauch also have the capability of processing constellations with various types of modulations, e.g., PAM, QAM, PSK, APSK, and QPSK. LGE1004, 29:18-23; LGE1005, claim 7. Accordingly, in view of the similarities between Eroz and Bauch, the combination of Eroz and Bauch (hereinafter referred to as "**EBC**") would also have been predictable and foreseeable. LGE1003, ¶[75].

The combination would also have been predictable because elements of the

combined system would have performed similar functions that had been known prior to the combination. LGE1003, ¶[76]. For example, Eroz's communication system (with a transmitter and a receiver) would still perform in the same or similar manner but use constellations specified by Bauch. *Id.*

Combining the teachings of Eroz and Bauch would also have been obvious because doing so would have merely involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[77]. For example, a POSITA would have combined the teachings of Eroz and Bauch such that Eroz's system would have implemented the constellation designs and coding described in Bauch. LGE1003, ¶[77]. For example, the data used in Eroz's system would have included unequally spaced LDPC constellations in which one or more constellation points can be placed at unique locations of the constellations. LGE1003, ¶[77].

A POSITA would have been able to combine the teachings of Eroz and Bauch as described above in a predictable manner because making such modifications would have merely involved implementing software code for configuring the desired code rates, modulation and constellation types. LGE1003, ¶[78]. For example, Bauch acknowledges that its invention "may be implemented in hardware or in software," or can be "realized as a computer program having a program code for performing" its method. LGE1004, 29:24-30:3; LGE1003,

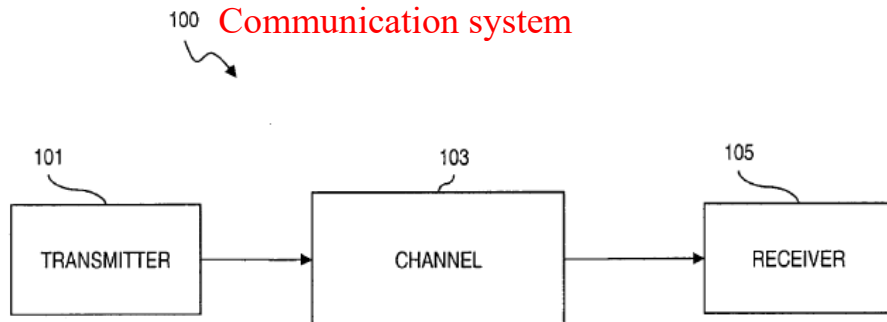
¶[78]. Reconfiguring the software in Erož’s system to incorporate the teachings of Bauch would have been well within the knowledge and capabilities of a POSITA, further indicating that EBC would have been obvious and predictable, and confirming that a POSITA would have had a reasonable expectation of success in making the combination. LGE1003, ¶[78]. Indeed, because the combination would have involved reprogramming software code in Erož’s system to use constellations that were known in the art, a POSITA would also have had a reasonable expectation of success. LGE1003, ¶[78].

4. Ground 1 Prior Art Mappings

[1pre]

To the extent the preamble is limiting, EBC renders [1pre] obvious. Erož discloses a **communication system** (illustrated below in Erož’s FIG. 1) that utilizes LDPC coding. LGE1005, cover, ¶¶[0030]-[0033]. Erož’s **communication system** 100 “includes a transmitter 101 that generates signal waveforms across a communication channel 103 to a receiver 105.” LGE1005, ¶[0030]; LGE1003, ¶[101].

FIG. 1

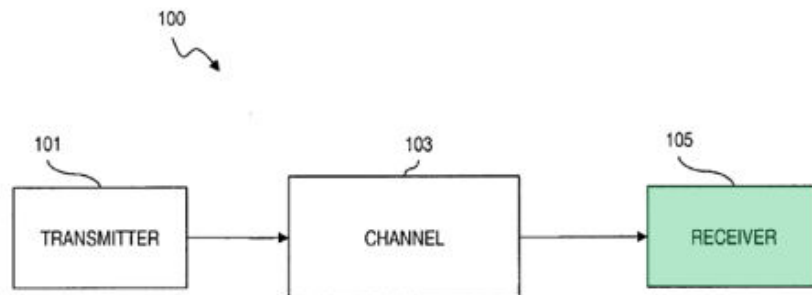


LGE1005, FIG. 1

[1a]

As shown below in Eroz's FIG. 1, Eroz's communication system includes *a receiver* 105 that is *capable of receiving signals via communication channel* 103 from transmitter 101. LGE1005, ¶[0030]. Eroz teaches that "*communication channels exhibit a fixed capacity that can be expressed* in terms of bits per symbol *at certain signal to noise ratio (SNR).*" LGE1005, ¶[0003]; *see also* FIG. 7. Accordingly, it would have been obvious to a POSITA that Eroz's communication channel 103 has a SNR. LGE1003, ¶[102].

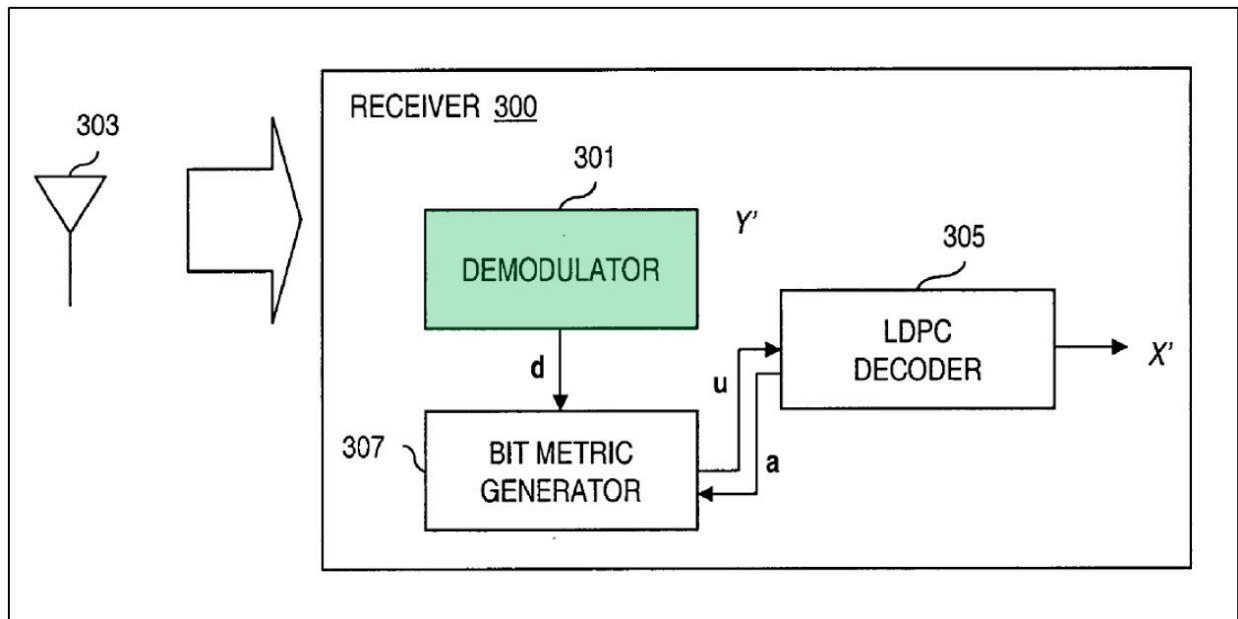
FIG. 1



LGE1005, FIG. 1

[1b]

Eroz's "FIG. 3 is a diagram of an exemplary receiver [300/105] in the system of FIG. 1." LGE1005, ¶[0058]. As shown in Erož's FIG. 3 below, Erož teaches that "receiver 300 includes a demodulator 301 that performs demodulation of received signals from transmitter" (*demodulator capable of demodulating a received signal into a demodulated signal*). *Id.*; see *supra* §IV.A.1. A demodulated signal generated by the demodulator 301 is provided to the bit metric generator 307 and LDPC decoder 305. LGE1005, ¶[0058]; LGE1003, ¶[103].

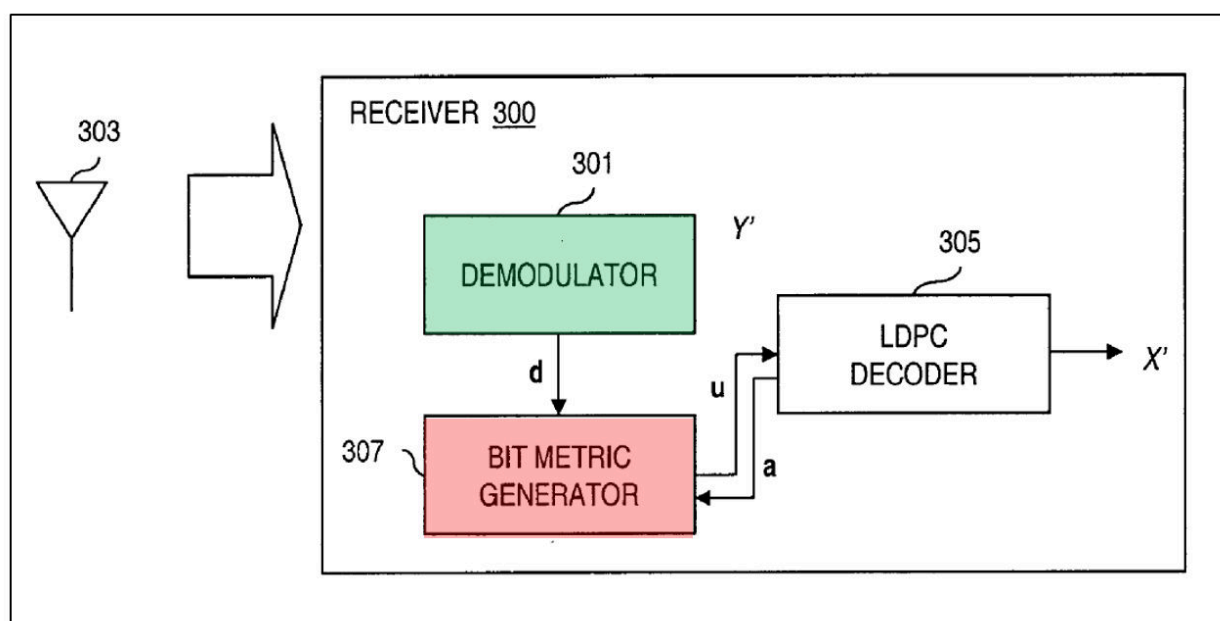


LGE1005, FIG. 3.

[1c-1]

As shown in Erož's FIG. 3 below, Erož's receiver 300 includes bit metric generator 307 (*a demapper*) that is coupled to demodulator 301. LGE1005,

¶[0058], FIG. 3. Based on the signal received from the demodulator 301, the bit metric generator 307 exchanges probability information (*demapper ... capable of determining likelihoods using the demodulated signal*) with the decoder 305 iteratively when non-Gray mapping is used or in a single iteration when Gray mapping is used. LGE1005, ¶[0058], FIGS. 10-11; LGE1003, ¶[104].



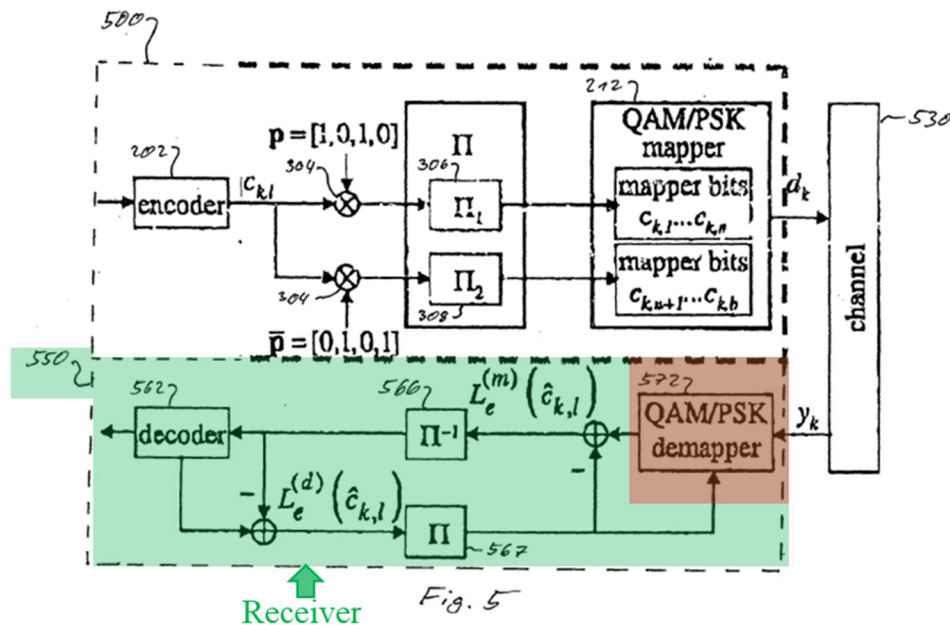
LGE1005, FIG. 3.

In one example of *a symbol constellation, an 8-PSK modulation* is used to communicate data, and Erož's "bit metric generator 307 communicates with the LDPC decoder 305 to exchange a priori probability information and a posteriori probability information, which respectively are represented as u , and a . That is, the vectors u and a respectively represent a priori and a posteriori probabilities of log likelihood ratios of coded bits." LGE1005, ¶[0076]-[0077]; LGE1003, ¶[105].

Next, the bit metric generator 307 determines symbol probabilities using a lookup table, and *determines a priori log likelihood ratios* of the coded bits, which are provided to the LDPC decoder 305. LGE1005, ¶¶[0078]-[0082]; LGE1003, ¶[106].

More generally (in addition to the 8-PSK modulation example above), Eroz discloses that its system can utilize a plurality of multidimensional symbol constellations. LGE1003, ¶[107]. For example, Eroz's claim 7 recites "modulating the LDPC coded signal according to a signal constellation that includes one of 8-PSK (Phase Shift Keying), 16-QAM (Quadrature Amplitude Modulation), QPSK (Quadrature Phase Shift Keying), 16-APSK (Amplitude Phase Shift Keying) and 32-APSK." LGE1005, claim 7; LGE1003, ¶[107].

Bauch also discloses a receiver including a demapper that "demap[s] a transmit symbol to a group of code bits." LGE1004, 12:27-32, FIG. 5 (reproduced below); LGE1003, ¶[108].



LGE1004, FIG. 5.

Like Erož's demapper, Bauch's *demapper is capable of determining likelihoods using the demodulated signal and a symbol constellation*. For instance, Bauch teaches that, using symbols y_k from data received from a channel, the demapper “computes soft values for the code bits in the form of log-likelihood ratios (L-values).” LGE1004, 5:1-15 (emphasis added); *see also, id.*, 6:1-25, 28:35-29:10. In particular, “the demapper 1472 produces soft extrinsic values $L_e^{(m)}(c_{k,l})$ about the code bits based on the received values y_k which are passed to the decoder 14062. The decoder, 1462 computes improved extrinsic information $L_e^{(d)}(c_{k,l})$ which is fed back to the demapper 1472 and used as a-priori information in a new decoding attempt.” LGE1004, 2:20-34. The demapper computes “code bits in the form of log-likelihood ratios (L-values),

$$\begin{aligned} L_e^{(d)}(\hat{c}_k) &= \log_2 \frac{p(c_{k,l} = +1|\mathbf{y})}{p(c_{k,l} = -1|\mathbf{y})} \\ &= \log_2 \frac{\sum_{d_k \in C_+} p(d_k|\mathbf{y})}{\sum_{d_k \in C_-} p(d_k|\mathbf{y})} \end{aligned}$$

where $p\{c_{k,l} = \pm 1|\mathbf{y}\}$ is the conditional probability that the code bit $c_{k,l}$ was transmitted given the received sequence $\mathbf{y}$. In case of a memoryless channel, $\mathbf{y}$ can be replaced by y_k . C_+ represents the set of all constellation points d_k associated with $c_{k,l} = +1$, C_- represents the set of all constellation points d_k associated with $c_{k,l} = -1$.” LGE1004 5:1-15; LGE1003, ¶[109].

As noted above in §IV.A.3, both Eroz and Bauch discloses a demapper such that the EBC’s system could implement the functionality of Eroz and Bauch’s demapper. Such a demapper would have been used to demap data at the receiver and would have been coupled to Eroz’s bit metric generator 307, so that the combined system would process (demap and decode) the received constellations. LGE1003, ¶[110].

As explained above in §IV.A.2, Bauch discloses various types of constellations, such as constellations in FIGS. 6a-6d and 15c (*see also* FIGS. 10a-d), *each of which include constellation points at a plurality of unique point locations.*” LGE1004, 8:28-33, 24:12-26:7, 18:8-10. For example, FIG. 15c illustrates four symbol constellation points (00, 01, 10, and 11) in three unique point locations (annotated in red). LGE1004, 8:28-33, 3:27-35; LGE1003, ¶[111].

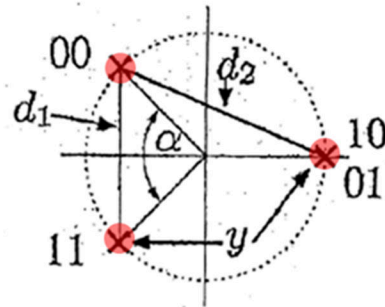


Fig 15c

LGE1004, FIG. 15c.

FIGS. 6b and 6d illustrate 16 constellation points at eight unique point locations (annotated in red). LGE1004, 24:34–26:7; LGE1003, ¶[112].

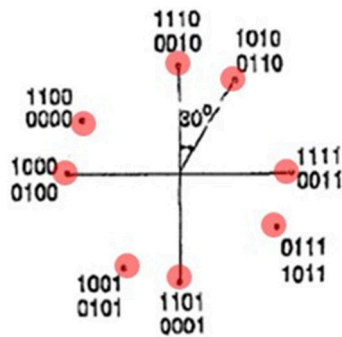


Fig 6b

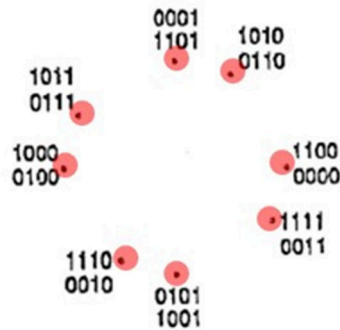


Fig 6d

LGE1004, FIGS. 6b (top), 6d (bottom).

Similarly, FIGS. 10a and 10c illustrate 16 constellation points at twelve and eight unique point locations, respectively (annotated in red). LGE1004, FIGS. 10a, 10c; LGE1003, ¶[113].



Fig. 10a

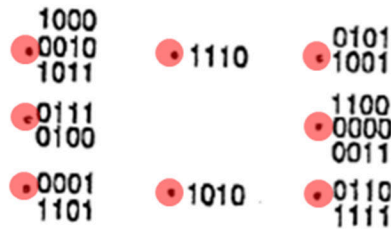
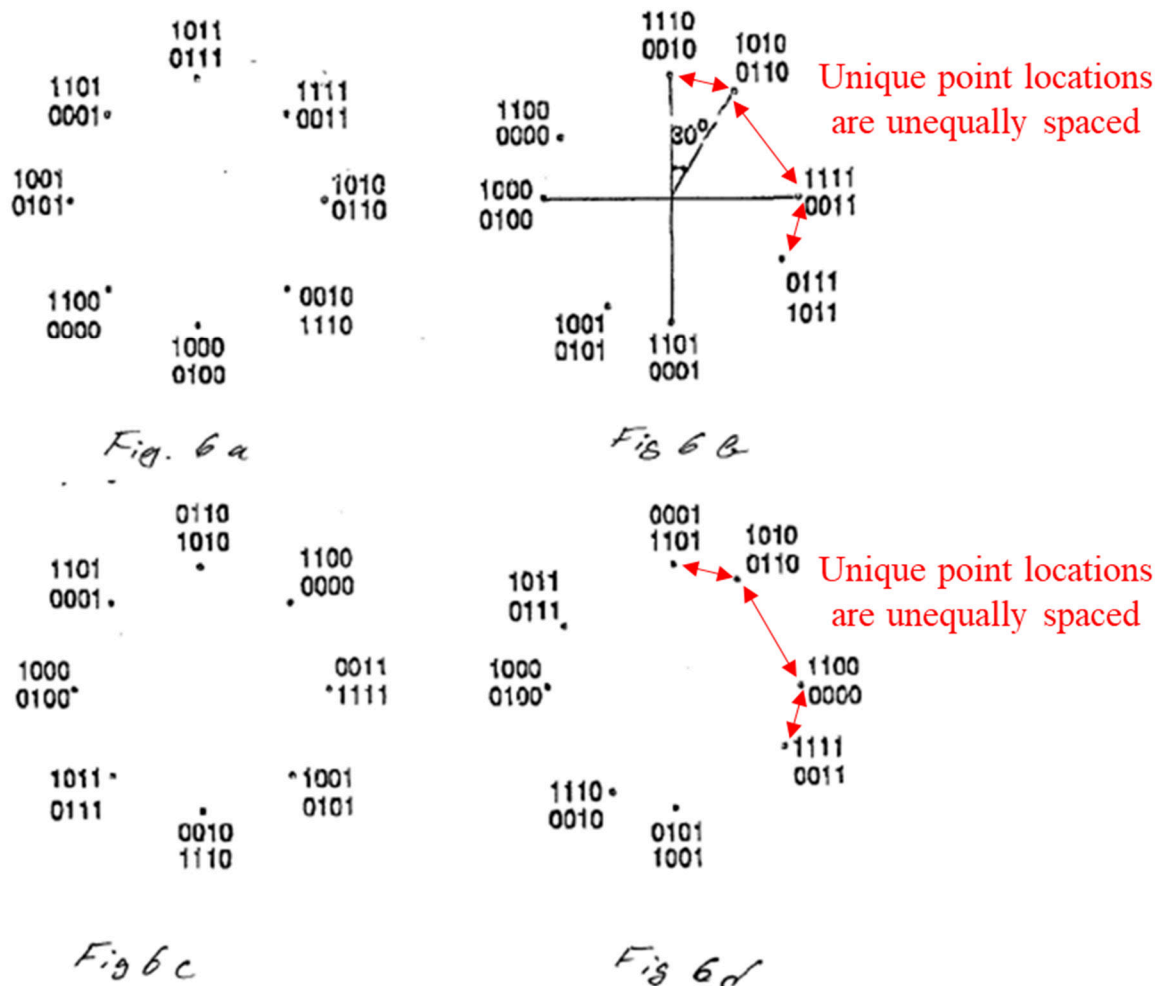


Fig 10c

LGE1004, FIGS. 10a, 10c.

[1c-2]

Bauch discloses that *the plurality of unique point locations in its symbol constellation are unequally spaced*. LGE1004, 24:34-37, FIGS. 6b and 6d. For example, Bauch's FIGS. 6b and 6d (reproduced below) also disclose examples of *a symbol constellation in which the plurality of unique point locations are unequally spaced*. Bauch explains that relative to FIGS. 6a and 6b, "the distance is additionally optimized in the constellations in FIGS. 6b and 6d." LGE1004, 24:34-37. For instance, while FIGS. 6a and 6d have pairs of constellation points at unique locations equal distant apart, the constellations shown in FIGS. 6b and 6d have pairs of constellation points at unique location points that are unequally spaced. LGE1003, ¶[114]. In FIG. 6b, a first set of constellation points 1110 and 0010 are located on the vertical axis; points 1010 and 0110 are located 30° from the first set of constellation points but 60° from points 1111 and 0011. LGE1003, ¶[114]. This means that the unique location point at which constellation points 1010 and 0110 are located is necessarily unequally spaced from its neighboring unique location points. LGE1003, ¶[114].



LGE1004, FIGs. 6b and 6d.

Similarly, FIGS. 10a and 10c illustrate 16 constellation points at twelve and eight unique point locations, respectively (annotated in red) and have constellation points at unique location points that are unequally spaced. LGE1004, FIGS. 10a, 10c.; LGE1003, ¶[115].



Fig. 10a



Fig 10c

LGE1004, FIGS. 10a, 10c.

[1c-3]

Bauch discloses that *the constellation points each having a location and a different label*. For example, FIGS. 6b and 6d (shown below) illustrate two transmit symbols mapped to each of the 8 constellation points (annotated in red.) Bauch discloses that:

According to the diagram shown in Fig. 6b,
a first constellation point corresponds to the group of code bits 1111 and 0011,
a second constellation point, corresponding to the group of code bits 1010 and 0110,
a third constellation point, corresponding to the group of code bits 1110 and 0010,
a fourth constellation point corresponding to the group of code bits 1100 and 0000,
a fifth constellation point, corresponding to the group of code bits 1000 and 0100,
a sixth constellation point, corresponding to the group of code bits 10001 and 0101,
a seventh constellation point, corresponding to the group of code bits 1101 and 0001, and
a eighth constellation point, corresponding to the group of code bits 0111 and 10101.

...

According to the diagram shown in Fig. 6d,
a first constellation point corresponds to the group of code bits 1100 and 0000,
a second constellation point, corresponding to the group of code bits 1010 and 0110,
a third constellation point, corresponding to the group of code bits 0001 and 1101,
a fourth constellation point corresponding to the group of code bits 1011 and 0111,
a fifth constellation point, 0111, a fifth constellation point, corresponding to the group of code bits 1000 and 0100,
a sixth constellation point, corresponding(to the group of code bits 1110 and 0010,

a seventh constellation point, corresponding to the group of code bits 0101 and 1001, and
a eighth constellation point, corresponding to the group of code bits 1111 and 0011.

LGE1004, 25:1–26:7.

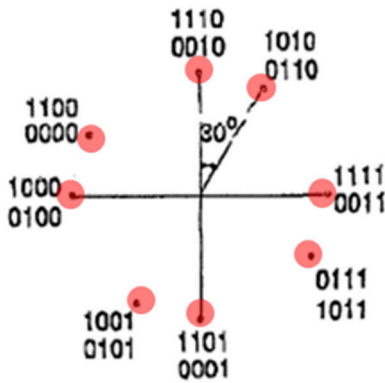


Fig 6b

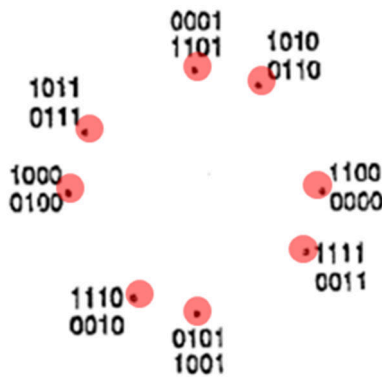


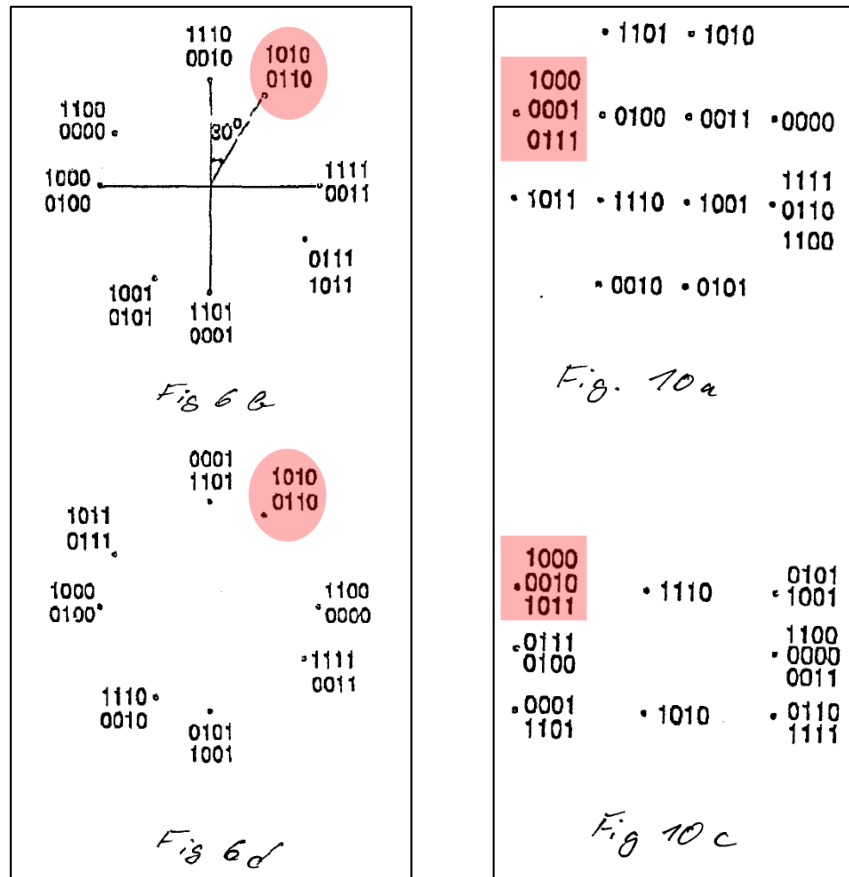
Fig 6d

LGE1004, FIGs. 6b and 6d.

Bauch's FIGS. 10a and 10c (reproduced above) similarly disclose that "*the constellation points each have a location and a different label.*" LGE1003, ¶¶[116]-[117].

[1c-4]

As noted above in [1c-1]-[1c-3] and shown in Bauch's FIGS 6b, 6d, 10a, 10c below, Bauch discloses that "*the locations of at least two of the constellation points are the same.*" LGE1003, ¶[118]. For instance, in FIGS. 6b and 6d, two constellation points 1010 and 0110 have the same location (as do several other pairs of points in FIGS. 6b and 6d). LGE1003, ¶[118]. In FIGS. 10a and 10c, three constellation points 1000, 0001, and 0111 have the same location. LGE1003, ¶[118].

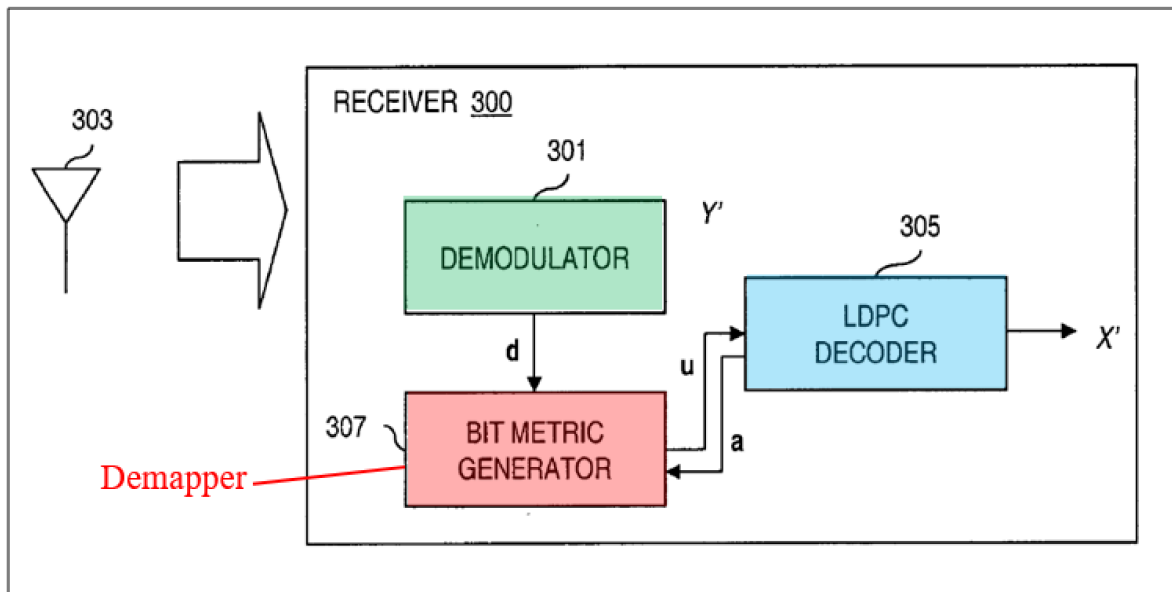


LGE1004, FIGS. 6b, 6d, 10a, 10d.

[1d]

As shown in Erož's FIG. 3 below, Erož's receiver 300 includes *a LDPC decoder* 305 that is *coupled to the* bit metric generator 307 (*demapper*).

LGE1005, ¶[0058], FIG. 3; LGE1003, ¶[119].



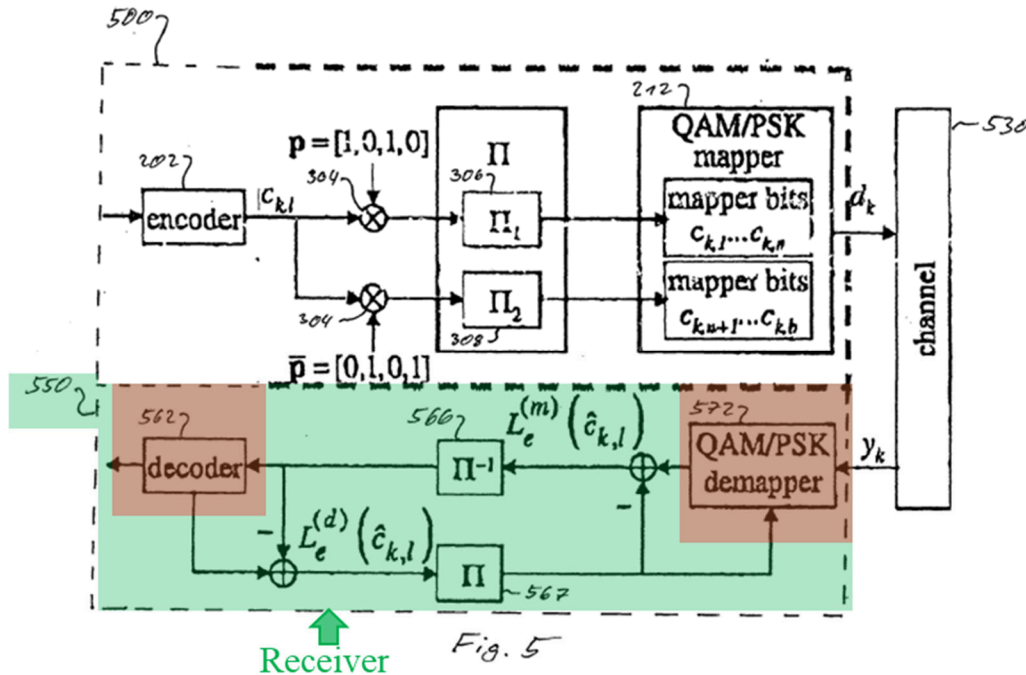
LGE1005, FIG. 3.

The decoder 305 *uses* the probability information (*likelihoods*) *determined by the* bit metric generator 307 (*demapper*) to reconstruct the original source messages. LGE1005, ¶[0058]; *see supra* [1c-1]. In particular, the LDPC decoder 305 “is considered a message passing decoder, whereby the decoder 305 aims to find the values of bit nodes” (*a sequence of received bits based upon a low density parity check (LDPC) code*). LGE1005, ¶¶[0061]-[0063], [0076]; *see also* FIGS. 10-11, ¶¶[0083]-[0107] (describing specifics of decoding non-Gray and Gray codes); LGE1003, ¶[120].

In addition, as discussed above in [1c-1], Bauch, like Eroç, also discloses a decoder, coupled to the demapper, capable of using the likelihoods determined by the demapper to provide a sequence of received bits. LGE1004, FIGS. 5, 14,

13:10-15, 23:1-24, 26:9-21, 2:20-34, 5:1-15, 6:1-25, 7:1-22, 9:24-35; LGE1003,

¶[121].

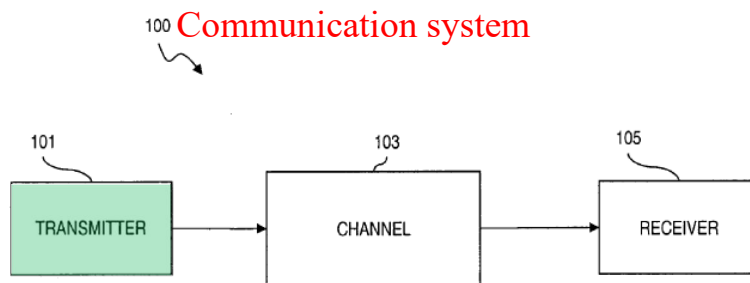


LGE1004, FIG. 5.

[9pre]

As explained above in §IV.A.1, Erož’s *communication system* 100 *includes a transmitter* 101 that is *capable of transmitting signals via communication channel* 103. LGE1005, ¶[0030], FIG. 1. The “signal waveforms are attenuated, or otherwise altered, by communications channel 103. *Id.*; LGE1003, ¶[122].

FIG. 1

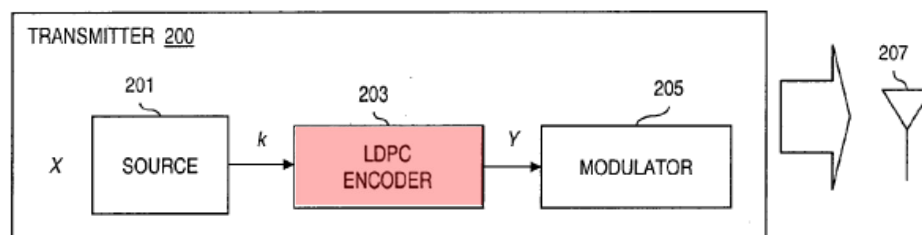


LGE1005, FIG. 1.

[9a]

Details of Erož's transmitter 101/200 are shown in Erož's FIG. 2A (reproduced below). LGE1005, ¶¶[0030], [0034]. Erož's transmitter 200 includes a LDPC encoder 203 ("*coder*") *that is capable of receiving bits* from k signals. LGE1005, ¶[0034]. The bits *are encoded using a LDPC code*. LGE1005, ¶[0034]. LDPC encoder 203 *outputs encoded bits* (using alphabet Y) and provides signals with the encoded bits to modulator 205. LGE1005, ¶[0035]; LGE1003 ¶[123].

FIG. 2A



LGE1005, FIG. 2A.

[9b]

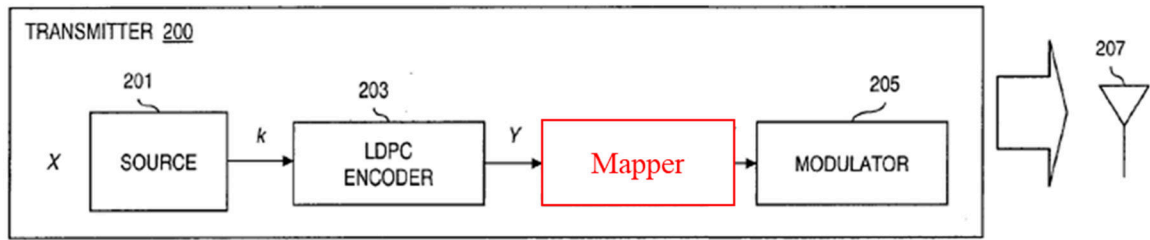
Eroz generally discloses the use of symbols and provide several examples utilizing 8-PSK symbols. LGE1005, ¶¶[0003], [0071], [0074]-[0075], [0108].

Although not explicitly shown in Erož's transmitter 200, it would have been obvious to a POSITA that a mapper is used in Erož's transmitter so that encoded bits can be mapped to symbols in a symbol constellation. LGE1003 ¶[124].

Bauch corroborates this and more explicitly discloses a mapper 212 "for mapping a group of code bits to a transmit symbol." LGE1004, Abstract. For instance, Bauch discloses that mapper 212 can map a first group of code bits to a first symbol point in a constellation, and a second group of code bits to a second symbol point in the same constellation. LGE1004, 21:27-22:2; LGE1003, ¶[124].

To the extent it is argued that Erož's transmitter does not include a mapper, it would have been obvious to a POSITA to include a Bauch's mapper in Erož's transmitter so that the mapper is coupled to and receives encoded bits from the coder (LDPC encoder 203) and maps the encoded bits to symbols in a symbol constellation. LGE1003 ¶[125]. A POSITA would have made such a combination to implement Bauch's mapping (e.g., assignment and location of points) in Erož's system for the reasons noted above in §IV.A.3. LGE1003 ¶[125].

FIG. 2A

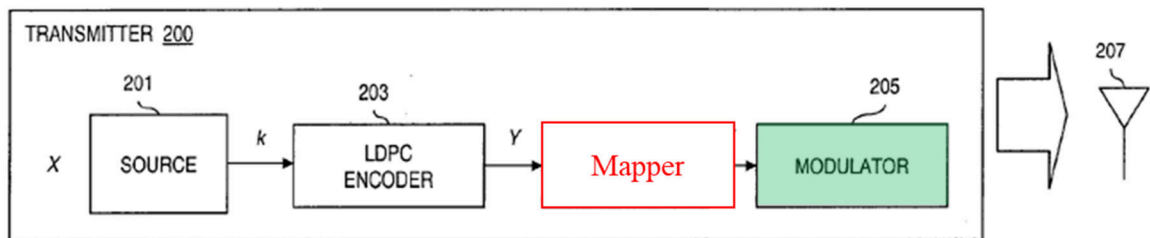


LGE1005, FIG. 2A (modified to include a mapper).

[9c]

Eroz discloses that **modulator 205** generates “signal waveforms that are transmitted to a transmit antenna 207, which emits these waveforms over the communication channel 103” (“*modulator ... capable of generating a signal for transmission via the communication channel*”). LGE1005, ¶[0036]; LGE1003 ¶[126].

FIG. 2A



LGE1005, FIG. 2A (modified to include a mapper).

As explained in [9b], in EDC, the **modulator 205 is coupled to a mapper** between the encoder 203 and the modulator 205, and the signals generated by

modulator 205 for transmission are based upon symbols selected by the mapper.

LGE1003 ¶[127].

[11pre]

To the extent the preamble is limiting, EBC renders [11pre] obvious. *See supra* [1pre]; LGE1003, ¶[128].

[11a]

See supra [1a]; LGE1003, ¶[129].

[11b]

See supra [1b]; LGE1003, ¶[130].

[11c-1]

See supra [1c-1]; LGE1003, ¶[131].

[11c-2]

See supra [1c-2]; LGE1003, ¶[132].

[11c-3]

See supra [1c-3]; LGE1003, ¶[133].

[11c-4]

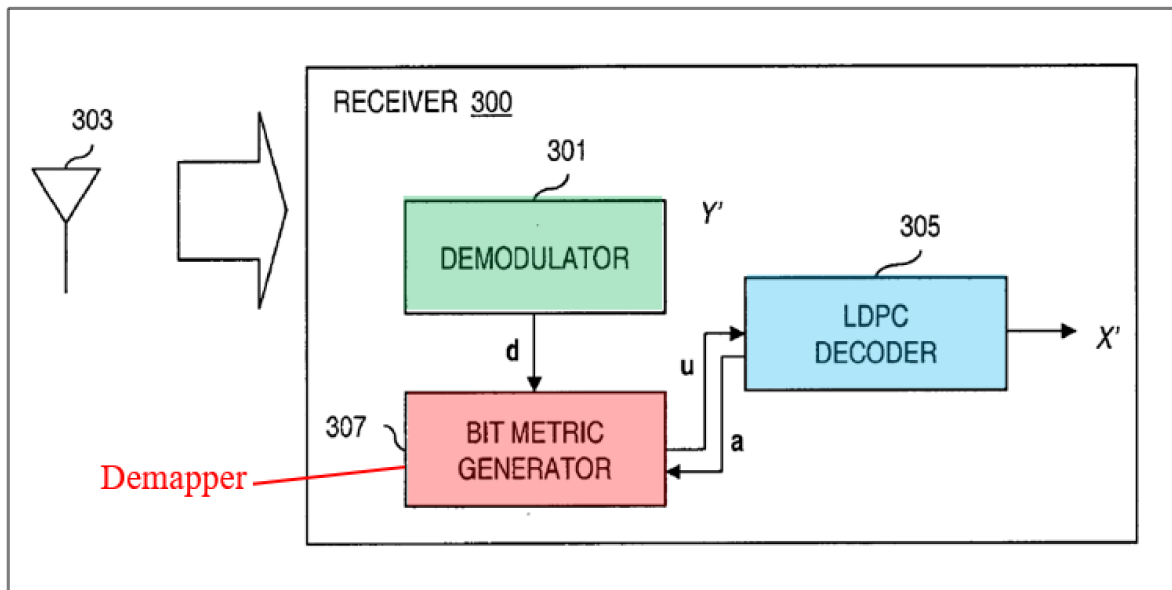
See supra [1c-4]; LGE1003, ¶[134].

[11d]

See supra [1d]; LGE1003, ¶[135].

[11e]

As explained above in [1c-1] and [1d], EBC renders obvious that “*the demapper is interposed between the demodulator and the decoder.*” As shown in Erož’s FIG. 3 (below), the bit metric generator 307 (*demapper*) receives information in the form of a demodulated signal *d* from the demodulator 301 and provides likelihood information *u* to the decoder 305. LGE1005, ¶¶[0058], [0061]-[0063], [0076], [0083]-[0107], FIGS. 10-11; see also LGE1004, FIGS. 5, 14, 13:10-15, 23:1-24, 26:9-21, 2:20-34, 5:1-15, 6:1-25, 7:1-22, 9:24-35; LGE1003, ¶[136].



LGE1005, FIG. 3.

[19pre]

See *supra* [9pre]; LGE1003, ¶[137].

[19a]

See supra [9a]; LGE1003, ¶[138].

[19b]

See supra [9b]; LGE1003, ¶[139].

[19c]

See supra [9c]; LGE1003, ¶[140].

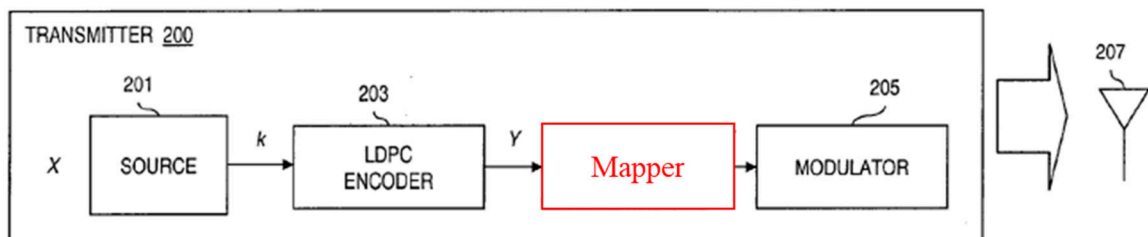
[19d]

As explained above in [19pre]-[19c], EBC renders obvious “*the mapper is interposed between the modulator and the coder,*” and the mapper receives information from the coder and provides information to the modulator. LGE1003, ¶[141]. Although not explicitly shown in Eroz’s transmitter 200, it would have been obvious to a POSITA that a mapper is used in Eroz’s transmitter so that encoded bits can be mapped to symbols in a symbol constellation. LGE1003 ¶[141]. Bauch corroborates this and more explicitly discloses a mapper 212 “for mapping a group of code bits to a transmit symbol.” LGE1004, Abstract. For instance, Bauch discloses that mapper 212 can map a first group of code bits to a first symbol point in a constellation, and a second group of code bits to a second symbol point in the same constellation. LGE1004, 21:27-22:2; LGE1003, ¶[141].

To the extent it is argued that Eroz’s transmitter does not include a mapper, it would have been obvious to a POSITA to include a Bauch’s mapper in Eroz’s

transmitter so that the mapper is coupled to and receives encoded bits from the coder (LDPC encoder 203), maps the encoded bits to symbols in a symbol constellation, and provides the symbol constellation to the modulator. LGE1003 ¶[142]. A POSITA would have made such a combination for the reasons noted above in §IV.A.3. LGE1003 ¶[142]. A POSITA would have readily understood that implementing a Bauch's mapper in EroZ's transmitter would result in the mapper receiving information from the LDPC encoder 209 and providing information to the modulator 205. LGE1005, ¶¶[0033]-[0036]; *see also* LGE1004, FIGS. 5, 14, 13:10-15, 23:1-24, 26:9-21, 2:20-34, 5:1-15, 6:1-25, 7:1-22, 9:24-35; LGE1003, ¶[142].

FIG. 2A



LGE1005, FIG. 2A (modified to include a mapper).

[21pre]

To the extent the preamble is limiting, EBC renders [21pre] obvious. *See supra* [1pre]; LGE1003, ¶[143].

[21a]

See supra [1a]; LGE1003, ¶[144].

[21b]

As explained above in [1a]-[1c-1], EBC discloses *a receiver 300 that transforms received signals into received bits* through its demodulator 301, demapper (bit metric generator 307), and decoder 305. LGE1005, FIG. 3, ¶¶[0058], [0076]-[0082]. To perform the transform in the EBC system, it would have been obvious to a POSITA that EBC's *receiver would use a symbol constellation*, e.g., one of the symbol constellations depicted in Bauch's FIGS. 6b, 6d, 10a, 10c, 15c among various other possible unequally spaced constellations, *which includes constellation points at a plurality of unique point locations*. LGE1003, ¶[145]. For instance, Eroze teaches that its modulator 205 uses "a simple encoding technique that makes use of only the parity check matrix by imposing structure onto the parity check matrix," and that the receiver "reconstruct[s] the original source messages." LGE1005, ¶¶[0035], [0058]. Bauch explains that a mapper in the transmitter maps "a group of code bits to a transmit symbol" and "is operative to map in accordance with a constellation diagram having a plurality of constellation points." LGE1004, Abstract. By referring to the terms, "encoding technique" and "mapper", a POSITA would have understood that these terms are part of the transmitter system. LGE1005, ¶¶[0035], [0058], Abstract; LGE1003, ¶[145]. Indeed, a POSITA would have understood in light of Ulrich, a textbook that describes technical features of digital video broadcasting systems and methods, which explains that at the receiver

of a communication system, “processing steps that were carried out at the encoder have to be reversed.” LGE1019, 198; LGE1003, ¶[145]. That is, when a particular type of modulation, mapping, and encoding is used on the transmitter, a corresponding [de]modulation, [de]mapping, and decoding is performed at the receiver to recover the information bits. LGE1003, ¶[145]. Each of Bauch’s FIGS. 6b, 6d, 10a, 10c, 15c are an example of a symbol constellation that *includes constellation points at a plurality of unique point locations*. LGE1003, ¶[145].

[21c-1]

See supra [1c-2]; LGE1003, ¶[146].

[21c-2]

See supra [1c-3]; LGE1003, ¶[147].

[21c-3]

See supra [1c-4]; LGE1003, ¶[148].

[22]

See supra [9pre]-[9c]; LGE1003, ¶[149].

B. Ground 2: EBC and DVB-T render obvious claims 10, 20, and 30

1. Overview of DVB-T

DVB-T is a standard document entitled “Digital Video Broadcasting (Terrestrial) titled Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television.” LGE1009, 1. DVB-T

describes details for inner and outer coding, mapping, constellations (uniform and non-uniform), modes of operation (e.g., 2K or 8K), and code rates in support of DVB communications over a communication network, and, particularly for “the adaptation of the baseband TV signals ... to the terrestrial channel characteristics.” LGE1009, 8-9; LGE1003, ¶[79].

DVB-T describes implementations in which different levels of QAM modulation and different inner code rates can be used to trade bit rate versus ruggedness. LGE1009, 9. In some implementations, DVB-T teaches the use of non-uniform constellations for QAM style modulation. For example, DVB-T discloses that “[a]ll data carriers in one OFDM frame are either QPSK, 16-QAM, 64-QAM, non-uniform-16-QAM or non-uniform-64-QAM using Gray mapping.” LGE1009, 20. Examples of four unequally spaced constellations are shown below in Figures 9b and 9c. LGE1003, ¶[80]. In particular, Figure 9b illustrates an unequally spaced 16-QAM (top) and an unequally spaced 64-QAM (bottom) when $\alpha=2$. LGE1009, 22. Figure 9C illustrates an unequally spaced 16-QAM (top) and an unequally spaced 64-QAM (bottom) when $\alpha=4$. LGE1009, 23. Alpha (α) is defined as a “constellation ratio which determines the QAM constellation for the modulation for hierarchical transmission.” LGE1009, 7. Dr. Hochwald explains that the value for α can be set to configure the shape, spacing, and uniformity of a constellation. LGE1003, ¶[81]. DVB-T teaches that “the α value defines the

modulation based on the cloud spacing of a generalized QAM constellation. It allows specification of uniform and non-uniform modulation schemes covering QPSK, 16-QAM, and 64-QAM.” LGE1009, 29. For example, when $\alpha=1$, a uniform constellation can be realized, as shown in DVB-T’s Figure 9a. LGE1009, 21. However, the spacing between different points in the constellation (and axes) increases when α is increased resulting in non-uniformity, as shown in Figures 9b and 9c. LGE1009, 22-23; LGE1003, ¶¶[80]-[81].

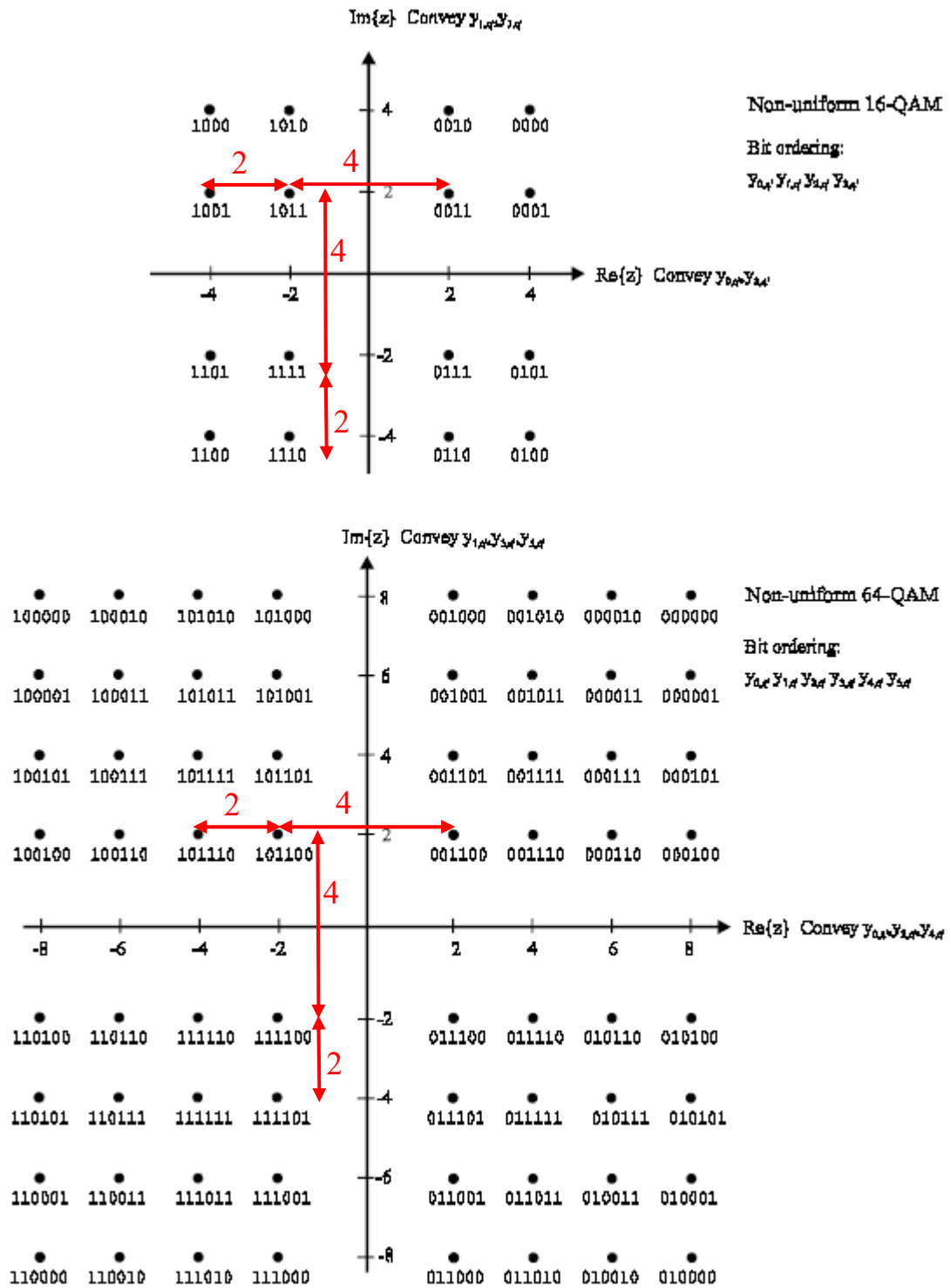


Figure 9b: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 2$

LGE1009, FIG. 9b.

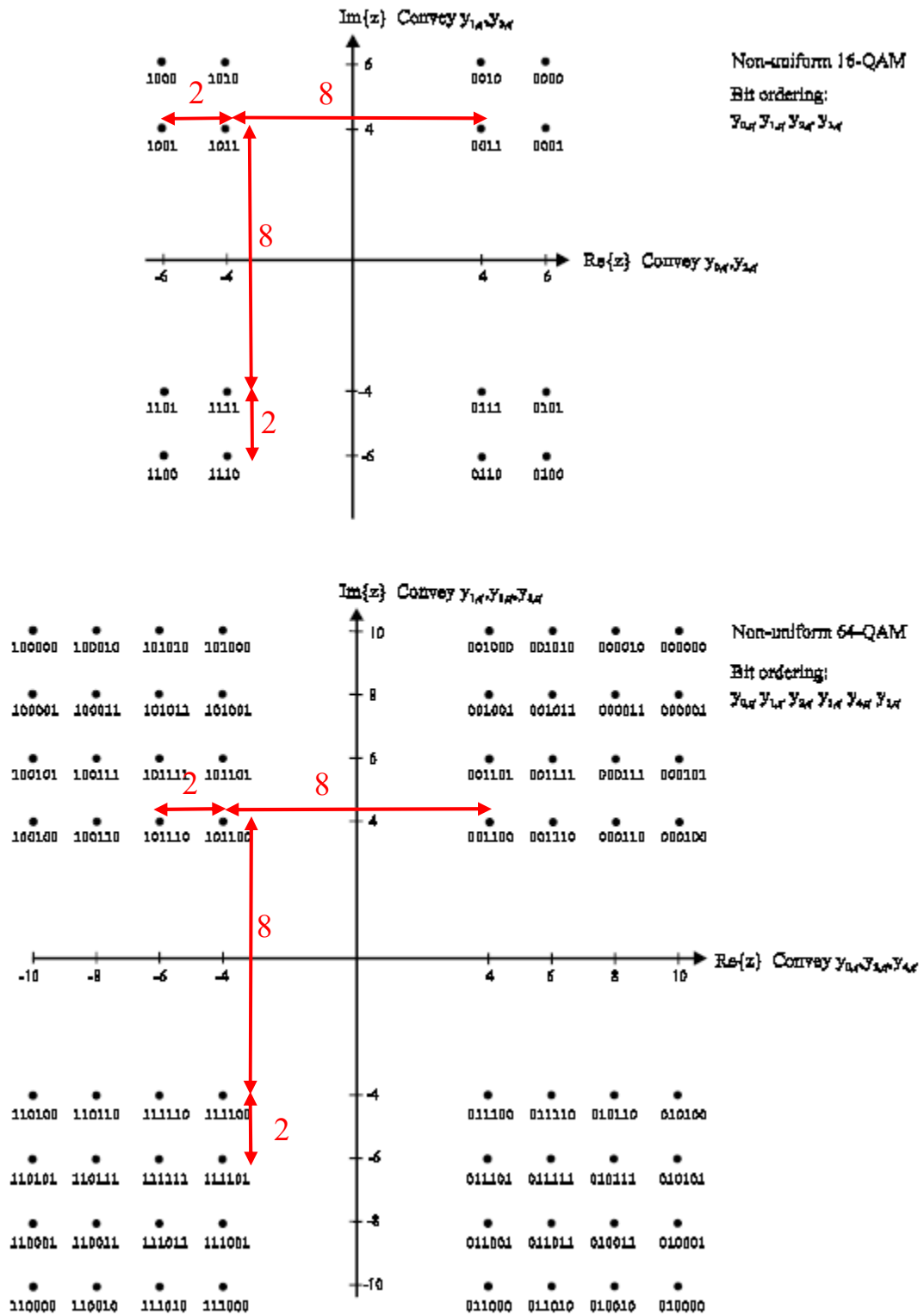


Figure 9c: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 4$

LGE1009, FIG. 9c.

DVB-T also describes the use of Transmission Parameter Signaling (TPS) in which “TPS carriers are used for the purpose of signalling parameters related to the transmission scheme, i.e. to channel coding and modulation,” to the receiver.

LGE1009, 29. “The TPS carriers convey information on: a) modulation including the a value of the QAM constellation pattern ...; b) hierarchy information; c) guard interval (not for initial acquisition but for supporting initial response of the receiver in case of reconfiguration); d) inner code rates; e) transmission mode (2K or 8K, not for the initial acquisition but for supporting initial response of the receiver in case of reconfiguration); and f) frame number in a super-frame.” LGE1009, 29; LGE1003, ¶[82].

2. Combination of EBC and DVB-T

As explained above in §IV.A.1, Erož is directed to a communication system in which a transmitter sends LDPC encoded data to a receiver over a communication channel. LGE1005, FIGS. 1-3, ¶¶[0029]-[0038]. Erož teaches that LDPC codes “can be used [in a] *variety of digital video applications, such as MPEG* (Motion Pictures Expert Group) packet transmission.” LGE1005, ¶[0057]. Furthermore, Erož contemplates concatenated coding where the outer code is a Reed-Solomon code, as is similarly done in the DVB-T standard. LGE1005, ¶[0069], LGE1009, 9. LGE1003, ¶¶[83]-[84].

It would have been obvious for a POSITA looking to implement Erož’s

teachings for digital video applications in a (terrestrial) digital video broadcasting communication system to turn to a digital video broadcasting standard, such as DVB-T. LGE1003, ¶¶[84]-[85]. It would have been obvious for a POSITA to combine the teachings of Eroz and DVB-T such that Eroz's LDPC communication system, including its transmitter and receiver, are modified to implement teachings of the DVB-T standard, to incorporate (1) non-uniform QAM constellations with $\alpha=2$ or $\alpha=4$ and different coding rates; and (2) DVB-T's use of signaling information, such as the TPS, to signal to a receiver the modulation, code rate, and constellation ratio being used for signal transmission. LGE1003, ¶[85]. DVB-T discloses "a general description of the baseline system for digital terrestrial TV;" "global performance requirements and features of the baseline system, in order to meet the service quality targets;" and information regarding a "digitally modulated signal in order to allow compatibility between pieces of equipment developed by different manufacturers." LGE1009, 6. Similar to Eroz's express use case, DVB-T states that it can be used for "performing the adaptation of the baseband *TV signals* from the output of the *MPEG-2 transport multiplexer*, to the terrestrial channel characteristics." LGE1009, 8; LGE1003, ¶[84].

By implementing LDPC codes in a DVB-T system, the combined system would also have improved performance relative to other DVB-T systems because LDPC codes have better performance and capacities that are closer to the Shannon

limit than convolutional codes generally used in the DVB-T standard. Indeed, a subsequent DVB standard eventually released in 2006 used LDPC codes.

LGE1016, 6. LGE1003, ¶[85].

In combining the teachings of Erož and DVB-T, it would have been obvious to a POSITA that the EBC system would have used the same or similar code rates, constellation ratios, and constellation types, as disclosed by DVB-T, to obtain the benefits of the DVB-T standard while using LDPC codes. LGE1003, ¶[86]. For example, in the EBC system, it would have been obvious to a POSITA that the same or similar code rate range values of $1/2$, $2/3$, $3/4$, $5/6$, and $7/8$ can be used to transmit LDPC codes from Erož's transmitter to receiver. LGE1009, 32. For instance, in a related DVB standard that incorporates LDPC codes, a similar but expanded code rate range of $1/4$ to $9/10$ is used. LGE1016, 6. Similarly, it would have been obvious to a POSITA that the constellation ratio α impacting the spacing of points in a constellation could also be the same or similar to the constellation ratio disclosed in DVB-T. LGE1009, 31. As can be appreciated from the foregoing, combining the teachings of EBC and DVB-T would have simply involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[86].

A POSITA would recognized that the teachings of the DVB-T standard would have been combined with those of EBC in the above-noted matter to

enhance the capability of a video transmission system. In particular, the DVB-T standard considers hierarchical modulation, as does Bauch. LGE1009, 9; LGE1004 14:19-25. LGE1003, ¶[87]. The performance benefits of the LDPC codes of Erooz versus the turbo codes of Bauch or the convolutional codes of DVB-T were understood at the time. *Id.* Hence, a POSITA would have been motivated to replace or substitute the channel coding methods of either DVB-T or Bauch with the LDPC codes of Erooz, while maintaining the modulation methods of DVB-T and Bauch. *Id.* Such a combination would have likely provided improved performance over any of these references alone. The effort needed for such replacement would be well within the knowledge and means of a POSITA since the encoding and decoding methods of LDPC codes were well understood and involved some of the same message passing iterations as with turbo codes. LGE1003, ¶[87].

The constellations described in DVB-T and Bauch both involve unequal spacings, and the methods needed to combine these constellation points with a channel code, whether convolutional, turbo, or LDPC, would be well understood to a POSITA. LGE1003, ¶[88]. Furthermore, the methods to modulate and transmit the signals corresponding to these constellations, and then demodulate the received signals differ in only minor ways among these references. *Id.* A POSITA would have implemented the teachings of DVB-T, including the various constellation and

code rate pairs, in EBC's system without much difficulty and in a predictable manner because making such modifications would have merely involved implementing software code for configuring the desired code rates, modulation and constellation types, which was well-known in the art. *Id.* Indeed, implementing such software code would have been foreseeable and predictable for a POSITA and well within the capabilities of a POSITA. *Id.* For example, Ulrich, a book by one of the chairpersons of the DVB standard, explains that manufactures would create devices for multiple applications and adapt the software. LGE1019, 267. For example, control software could "be adapted, which usually is rather simply done..." LGE1019, 267. *Id.* Ulrich continues to describe that "[f]or various reasons, manufacturers need to be able to update the receiver's software, of products which are already on the market." LGE1019, 299. As can be appreciated from the foregoing, combining EBC and DVB-T would have involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[88].

EBC would also have been predictable because elements of the combined system would have performed similar functions that had been known prior to the combination. LGE1003, ¶[89]. For example, Erož's communication system (with a transmitter and a receiver) would still perform in the same or similar manner but use the constellation and code rate pairs specified by the DVB-T standard. *Id.*

Another example includes the TPS carriers, which would have been used in the same manner as taught in DVB-T, to help provide signal transmission information to a receiver in the EBC system. *Id.* EBC would have still used Erozi's LDPC coding in a "variety of digital video applications, such as MPEG (Motion Pictures Expert Group)" and DVB-T's "adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer." LGE1004, ¶[0057], LGE1005, 8. In combining these references, a POSITA would know that the DVB-T standard could be adapted to the LDPC code in a predictable manner to include the improved performance of the LDPC code. LGE1003, ¶[89].

3. Ground 2 Prior Art Mappings

[10a]

For the reasons noted below in [2a], EBC and DVB-T disclose that a symbol constellation is selected from a plurality of symbol constellations. LGE1003, ¶[150]. In addition, it would have been obvious to a POSITA that, in some instances of EBC-DVB-T, the plurality of symbol constellations (from which a symbol constellation is chosen) is configured to only include constellations with the same number of constellation points, e.g., 16 points. LGE1003, ¶[150]. Specifically, in the EBC and DVB-T combination, the selected symbol constellation can include one of the symbol constellations shown in Bauch in FIGS. 6b and 10a (reproduced below). LGE1003, ¶[150]. As the FIGS. 6B and

10A illustrate, symbol constellations each having a same number of constellation points (16 constellation points) that are unequally spaced. Also, FIGS. 6B and 10A illustrate 8 unique point locations and 12 unique point locations, respectively. LGE1004, FIGS. 6B and 10A; LGE1003, ¶[150].

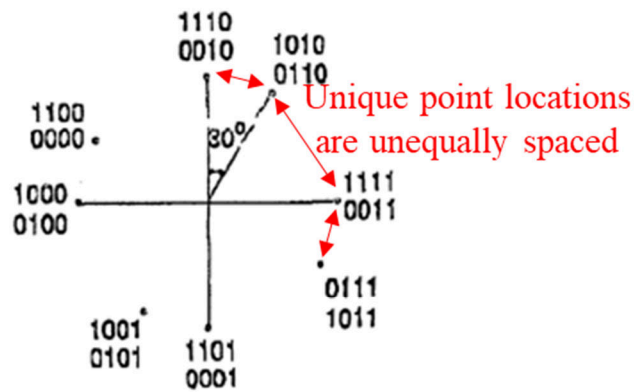


Fig 6 B

Total unequally spaced constellation points – 16
Unique point locations – 8

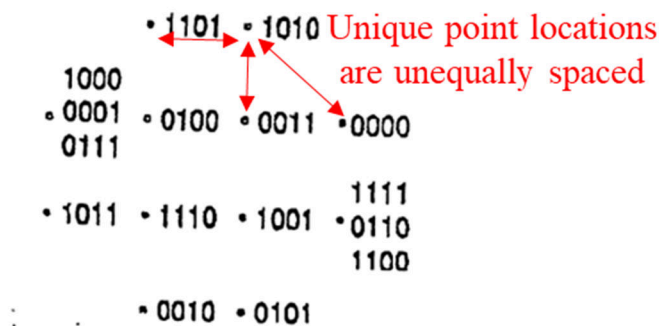


Fig. 10a

Total unequally spaced constellation points – 16
Unique point locations – 12

LGE1004, FIGS. 6B and 10A.

[10b]

As noted above in [10a], Bauch discloses a first of the plurality of symbol constellations includes constellation points at a first set of unique point locations that are unequally spaced. *See supra* [10a]. In one example, the first set of unique point locations is shown in Bauch's FIG. 6b (shown above). *Id.*; LGE1003, ¶[151].

[10c]

As noted above in [10a], Bauch discloses a second of the plurality of symbol constellations includes constellation points at a second set of unique point locations that are unequally spaced. *See supra* [10a]. In one example, the second set of unique point locations is shown in Bauch's FIG. 10a. *Id.*; LGE1003, ¶[152].

[10d]

As noted above in [10a], the number of unique point locations in Bauch's first set of unique point locations is different from the number of unique point locations in Bauch's second set of unique point locations. *See supra* [10a]; LGE1003, ¶[153].

[20a], [30a]

See supra [10a]; LGE1003, ¶[154].

[20b], [30b]

See supra [10b]; LGE1003, ¶[155].

[20c], [30c]

See supra [10c]; LGE1003, ¶[156].

[20d], [30d]

See supra [10d]; LGE1003, ¶[157].

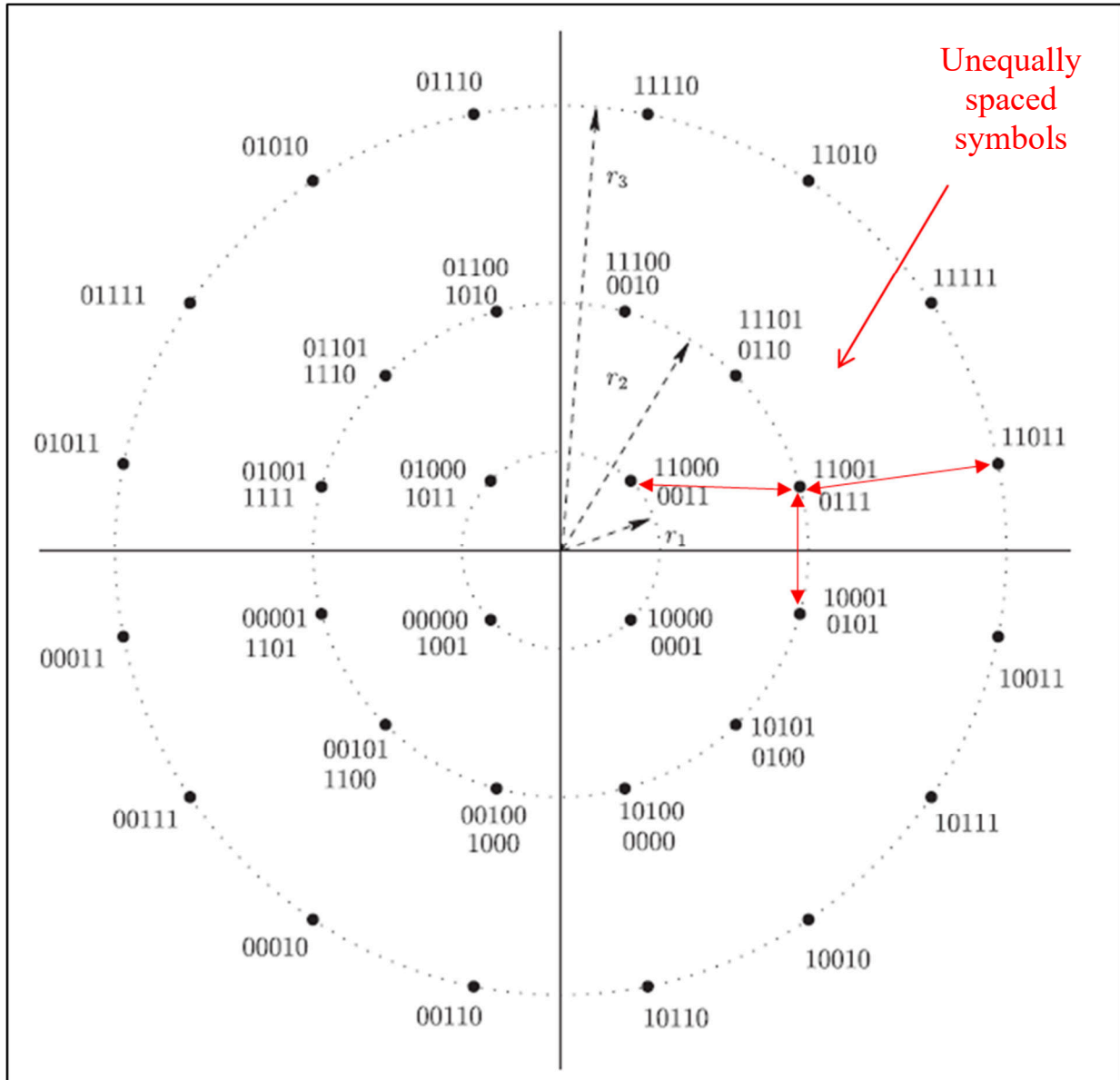
C. Ground 3: EBC, DVB-T, and DeGaudenzi render obvious claims 2, 8, 12, 18, 23, and 29

1. Overview of DeGaudenzi

DeGaudenzi, titled *Turbo-coded APSK modulations design for satellite broadband communications*, is directed to “coded modulations based on amplitude phase shift keying (APSK) modulation.” LGE1014, 261. DeGaudenzi is related to the optimization of the APSK constellation based on the “mutual information,” or equivalently, capacity, which generates an optimum constellation for a given signal to noise ratio (SNR) or spectral efficiency. *Id.* 261, 266; LGE1003, ¶[90].

DeGaudenzi describes that “M-APSK constellations are composed of n_R concentric rings” and, for the l th ring, there are a number of points (n_l), a radius (r_l) and a relative phase shift (θ_l). LGE1014, 264. As shown in FIG.1, although DeGaudenzi discloses uniformly-spaced PSK points around each of its concentric rings, the radii of the rings are not uniformly spaced, nor are the numbers of points on individual rings equal or multiples of each other, hence making the resulting APSK constellation, as a whole, unequally spaced or non-uniform. LGE1014, 264; LGE1003, ¶[91]. This is especially true given that the number of concentric rings (n_R), the number of points (n_l), the radius (r_l) and the relative phase shift (θ_l) can

vary and be optimized for capacity, for a fixed constellation size M . *See* LGE1014, Table I; LGE1003, ¶[91]. For example, for 32-APSK, the optimized constellation can have 3 rings, with 4, 12, and 16 constellation points, respectively. The numbers of constellation points are unequal or non-uniform, and the radii of the rings are not multiples of a single number. *Id.* As shown in the below annotated FIG.1, the constellation points are not uniformly or equally spaced given the unequal distances between the constellation points on different rings, even for the nearest neighbors across two rings. LGE1014, FIG.1, Table I; LGE1003, ¶[91].



LGE1014, FIG.1.

“Table I provides the optimized 16- and 32-APSK parameters for various coding rates, giving an optimum constellation for each given spectral efficiency.” LGE1014, 268. Table I (reproduced below) lists 11 different constellations having two types of modulations, namely 4+12 APSK and 4+12+16-APSK. The

optimized coding rate, spectral efficiency, and radii ratio (ρ_2 and ρ_3) associated with the second and third rings is provided in the table. LGE1003, ¶[92]. Because the optimized ρ_2 and ρ_3 have different values, each of the listed constellations has a different shape and size. LGE1003, ¶[92].

16 (4+12) Unequally spaced
symbol constellation points

Table I. Optimized constellation parameters for 16- ary and 32-ary APSK.

Modulation order	Coding rate, r	Spectral eff. (bps/Hz)	ρ_1^{opt}	ρ_2^{opt}	ρ_3^{opt}
4 + 12-APSK	2/3	2.67	3.15	N/A	N/A
4 + 12-APSK	3/4	3.00	2.85	N/A	N/A
4 + 12-APSK	4/5	3.20	2.75	N/A	N/A
4 + 12-APSK	5/6	3.33	2.70	N/A	N/A
4 + 12-APSK	8/9	3.56	2.60	N/A	N/A
4 + 12-APSK	9/10	3.60	2.57	N/A	N/A
4 + 12 + 16-APSK	3/4	3.75	2.84	5.27	
4 + 12 + 16-APSK	4/5	4.00	2.72	4.87	
4 + 12 + 16-APSK	5/6	4.17	2.64	4.64	
4 + 12 + 16-APSK	8/9	4.44	2.54	4.33	
4 + 12 + 16-APSK	9/10	4.50	2.53	4.30	

Constellation
and
predetermined
code rate pair

32 (4+12+16) Unequally spaced
symbol constellation points

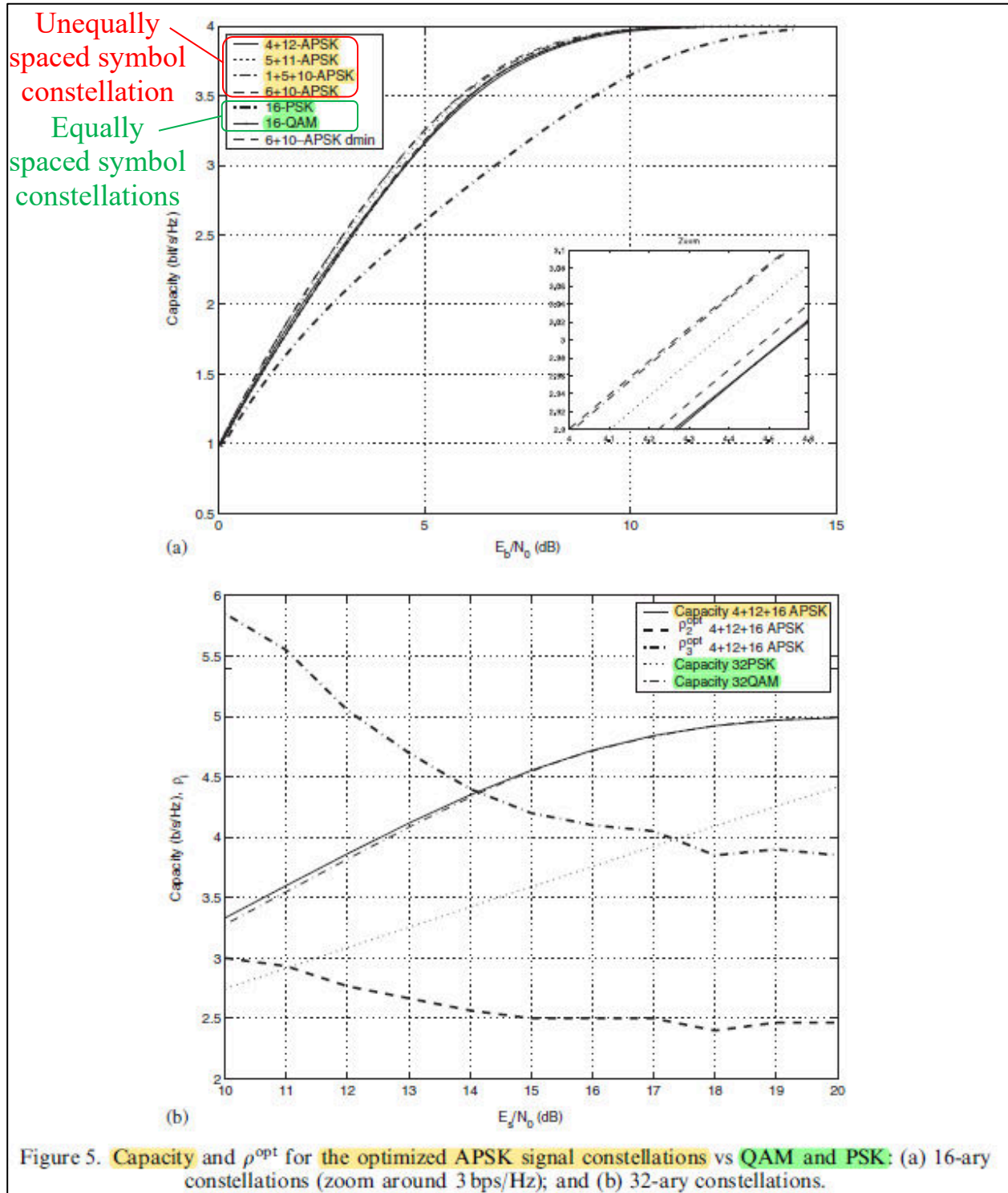
LGE1014, Table I⁴.

⁴ Dr. Hochwald explained that Table I has a typographical error. DeGaudenzi defines ρ_l (see LGE1014, 264) as the relative radii of the l th ring with respect to first ring i.e., r_l , $\rho_l = r_l/r_1$. Thus for $l = 1$, ρ_1 will always be $r_1/r_1=1$. Hence, ρ_1 and ρ_2 should be replaced with ρ_2 and ρ_3 as ρ_1 always has a unity value. LGE1014, 264; LGE1003, ¶[92].

DeGaudenzi discloses the optimization of the multi-ring APSK constellations for mutual information maximization, and addresses the coupling of a forward error correction code (FEC) code (e.g., turbo code) and the APSK signal constellations through bit-interleaved coded modulation (BICM). LGE1014, 262-263, 266-267 (§3.2.2), 272-18 (§4). Notably, DeGaudenzi discloses that “the optimization method based on the mutual information proposed in §3.2.2 can be easily extended to the case of the BICM mutual information [13](sic, [14]) with almost identical results assuming Gray mapping.” LGE1014, 272. DeGaudenzi discloses that *locations* (e.g., the radii and phase shifts) *and labels* (e.g., using Gray labeling/mapping) *of constellation points* are assigned to maximize parallel decode capacity (e.g., BICM mutual information/capacity) *of the symbol constellation at a given signal-to-noise ratio*. *Id.*, 4, 6, 12-13, FIG.1. In particular, DeGaudenzi discloses “[c]onstellation optimization” in “finding an [optimized] APSK constellation” via “[m]utual information maximization” by varying the parameters $\boldsymbol{\rho} = (\rho_1, \dots, \rho_{n_R})$ and $\boldsymbol{\phi} = (\phi_1, \dots, \phi_{n_R})$, i.e., the relative radii and phase shifts (i.e., *locations*) of the constellation points. LGE1014, 264, 266; LGE1003 ¶[93]. Thus, BICM mutual information/capacity is a type of parallel decoding (PD) capacity. LGE1003, ¶[93] (citing LGE1001, 6:53-67 (“[e]xpressed another way, the PD capacity of a channel can be viewed in terms of the mutual information”); LGE1014, 262, 272; LGE1018, (equation (14))). Indeed, DeGaudenzi shows example optimized 16- and 32-APSK

constellations with coding “for various coding rates” in Table I. LGE1014, 268, 271, Table I; LGE1003, ¶[93].

Like the '509 Patent, DeGaudenzi shows non-uniform/unequally-spaced APSK constellations have a capacity gain over the uniform classical QAM and PSK. LGE1014, 261-264, 266-268, 272-273; LGE1001, 9:35-11:11; LGE1003, ¶[94]. FIG.5 (a) and (b) (highlighted below) shows that, for a given SNR (x-axis), the multi-ring APSK constellations (see yellow highlights in FIGS. 5(a) and 5(b)) have higher capacities (y-axis) compared to uniform classical QAM and PSK (see green highlights in FIGS. 5(a) and 5(b)). LGE1014, 270. Equivalently, for a given capacity (y-axis), the unequally spaced APSK constellations require lower SNR (x-axis) compared to uniform classical QAM and PSK. LGE1003, ¶[94]. Further, DeGaudenzi discloses that “for a given SNR, or equivalently, for a given spectral efficiency R ; an optimum constellation can be obtained.” LGE1014, 266. As an example, in Table 1 (reproduced above), DeGaudenzi illustrates “the optimized 16- and 32-APSK parameters for various coding rates, giving an optimum constellation for each given spectral efficiency.” *Id.*, 8. With regards to parallel decoding, DeGaudenzi teaches that in a decoder, “parallel SISO units are used to achieve high-speed decoding as memory requirements does not increase with the degree of parallelism.” *Id.*, 14; LGE1003, ¶[94].



LGE1014, FIGS. 5(a), 5(b).

2. Combination of EBC, DVB-T, and DeGaudenzi

Recall that:

- The EBC system can process a plurality of constellation types include unequally spaced symbol constellations having the following modulations - PAM, QAM, PSK, APSK, QPSK. LGE1004, 29:18-23; LGE1005, claim 7; *see supra* §IV.A.3.
- DVB-T describes the use of Transmission Parameter Signaling (TPS) in which “TPS carriers are used for the purpose of signalling parameters related to the transmission scheme, i.e. to channel coding and modulation,” to the receiver. LGE1009, 29; *see supra* §IV.B.1.
- DeGaudenzi is related to the optimization of the APSK constellation based on the “mutual information,” or equivalently, capacity, which generates an optimum constellation for a given signal to noise ratio (SNR) or spectral efficiency. LGE1014, 261, 266; *see supra* §IV.C.1. LGE1003, ¶[95].

A POSITA would have combined the teachings of EBC and DVB-T for the reasons note above in §IV.B.2 such that signaling information is shared between the transmitter and receiver and both devices select a symbol constellation from among a plurality of unequally spaced symbol constellations. LGE1003, ¶[96]. A POSITA would have combined the teachings of DeGaudenzi with the EBC and DVB-T so

that the parallel decoding capacities of EBC-DVB-T's plurality of different unequally spaced symbol constellations would have been optimized. *Id.* In particular, a POSITA would have incorporated DeGaudenzi's teachings to configure constellation designs (including the labels and spacing of points) to maximize the parallel decoding capacity of each of a plurality of constellation and also realize an optimal spectral efficiency or SNR, as shown above in DeGaudenzi's Table I. LGE1014, 271. Advantageously, by maximizing the parallel decoding capacity and optimizing the spectral efficiency/SNR, EBC's system can realize constellations that are power and spectrally efficient, and thereby increase the capability of using such constellations in various communication systems (e.g., systems that include terrestrial and satellite communications). LGE1014, 261-262. Indeed, DeGaudenzi also suggests that its optimization technique would allow EBC's terrestrial system to perform better if complemented with satellite communication systems. LGE1003, ¶[96].

In addition, it would have been obvious to a POSITA to combine the teachings of EBC, DVB-T, and DeGaudenzi so that constellations, such as unequally spaced APSK constellations (*see e.g.*, Bauch's FIGS. 6b, 6d, DeGaudenzi's FIG. 1), would have been optimized for a particular SNR and spectral efficiency, thereby improving the performance of EBC's system. LGE1003, ¶[97].

Combining the teachings of EBC, DVB-T, and DeGaudenzi would have

merely involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[98]. For example, EBC's system would have been combined with DeGaudenzi's optimization method to yield the predictable result of configuring and selecting constellations that have optimized parallel decoding capacity and SNR (as described in more detail below in §IV.C.3). LGE1003, ¶[98]. Moreover, the combination of EBC and DeGaudenzi would also have been foreseeable. *Id.* As noted in DeGaudenzi, a new standard, namely the Digital Video Broadcasting standard for satellite communications (which is described in the next section) was released around the same time that DeGaudenzi was published/written and focused on applying similar techniques in satellite communication systems. *Id.* Thus, the application of DeGaudenzi's teachings to extend or complement the DVB-T standard, as noted above, would not only have been obvious and predictable for the reasons noted above, but it would also have been foreseeable as it was actually being done at the time of the DeGaudenzi publication and disclosed in DeGaudenzi as a way to provide digital broadcasting data to scarcely populated regions. LGE1014, 261-262. LGE1003, ¶[98]

A POSITA would have combined EBC, DVB-T, and DeGaudenzi as described above in a predictable manner because making such modifications would have simply involved implementing software code for optimization of

constellations, as disclosed by DeGaudenzi. LGE1003, ¶[99]. Amending the software in EBC's system to incorporate the teachings of DeGaudenzi would have been well within the knowledge and capabilities of a POSITA and would have simply involved implementing optimization formulas and codes for the same/similar types of constellations (e.g., APSK) disclosed by both EBC and DeGaudenzi. LGE1003, ¶[99].

3. Ground 3 Prior Art Mappings

[2a]

As explained above in §IV.A.1-§IV.A.4.[1d], in EBC's system, a plurality of unequally spaced symbol constellations, such as the constellations shown in Bauch's FIGS. 6b, 6d, 10a, 10c, and 15c, can be used. LGE1004, 29:18-23, 17:30-35, 24:15-26:31. DVB-T also discloses using unequally spaced 16-QAM and 64-QAM constellations. LGE1009, 22, 23. It would have been obvious to a POSITA that to use any one of the unequally spaced symbol constellations, a symbol constellation would have been selected from the plurality of unequally spaced symbol constellations by both the transmitter and receiver in EBC's system. LGE1003, ¶[158].

For example, Erozi explains that its modulator 205 in transmitter 101/200 can map encoded messages from encoder 203 to signal waveforms that are transmitted

to a transmit antenna 207, and “[t]he transmissions from the transmit antenna 207 propagate to a receiver.” LGE1005, ¶¶[0034]-[0036], FIGS. 2A, 2B. When, for example, the data to be transmitted were to be transmitted using an unequally spaced QAM constellation, the transmitter would have selected an unequally spaced QAM constellation from the plurality of unequally spaced constellations it is capable of configuring. LGE1003, ¶[159]. The receiver would make a similar selection to ensure it demodulates the data according to the modulation used by the transmitter. LGE1003, ¶[159].

DVB-T, confirms this understanding. For example, DVB-T teaches that a transmitter uses transmission parameter signaling (TPS) carriers “for the purpose of signalling parameters related to the transmission scheme, i.e. to channel coding and modulation.” LGE1009, 29. “The TPS carriers convey information on: a) modulation including the α value of the QAM constellation pattern ... b) hierarchy information; ... d) inner code rates; e) transmission mode.” *Id.* “The α value defines the modulation based on the cloud spacing of a generalized QAM constellation. It allows specification of uniform and non-uniform modulation schemes, covering QPSK, 16-QAM, and 64-QAM.” *Id.* The constellation type, hierarchy information including the α value, and code rate to be used in a transmission can be signaled to the receiver by using designated sets of bits, as shown in DVB-T’s Tables 11-13 below. LGE1009, 31-32; LGE1003, ¶[160].

Table 11: Signalling format for the possible constellation patterns

Bits s_{25}, s_{26}	Constellation characteristics
00	QPSK
01	16-QAM
10	64-QAM
11	reserved

Table 12: Signalling format for the α values

Bits s_{27}, s_{28}, s_{29}	α value
000	Non hierarchical
001	$\alpha = 1$
010	$\alpha = 2$
011	$\alpha = 4$
100	reserved
101	reserved
110	reserved
111	reserved

Table 13: Signalling format for each of the code rates

Bits s_{30}, s_{31}, s_{32} (HP stream) s_{33}, s_{34}, s_{35} (LP stream)	Code rate
000	1/2
001	2/3
010	3/4
011	5/6
100	7/8
101	reserved
110	reserved
111	reserved

Table 9 (reproduced below) lists the transmission parameter information that can be provided by the TPS carriers. LGE1009, 30. LGE1003, ¶[160].

Table 9: TPS signalling information and format

Bit number	Format	Purpose/Content
s_0	see subclause 4.6.2.1	Initialization
s_1 - s_{16}	0011010111101110 or 1100101000010001	Synchronization word
s_{17} - s_{22}	010 111	Length indicator
s_{23} , s_{24}	see table 10	Frame number
s_{25} , s_{26}	see table 11	Constellation
s_{27} , s_{28} , s_{29}	see table 12	Hierarchy information
s_{30} , s_{31} , s_{32}	see table 13	Code rate, HP stream
s_{33} , s_{34} , s_{35}	see table 13	Code rate, LP stream
s_{36} , s_{37}	see table 14	Guard interval
s_{38} , s_{39}	see table 15	Transmission mode
s_{40} - s_{53}	all set to "0"	Reserved for future use
s_{54} - s_{67}	BCH code	Error protection

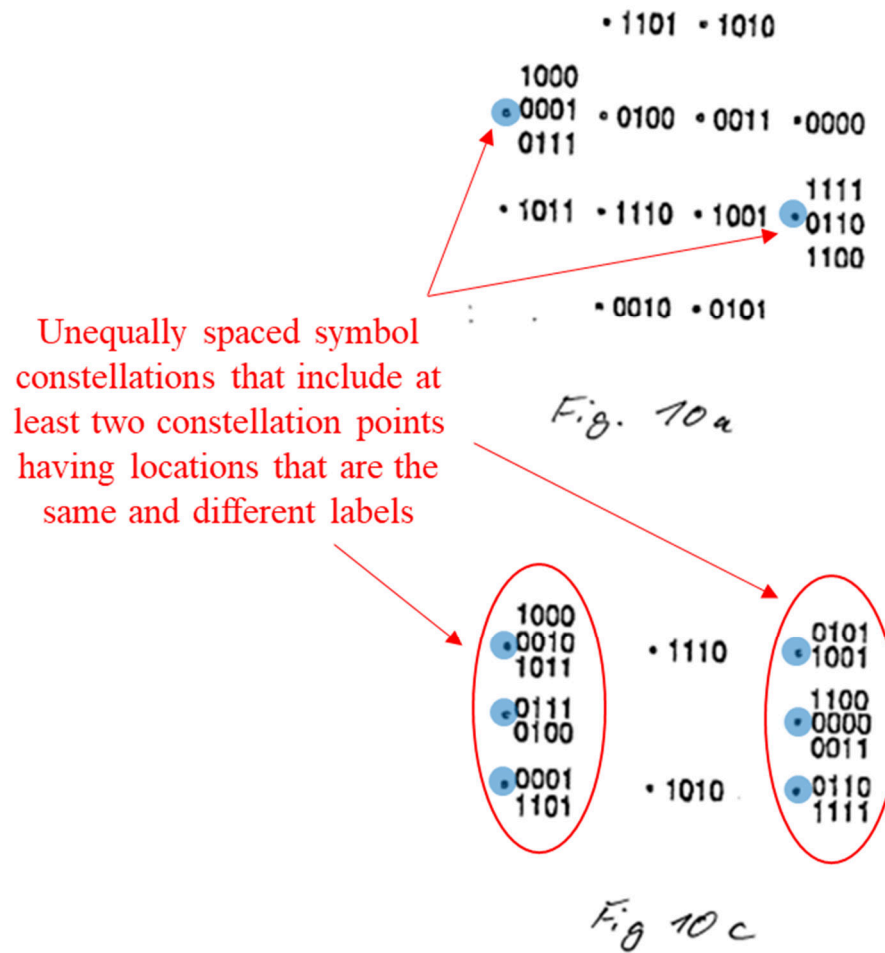
Ulrich, a textbook that describes technical features of digital video broadcasting systems and methods, also explains that at the receiver of a communication system, “processing steps that were carried out at the encoder have to be reversed.”

LGE1019, 198. That is, when a particular type of modulation, mapping, and encoding is used on the transmitter, a corresponding demodulation, demapping, and decoding is performed at the receiver to recover the information bits.

LGE1003, ¶[162]. For example, if an unequally spaced QAM modulation, such as the constellation depicted in Bauch’s FIG. 10a, is used to modulate data at a transmitter, the receiver would have received transmission parameter information and selected the same unequally spaced QAM constellation, from among the various unequally spaced constellations it is capable of using, to demodulate, demap, and decode the received signal. LGE1003, ¶¶[161]-[163].

[2b]

As discussed above in §IV.A.2, Bauch teaches that its “mapping scheme is not restricted to PSK and QAM constellations, but *can be used for any other signal space constellation diagram* based, for example, on QPSK, PAM, QAM, PSK, M-QAM, MPSK, *wherein M is a number equal to or greater than 1.*” LGE1004, 29:18-23. With such a wide applicability of Bauch in EBC, it would have been obvious to a POSITA that EBC’s system would have been capable of processing *a plurality of unequally spaced symbol constellations of a first type* including, for example, 64-QAM, 256-QAM, and 1024-QAM (when M equals 64, 256, and 1024, respectfully). *Id.*; LGE1003, ¶[164] (*citing to* LGE1007 showing that LDPC 64-QAM, 256-QAM, and 1024-QAM were known in the art and used in communication systems). As explained above in [1c-1]-[1c-4], Bauch also teaches that the “*unequally spaced symbol constellations of the first type include at least two constellation points having locations that are the same and different labels.*” Here, for example, the 64-QAM, 256-QAM, and 1024-QAM would have at least two constellation points having locations that are the same and different labels, similar to the manner in which two constellation points having locations that are the same and different labels in Bauch’s FIGS. 10a and 10c. LGE1003, ¶[164].



LGE1004, FIGS. 10A, 10C.

[2c]

As explained in [2a] and [2b], EBC's receiver can receive TPS carriers with transmission parameter information used to configure signals received by the receiver. LGE1009, 29-34. The information includes the modulation type, code rate, α value and other configuration information that would allow the receiver to select a symbol constellation consistent with the one used to demodulate, demap, and decode the received signal. LGE1009, 29-34. When the symbol constellation

includes an unequally spaced constellation, it would have been obvious to a POSITA that “*the receiver is capable of selecting an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs*”). *See supra* [2a]; LGE1019, 198; LGE1003, ¶[165]. Recall that Eroz is directed to LDPC encoding and decoding and that Eroz and DVB-T also would have performed LDPC encoding and decoding. *See supra* §§IV.B.1-3; LGE1005, Abstract, ¶¶[0029]-[0039], [0058]-[0061]; LGE1003, ¶¶[165]-[166].

Indeed, the use of TPS carriers to signal unequally spaced constellations and code rate pairs was known and part of standard guidelines. LGE1003, ¶[167]. Recall, that the standard document, DVB-T, disclosed unequally spaced 16-QAM and 64-QAMs with α equal to 2 and 4, as shown in DVB-T’s Figures 9b and 9c. LGE1009, 20-24. The TPS carriers can specify a QAM modulation (16- or 64-point), α value (non-uniform 2 or 4), and a code rate (1/2-7/8) to specify a particular constellation from among a plurality of constellations. LGE1009, 39-40. LGE1003, ¶[167].

Alternatively, or in addition to the method of selecting a symbol constellation through the use of TPS carriers and signaling information, it was also well-known in the art as of June 5, 2007 that receivers could select constellation and code rate pairs based on measured channel conditions and quality parameters.

LGE1003, ¶[168]. For instance, as corroborated by a related digital video broadcasting standard (DVB-S2), a receiver could measure the carrier to noise plus interference ratio (CNI) “by using symbols known a-priori at the receiver, such as those in the SOF field of the PLFRAME Headers and, when available, pilot symbols.” LGE1016, 53; LGE1003, ¶[168]. Subsequently, the receiver selects a modulation and code rate pair (MODCOD information) and sends the MODCOD information along with the CNI to a transmitter. LGE1016, 53, 48. LGE1003, ¶[168].

[2d]

See supra [2c], §IV.C.1. A POSITA would have understood that various combinations of code rates and constellation pairs are possible, e.g., according to design and capacity requirements. LGE1003, ¶[169]. Indeed, when optimizing constellation designs for efficiency such as spectral efficiency, it would have been obvious to determine and combine each of a plurality of unequally spaced constellations with its own code rate uniquely to attain the optimized spectral efficiency. *Id.* A POSITA would have been motivated to implement the teachings of DeGaudenzi which “investigates the design of power and spectrally efficient coded modulations based on amplitude phase shift keying (APSK) modulation” LGE1014, 261. Particularly, DeGaudenzi discloses a “new method [that] generates an optimum constellation for each spectral efficiency.” LGE1014, 261.

In so doing, each constellation would be only included in one of the plurality of predetermined code rate and constellation pairs. *See*, for example, referring to Table 1 and FIG. 5b (both reproduced below), DeGaudenzi discloses optimizing the spectral efficiency or SNR of non-uniform symbol constellations by optimizing their parameters such as the location of the constellation points and the code rates. LGE1014, 279. For example, as shown in DeGaudenzi's Table I, the spectral efficiency/SNR of a number of 32-ary APSKs has been optimized. LGE1014, 266. Each 32-ary APSK in Table I has different ρ_2 and ρ_3 indicating that each of the listed constellations is a unique non-uniform constellation. LGE1014, 268. LGE1003, ¶[169].

It would have been obvious to a POSITA that when the teachings of DeGaudenzi (such as Table I) are incorporated into EBC-DVB-T system (for the reasons explained above in §IV.C.2), each of the plurality of different unequally spaced symbol constellations would only be included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs in EDC's system. LGE1003, ¶[170]. For instance, there is only one 4+12+16 APSK constellation with $\rho_2 = 2.72$ and $\rho_3 = 4.87$ that is included in the list of predetermined constellation-code rate pairs. LGE1003, ¶[170].

DeGaudenzi's teachings are broad, are not limited to APSKs, and can be applied to LDPC encoded signals and other constellations (for example, QAM).

LGE1014, 262-264 (“[w]e propose new criteria for the design of digital QAM constellations of 16 and 32 points”). LGE1003, ¶[171]. Accordingly, in the combination of EBC, DVB-T and DeGaudenzi, a table similar to DeGaudenzi’s Table I but with optimized 16-QAM or 64-QAM constellations and corresponding parameters (e.g., code rate, α , spectral efficiency) would have been provided. *Id.* For instance, in such a table, an LDPC code rate-constellation pair of non-uniform-16-QAM with $\alpha=2$ and code rate $\frac{1}{2}$ that is optimized for a particular spectral efficiency/SNR would similarly have only been included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs. Each non-uniform constellation (16-QAM with $\alpha=2$; 16-QAM with $\alpha=4$; 64-QAM with $\alpha=2$; 64-QAM with $\alpha=4$) would have been included in only one of the LDPC code rate-constellation pairs for the reasons explained above. LGE1003, ¶[171].

16 (4+12) Unequally spaced symbol constellation points

Table I. Optimized constellation parameters for 16-ary and 32-ary APSK.

Modulation order	Coding rate, r	Spectral eff. (bps/Hz)	ρ_1^{opt}	ρ_2^{opt}	ρ_3^{opt}
4 + 12-APSK	2/3	2.67	3.15	N/A	
4 + 12-APSK	3/4	3.00	2.85	N/A	
4 + 12-APSK	4/5	3.20	2.75	N/A	
4 + 12-APSK	5/6	3.33	2.70	N/A	
4 + 12-APSK	8/9	3.56	2.60	N/A	
4 + 12-APSK	9/10	3.60	2.57	N/A	
4 + 12 + 16-APSK	3/4	3.75	2.84	5.27	
4 + 12 + 16-APSK	4/5	4.00	2.72	4.87	
4 + 12 + 16-APSK	5/6	4.17	2.64	4.64	
4 + 12 + 16-APSK	8/9	4.44	2.54	4.33	
4 + 12 + 16-APSK	9/10	4.50	2.53	4.30	

32 (4+12+16) Unequally spaced symbol constellation points

Unequally Spaced Symbol Constellations and predetermined LDPC code rate pairs

LGE1014, Table I.

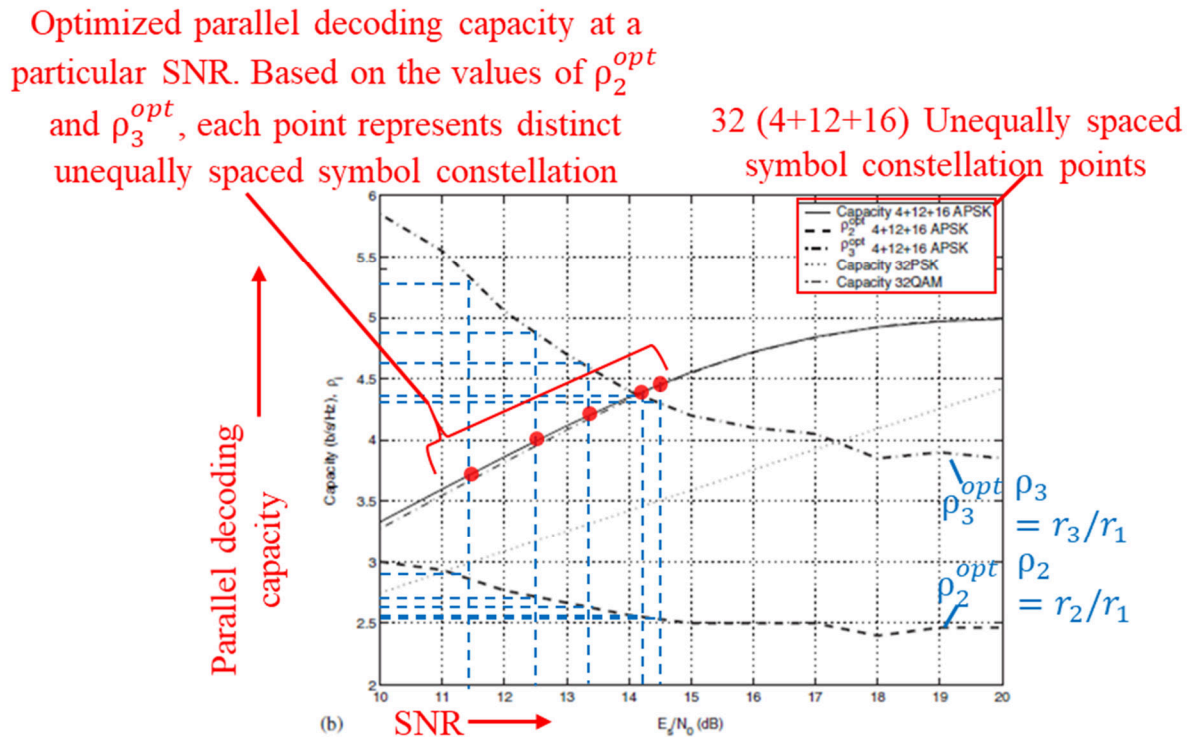


Figure 5. Capacity and ρ^{opt} for the optimized APSK signal constellations vs QAM and PSK: (a) 16-ary constellations (zoom around 3 bps/Hz); and (b) 32-ary constellations.

LGE1014, FIG 5b.

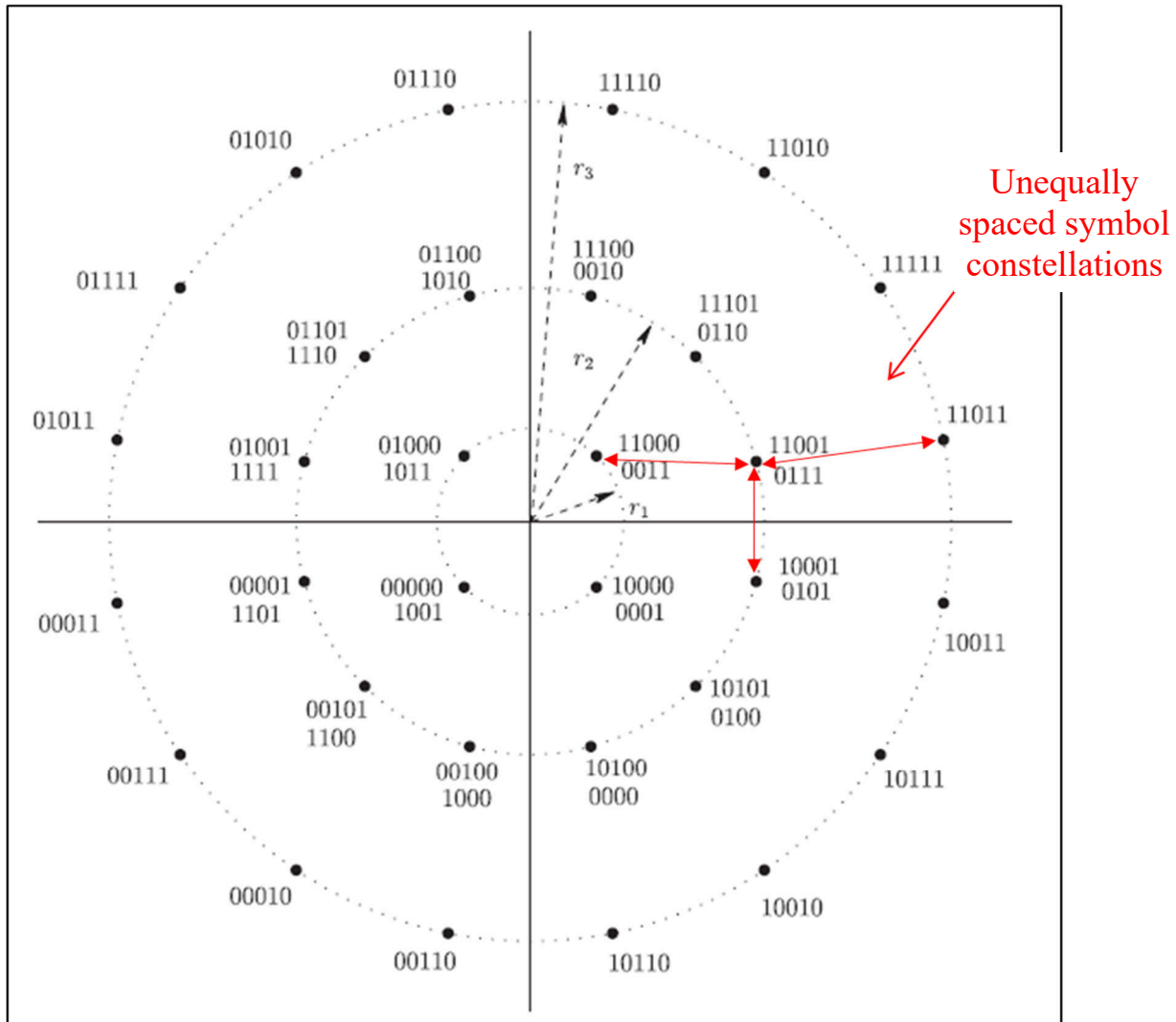
[8a]

See *supra* [2a]; LGE1003, ¶[172].

[8b]

As explained above in §IV.C.1, DeGaudenzi, like Bauch, discloses unequally spaced symbol constellations, e.g., “M-APSK constellations [that] are composed of n_R concentric rings.” LGE1014, 264. Although DeGaudenzi discloses “each [ring of the M-APSK] with uniformly spaced PSK points,” the overall M-APSK constellation is an unequally spaced symbol constellation because it includes multiple rings (e.g., two rings for optimized 16-APSK and three rings for optimized

32-APSK per Table I) and the spaces/distances between any two pairs of the M-APSK constellation points are not necessarily equal, as shown in FIG.1. LGE1014, 264, Table I; LGE1003, ¶[173].

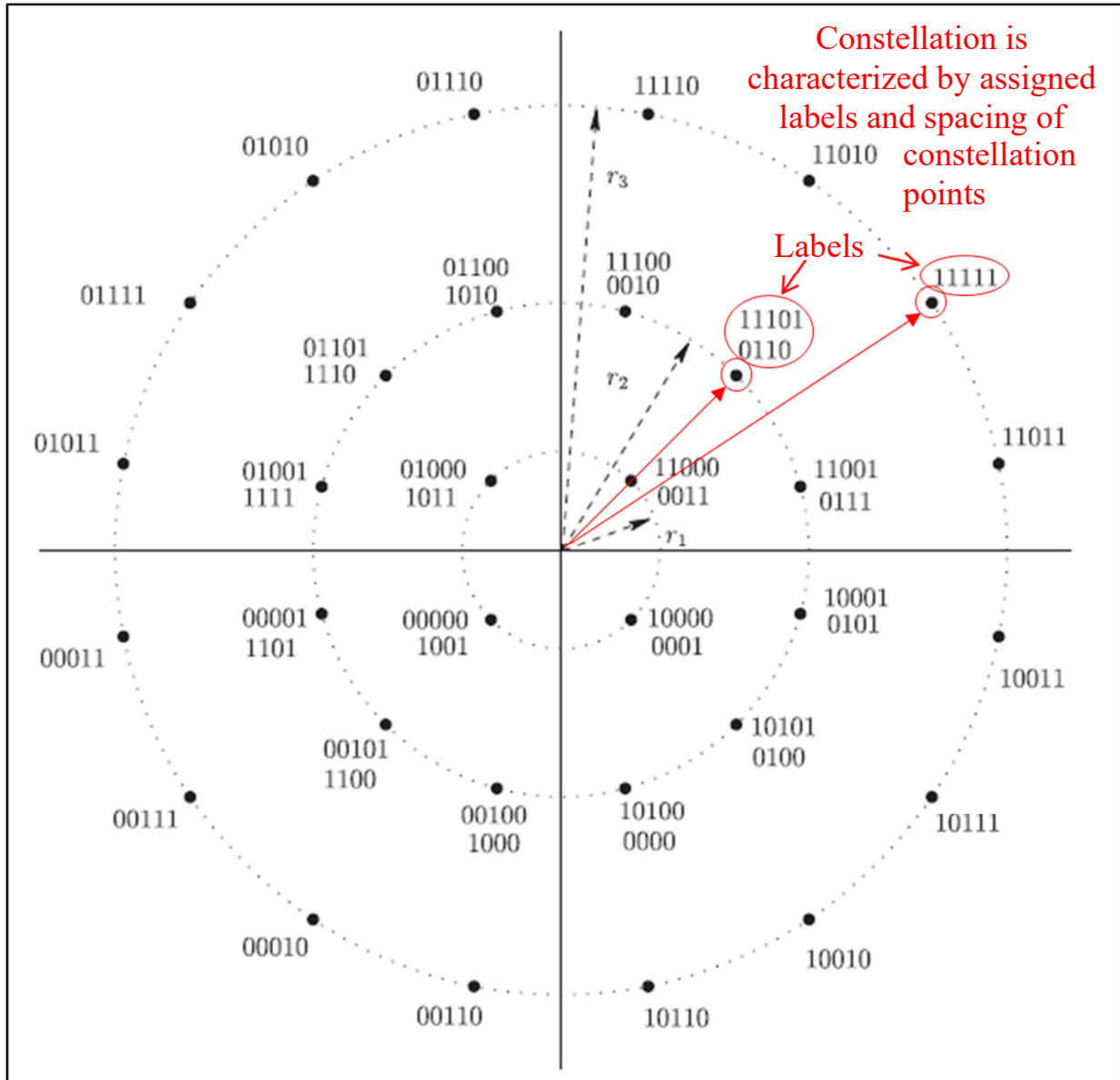


LGE1014, FIG.1.

DeGaudenzi discloses that *locations* (e.g., the radii and phase shifts) and *labels* (e.g., using Gray labeling/mapping) of constellation points are assigned to

maximize parallel decode capacity (e.g., BICM mutual information/capacity) of the symbol constellation at a symbol constellation operating signal-to-noise ratio. LGE1014, 264, 266, 272-273, FIG. 1. In particular, DeGaudenzi discloses “[c]onstellation optimization” in “finding an [optimized] APSK constellation” via “[m]utual information maximization” by varying the parameters $\boldsymbol{\rho} = (\rho_1, \dots, \rho_{n_R})$ and $\boldsymbol{\phi} = (\phi_1, \dots, \phi_{n_R})$, e.g., the relative radii and phase shifts (i.e., *locations*) of the constellation points. LGE1014, 264, 266; LGE1003, ¶[174].

DeGaudenzi also discloses a labelling rule $\mu : \mathbb{F}_2^M \rightarrow \mathcal{X}$,” according to which the “bit-interleaved sequence c_π ” is mapped to “a sequence of modulation symbols $\mathbf{x}$.” LGE1014, 272. The labelling rule can be “Gray labelling”/“Gray mapping,” or “the pseudo-Gray labellings.” As shown in FIG.1 (annotated below), DeGaudenzi discloses assigning locations, (e.g., the radii and phase shifts), *spacings, and labels* (e.g., “11101” “0110” based on “pseudo-Gray labellings”) *of constellation points*. LGE1003, ¶[175].



LGE1014, FIG.1.

In its complaint, Patent Owner asserts that “[t]he term parallel decode capacity is equivalent to the term Bit Interleaved Coding Modulation (BICM) capacity.” LGE1023, 70. For the purposes of this petition, Petitioner agrees. In fact, the ’509 Patent defines the parallel decoding capacity with the expression $C_{PD} =$

$\sum_{i=0}^{l-1} I(X_i; Y)$. LGE1001, 6:53-63. DeGaudenzi and in equation (14) of Caire describe BICM in the same manner as parallel decoding capacity is defined in the '509 Patent. *Id.*; LGE1014, 262, 272; LGE1018, 4; LGE1003, ¶[176].

DeGaudenzi discloses the “coupling of turbo-codes and the APSK signal constellations through BICM” and explicitly notes that “the optimization method based on the mutual information [maximization] proposed in Section 3.2.2 can be easily extended to the case of the BICM mutual information [maximization] [13](sic, [14]) with almost identical results assuming Gray mapping” as discussed in Section 4, LGE1014, 272. DeGaudenzi discloses that “*for a given SNR,*” “an optimum constellation can be obtained,” for example, using “numerical techniques” by *assignment of labels* (e.g., “assuming Gray mapping”) and *locations and spacings* (e.g., the relative radii and phase shifts) *of constellation points to maximize parallel decode capacity* (e.g., “BICM mutual information”) *of the symbol constellation* (e.g., BICM-capacity-optimized 16-APSK and 32-APSK constellations as shown in Table I). LGE1014, 264, 266, 272-273, Table I; LGE1003, ¶[177].

For example, as noted above in §IV.C.1, Table I provides the optimized parameter values for various 4+12-APSK and 4+12+16-APSK constellations. LGE1014, 271. FIG.5b has been annotated with red dots to show the optimized

parallel decoding capacity (which is also the maximized parallel decoding capacity here) for at least the 4+12+16-APSK constellations. LGE1014, 270. As noted above, these constellations have also been optimized at a symbol constellation operating SNR. LGE1014, 264, 266, 272-273. LGE1003, ¶[178].

16 (4+12) Unequally spaced
symbol constellation points

Table I. Optimized constellation parameters for 16- ary and 32-ary APSK.

	Modulation order	Coding rate, r	Spectral eff. (bps/Hz)	ρ_1^{opt}	ρ_2^{opt}	ρ_3^{opt}
				ρ_1^{opt}	ρ_2^{opt}	ρ_3^{opt}
Constellation and predetermined code rate pair	4 + 12-APSK	2/3	2.67	3.15	N/A	N/A
	4 + 12-APSK	3/4	3.00	2.85	N/A	N/A
	4 + 12-APSK	4/5	3.20	2.75	N/A	N/A
	4 + 12-APSK	5/6	3.33	2.70	N/A	N/A
	4 + 12-APSK	8/9	3.56	2.60	N/A	N/A
	4 + 12-APSK	9/10	3.60	2.57	N/A	N/A
	4 + 12 + 16-APSK	3/4	3.75	2.84	5.27	4.87
	4 + 12 + 16-APSK	4/5	4.00	2.72	4.64	4.33
	4 + 12 + 16-APSK	5/6	4.17	2.64	4.30	4.00
	4 + 12 + 16-APSK	8/9	4.44	2.54	4.00	3.75
	4 + 12 + 16-APSK	9/10	4.50	2.53	3.75	3.50

32 (4+12+16) Unequally spaced
symbol constellation points

LGE1014, Table I.

Maximized parallel decoding capacity at a particular SNR. Based on the values of ρ_2^{opt} and ρ_3^{opt} , each point represents distinct non-uniform constellation

32 (4+12+16) Unequally spaced symbol constellation points

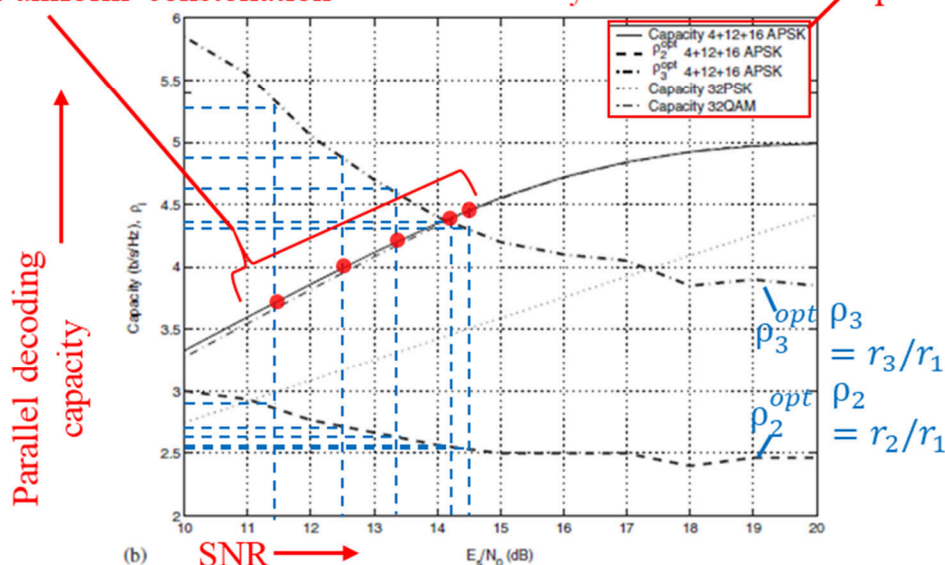


Figure 5. Capacity and ρ^{opt} for the optimized APSK signal constellations vs QAM and PSK: (a) 16-ary constellations (zoom around 3 bps/Hz); and (b) 32-ary constellations.

LGE1014, FIG.5b.

For the reasons explained above in §IV.C.2, it would have been obvious to a POSITA to optimize each of the plurality of unequally spaced constellations in the EBC and DVB-T combination in the above-noted manner, as described by DeGaudenzi, for improved performance. LGE1003, ¶[179]. Accordingly, the combination of EBC, DVB-T, and DeGaudenzi renders obvious “*each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of constellation points so as to maximize parallel*

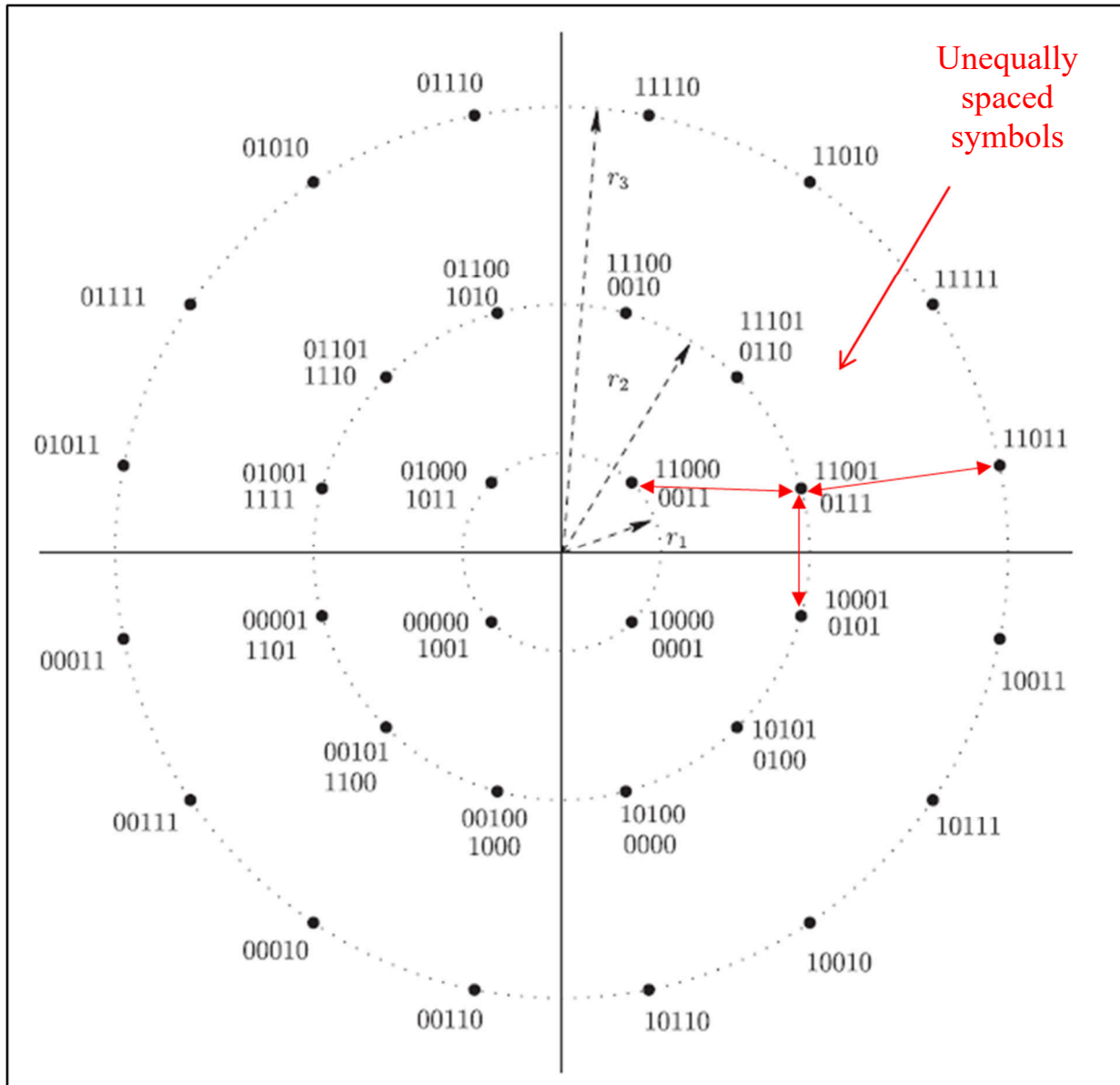
decoding capacity at a symbol constellation operating SNR.” LGE1014, 264, 266, 272-274, 279, FIG. 1; LGE1003, ¶[179].

Furthermore, DeGaudenzi also explains that its optimization method for maximizing parallel decoding capacity *is subject to at least one constraint*. As described above in [6a], DeGaudenzi discloses multiple optimization constraints (e.g., a given SNR, a given constellation size, M , and an assumption of “equiprobable symbols”) so that a fair performance comparison can be evaluated. LGE1014, 266 (Section 3.2.2). *Mutual information maximization*. LGE1003, ¶[180].

DeGaudenzi further discloses that “signal constellation points x are complex numbers, drawn from a set $\mathcal{X}$ ”, which is “a complex-valued APSK signal constellation $\mathcal{X}$, with $|\mathcal{X}| = M$,” and “we consider that $\mathcal{X}$ is normalized in energy, i.e. $E[|x|^2] = 1$ ”. LGE1014, 263-264. Namely, *the symbol constellation, $\mathcal{X}$* , under optimization is subject to an optimization constraint on average power of the symbol constellation such that $E[|x|^2] = 1$. *Id.* LGE1022, 32-37. LGE1003, ¶[181]

In addition, it would also have been obvious to a POSITA that the number of constellations points in the each ring would also be a constraint. LGE1003, ¶[184]. For example, in the example shown below in annotated FIG.1, the rings have a number of constellations points (r_1 has 4 points, r_2 has 12 points and r_3 has 16 points)

which could be modified to optimize the parallel decoding capacity of the constellation. LGE1014, FIG.1, LGE1003, ¶[182].



LGE1014, FIG.1.

[12a], [23a]

See *supra* [2a]; LGE1003, ¶[183].

[12b], [23b]

See supra [2b]; LGE1003, ¶[184].

[12c], [23c]

See supra [2c]; LGE1003, ¶[185].

[12d], [23d]

See supra [2d]; LGE1003, ¶[186].

[18a], [29a]

See supra [8a]; LGE1003, ¶[187].

[18b], [29b]

See supra [8b]; LGE1003, ¶[188].

V. THE *ADVANCED BIONICS* TEST FAVORS INSTITUTION—§ 325(d)

Under the Board’s two-part § 325(d) framework, the Board first considers as a threshold matter: “whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office.” *Advanced Bionics, LLC v. Med-El Electromedizinische Gerate GMBH*, IPR2019-01469, Paper 6.

DeGaudenzi was cited in IDS submitted on January 9, 2020 that cited more than 100 references. LGE1002, 104. Additional IDSs citing several other references were filed on July 10, 2020, August 10, 2020, and March 8, 2021.

LGE1002, 1078, 1088, and 3160. The Examiner indicated that the filed IDSs had been considered. LGE1002, 1021, 3089, 3110, 3219. As discussed above in Section II.C, during prosecution, the Examiner did not rely on DeGaudenzi or any of the 100+ references cited by the Patent Owner in the various IDSs. And even if the Examiner had considered DeGaudenzi, the same or substantially the same arguments noted in this Petition were not previously presented to the Office. For at least this reason, discretionary denial under 35 U.S.C. § 325(d) is not merited. Indeed, the Board has previously indicated that when a prior art reference is merely cited in an Information Disclosure Statement, this was generally not enough for the PTAB to deny institution. *Comcast Cable Communs., LLC v. Promptu Sys. Corp.*, IPR2018-00342, Paper 13 at 17 (PTAB July 19, 2018).

VI. DISCRETIONARY DENIAL IS NOT MERITED IN VIEW OF PETITIONER'S *SOTERA* STIPULATION

Patent Owner (“Constellation”) filed an infringement action against LGE involving seven patents. *See* LGE1022 (Complaint). The action, assigned Case No. 2:21-cv-00448 (“the Related Litigation”), is concurrently pending in the Eastern District of Texas before the Honorable Judge Rodney Gilstrap. LGE1026.

In *Apple Inc. v. Fintiv, Inc.*, the Board enumerated six factors that provide a “holistic view” as to “whether efficiency, fairness, and the merits support the

exercise of authority to deny institution.” IPR2020-00019, Paper 11 at 2-3 (PTAB “precedential” Mar. 20, 2020) (“*Fintiv*”). In June 2022, the USPTO issued updated discretionary denial guidance in view of the *Fintiv* factors and expressly noted that “***the PTAB will not discretionarily deny institution in view of parallel district court litigation*** where a petitioner presents a stipulation not to pursue in a parallel proceeding the same grounds or any grounds that could have reasonably been raised before the PTAB.” LGE1025, 3, 7-8.

Here, Petitioner has eliminated any risk of duplicated effort by voluntarily stipulating to counsel for Patent Owner that, if the Board institutes an IPR, Petitioner will not pursue, in the District Court proceedings with respect to the ’700 Patent, the grounds asserted in this IPR petition or on any other ground that was raised or could have been reasonably raised by Petitioner in an IPR.

LGE1021; *Sotera Wireless, Inc. v. Masimo Corp.*, Case IPR2020-0109, Paper 12 (PTAB Dec. 1, 2020). Because Petitioner is submitting a *Sotera*-style stipulation in these proceedings that has the same scope as the stipulation described in the PTAB’s updated *Fintiv* guidance, the *Fintiv* factors do **not** favor discretionary denial.

VII. CONCLUSION

Petitioner respectfully requests institution of an IPR because the Challenged Claims are unpatentable.

VIII. PAYMENT OF FEES – 37 C.F.R. § 42.103

LGE authorizes the Patent and Trademark Office to charge Deposit Account No. 06-1050 for the fee set in 37 C.F.R. § 42.15(a) for this Petition and further authorizes payment for any additional fees to be charged to this Deposit Account.

IX. MANDATORY NOTICES UNDER 37 C.F.R § 42.8(a)(1)

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

LG Electronics, Inc., LG Electronics USA, Inc., and LG Electronics Alabama, Inc. are the real parties-in-interest.

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

The '509 Patent is the subject of a civil action, *Constellation Designs, LLC. v. LG Electronics, Inc. et al.*, 2:21-cv-00448, E.D. Tex., Dec. 9, 2021 (LGE1022). Petitioner is not aware of any disclaimers, reexamination certificates, or IPR petitions for the '509 Patent.

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

Petitioner provides the following designation of counsel.

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D. Service Information

Please address correspondence/service to the above-listed address.

Petitioner consents to email service at IPR19688-0197IP1@fr.com (referencing No. 19688-0197IP1 and cc'ing PTABInbound@fr.com).

Respectfully submitted,

Dated: December 8, 2022

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter partes* Review totals 13,823 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: December 8, 2022

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on December 8, 2022, a complete and entire copy of this Petition for *Inter partes* Review and all supporting exhibits were provided via Federal Express, to the Patent Owner, by serving the correspondence address of record as follows:

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