

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Maged F. Barsoum et al.
U.S. Patent No.: 10,693,700 Attorney Docket No.: 19688-0196IP1
Issue Date: June 23, 2020
Appl. Serial No.: 16/726,037
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Title: RECEIVERS INCORPORATING NON-UNIFORM
MULTIDIMENSIONAL CONSTELLATIONS AND CODE RATE
PAIRS

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 10,693,700 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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EXHIBITS

LGE1001	U.S. Patent No. 10,693,700
LGE1002	Prosecution History for U.S. Patent No. 10,693,700
LGE1003	Expert Declaration of Dr. Bertrand Hochwald
LGE1004	U.S. Patent Pub. No. 2004/0054960 to Eroz et al. (“Eroz”)
LGE1005	ETSI EN 300 744 V1.2.1, <i>Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television</i> , July 1999 (“DVB-T”)
LGE1006	D. Sommer and G.P. Fettweis, <i>Signal Shaping by Non-Uniform QAM for AWGN Channels and Applications Using Turbo Coding</i> , January 2000 (“Sommer”)
LGE1007	[RESERVED]
LGE1008	Ulrich Reimers et al., <i>DVB The Family of International Standards for Digital Video Broadcasting</i> , Second Edition, 2005 (“Ulrich”)
LGE1009	ETSI EN 302 307 V1.1.2, <i>Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications</i> , June, 2006 (“DVB-S2”)
LGE1010	U.S. Provisional application No. 60/933,319 (“’319 Provisional”)
LGE1011	Declaration of June Munford
LGE1012	Stipulation by Petitioner, LGE, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)

- LGE1013 ETSI TS 102 006 V1.2.1, *Digital Video Broadcasting (DVB); Specifications for System Software Update in DVB Systems*, October 2002 (“DVB-TS”)
- LGE1014 De Gaudenzi et al., *Turbo-coded APSK modulations design for satellite broadband communications*, Int. J. Satell. Commun. Network. 2006; 24:261–281, Published online 19 May 2006 in Wiley InterScience (“DeGaudenzi”)
- LGE1016 G. Robins, *Signal constellation design tool: A case study in user interface synthesis*, International Conference on Computer Assisted Learning, 1989. First Online: 01 January 2005. (“Robins”)
- LGE1017 Declaration of Friedhelm Rodermund
- LGE1018 Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (USPTO June 21, 2022) (“Interim Procedure”)
- LGE1019 Docket Control Order, *Constellation Designs, LLC v. LG Electronics, Inc. et al*, Case No. 2:21-cv-00448 (E.D. Tex.)
- LGE1020 Complaint, *Constellation Designs, LLC v. LG Electronics, Inc. et al*, Case No. 2:21-cv-00448 (E.D. Tex.)
- LGE1021 Proakis, John G. *Digital Communications*, Fourth Edition, 2000. (“Proakis”)

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]	a demapper, coupled to the demodulator, capable of determining likelihoods using the demodulated signal and a multidimensional symbol constellation selected from a plurality of multidimensional symbol constellations; 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;

[1e]	wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points, where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;
[1f]	wherein the receiver is capable of selecting an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.

Claim 4	
[4]	The communication system of claim 1, wherein each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than a similar multidimensional symbol constellation at the same SNR, where the similar multidimensional symbol constellation differs only in that the constellation points in the similar multidimensional symbol constellation are uniformly spaced in each degree of freedom.
Claim 6	
[6]	The communication system of claim 1, wherein each of the plurality of different non-uniform multidimensional symbol constellations are characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a specific SNR subject to at least one constraint.
Claim 7	
[7a]	The communication system of claim 1, wherein: the receiver is capable of measuring the quality of the communication channel;

[7b]	the receiver is capable of selecting an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs based at least in part on a quality measurement;
[7c]	the receiver is capable of sending a request to a remote transmitter to use a selected LDPC code rate and multidimensional symbol constellation pair.
Claim 8	
[8]	The communication system of claim 1, wherein the demodulator is capable of using a demodulation scheme that is based on phase shift keying and the degrees of freedom available to the multidimensional symbol constellations are amplitude and phase.
Claim 9	
[9]	The communication system of claim 1, wherein the receiver is capable of substituting the plurality of multidimensional symbol constellations by an upgrade to at least one of the receiver software and firmware.

Claim 10	
[10pre]	The communication system of claim 1, further comprising a transmitter capable of transmitting signals via the communication channel, where the transmitter comprises:
[10a]	a coder capable of receiving bits and outputting encoded bits using the Low Density Parity Check (LDPC) code;
[10b]	a mapper, coupled to the coder, capable of mapping the encoded bits to symbols in the selected multidimensional symbol constellation; and
[10c]	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 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]	a demapper that determines likelihoods using the demodulated signal and a multidimensional symbol constellation selected from a plurality of multidimensional symbol constellations; 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;
[11f]	wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points, where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;

[11g]	wherein the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.
Claim 14	
[14]	The communication system of claim 11, wherein each of the plurality of different non-uniform multidimensional symbol constellations has a greater parallel decoding capacity at a specific SNR than a similar multidimensional symbol constellation at the same SNR, where the similar multidimensional symbol constellation differs only in that the constellation points in the similar multidimensional symbol constellation are uniformly spaced in each degree of freedom.
Claim 16	

[16]	The communication system of claim 11, wherein each of the plurality of different non-uniform multidimensional symbol constellations are characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a specific SNR subject to at least one constraint.
Claim 17	
[17a]	The communication system of claim 11, wherein: the receiver measures the quality of the communication channel;
[17b]	the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs based at least in part on a quality measurement;
[17c]	the receiver sends a request to a remote transmitter to use a selected LDPC code rate and multidimensional symbol constellation pair.

Claim 18	
[18]	The communication system of claim 11, wherein the demodulator uses a demodulation scheme that is based on phase shift keying and the degrees of freedom available to the multidimensional symbol constellations are amplitude and phase.
Claim 19	
[19]	The communication system of claim 11, wherein the receiver can substitute the plurality of multidimensional symbol constellations by an upgrade to at least one of the receiver software and firmware.
Claim 20	
[20pre]	The communication system of claim 11, further comprising a transmitter that transmits signals via the communication channel, where the transmitter comprises:
[20a]	a coder that receives bits and outputs encoded bits using the Low Density Parity Check (LDPC) code;
[20b]	a mapper that maps the encoded bits to symbols in the selected multidimensional symbol constellation; and

[20c]	a modulator that generates a signal for transmission via the communication channel based upon symbols selected by the mapper;
[20d]	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 21	
[21pre]	A communication system, comprising:
[21a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver uses a multidimensional symbol constellation to transform the received signals into received bits and the multidimensional symbol constellation is selected from a plurality of multidimensional symbol constellations;

[21b]	wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points, where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;
[21c]	wherein the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.

Claim 24

- | | |
|------|---|
| [24] | The communication system of claim 21, wherein each of the plurality of different non-uniform multidimensional symbol constellations has a greater parallel decoding capacity at a specific SNR than a similar multidimensional symbol constellation at the same SNR, where the similar multidimensional symbol constellation differs only in that the constellation points in the similar multidimensional symbol constellation are uniformly spaced in each degree of freedom. |
|------|---|

Claim 26

- | | |
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| [26] | The communication system of claim 21, wherein each of the plurality of different non-uniform multidimensional symbol constellations are characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a specific SNR subject to at least one constraint. |
|------|--|

Claim 27

- | | |
|-------|---|
| [27a] | The communication system of claim 21, wherein:

the receiver measures the quality of the communication channel; |
|-------|---|

[27b]	the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs based at least in part on a quality measurement; and
[27c]	the receiver sends a request to a remote transmitter to use a selected LDPC code rate and multidimensional symbol constellation pair.
Claim 28	
[28]	The communication system of claim 21, wherein the receiver uses a demodulation scheme that is based on phase shift keying and the degrees of freedom available to the multidimensional symbol constellations are amplitude and phase.
Claim 29	
[29]	The communication system of claim 21, wherein the receiver can substitute the plurality of multidimensional symbol constellations by an upgrade to at least one of the receiver software and firmware.

Claim 30	
[30]	The communication system of claim 21, further comprising a transmitter that transmits signals via the communication channel, where the transmitter uses the selected multidimensional symbol constellation to transform encoded bits into the transmitted signals.

LG Electronics, Inc. (“**Petitioner**” or “**LGE**”) petitions for *inter partes* review (“**IPR**”) of claims 1, 4, 6-11, 14, 16-21, 24, and 26-30 (“**the Challenged Claims**”) of U.S. Patent 10,693,700 (“**the ’700 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 ’700 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 ’700 Patent less than one year ago. LGE1020.

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).

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	Prior Art Basis
1A	1, 8, 10-11, 18, 20-21, 28, 30	§103 – Eroz in view of DVB-T
1B	1, 6, 8, 10-11, 16, 18, 20-21, 26, 28, 30	§103 – Eroz in view of DVB-T and DeGaudenzi
2A	4, 14, 24,	§103 – Eroz in view of DVB-T and Sommer
2B	4, 14, 24,	§103 – Eroz in view of DVB-T and Sommer and DeGaudenzi
3A	7, 17, 27	§103 – Eroz in view of DVB-T and DVB-S2
3B	7, 17, 27	§103 – Eroz in view of DVB-T and DVB-S2 and DeGaudenzi
4A	9, 19, 29	§103 – Eroz in view of DVB-T and DVB-TS
4B	9, 19, 29	§103 – Eroz in view of DVB-T and DVB-TS and DeGaudenzi

The '700 Patent was filed on Dec. 23, 2019 and claims priority from U.S. Provisional application No. 60/933,319 (“**319 Provisional**” or LGE1010), which was filed on June 5, 2007. While Petitioner does not concede that the '700 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 '700 Patent. The declarations of Friedhelm Rodermund (LGE1017) and June Munford (LGE1011) provide additional information regarding the public availability of the non-patent literature references listed in the table.

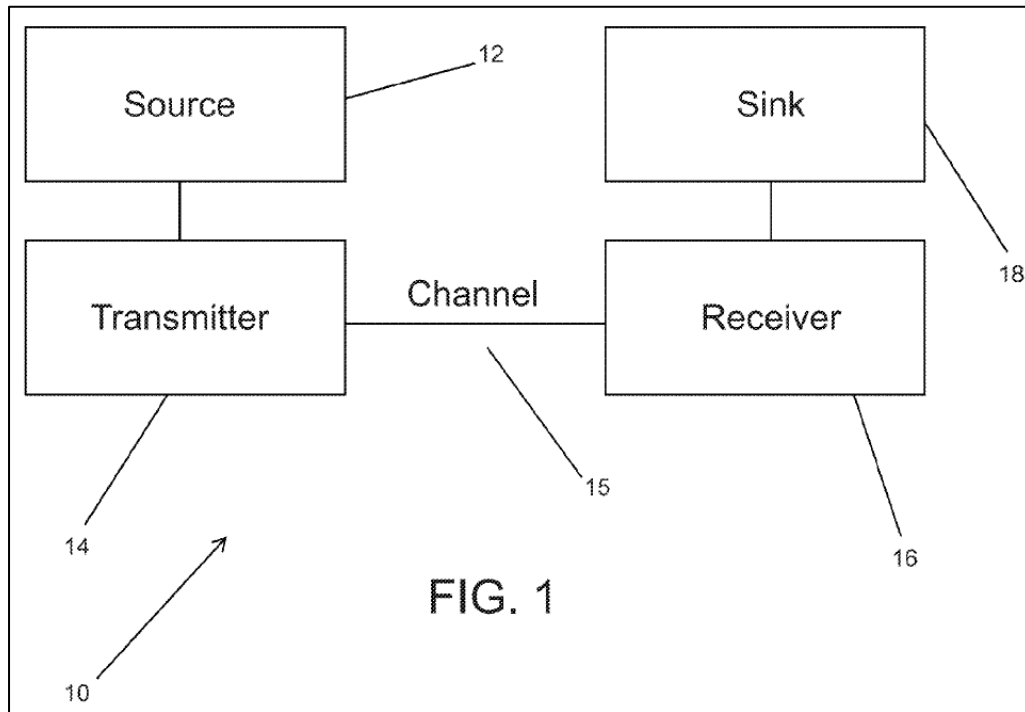
Reference	Date	Section
U.S. Patent Pub. No. 2004/0054960 (“Eroz” or LGE1004)	March 18, 2004	102(a)
ETSI EN 300 744 V1.2.1 (DVB-T) (“DVB-T” or LGE1005)	July, 1997	102(a)/(b)
D. Sommer and G.P. Fettweis, <i>Signal Shaping by Non-Uniform QAM for AWGN Channels and Applications Using Turbo Coding</i> , January 2000 (“Sommer” or LGE1006)	January 2000	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, Published online 19 May 2006 in Wiley InterScience (“DeGaudenzi” or LGE1014)	July/August 2006	102(a)/(b)
ETSI EN 302 307 V1.1.2 (“DVB-S2” or LGE1009)	June, 2006	102(a)/(b)
ETSI TS 102 006 V1.2.1, <i>Digital Video Broadcasting (DVB); Specification for System Software Update in DVB System</i> , Oct. 2002 (“DVB-TS” or LGE1013)	Oct., 2002	102(a)/(b)

II. OVERVIEW OF THE '700 PATENT

A. Brief Description of the '700 Patent

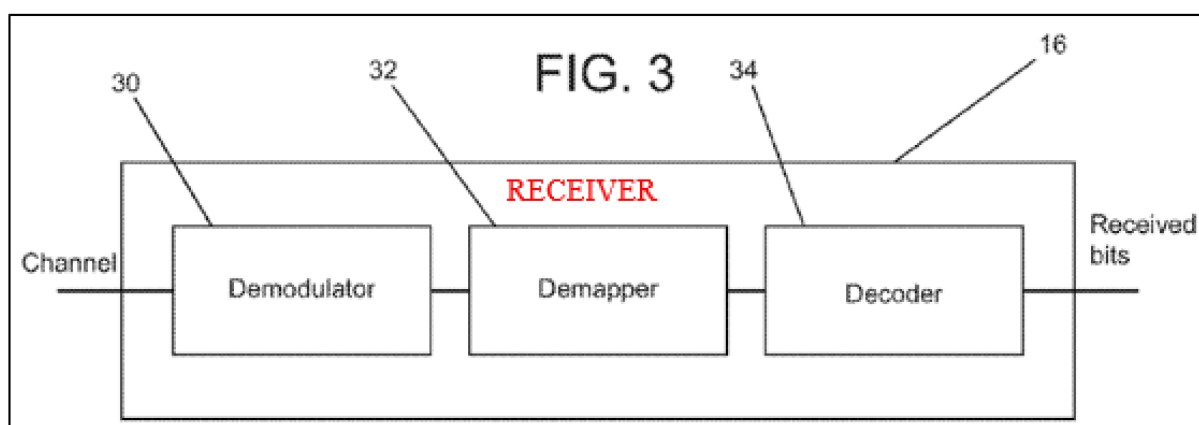
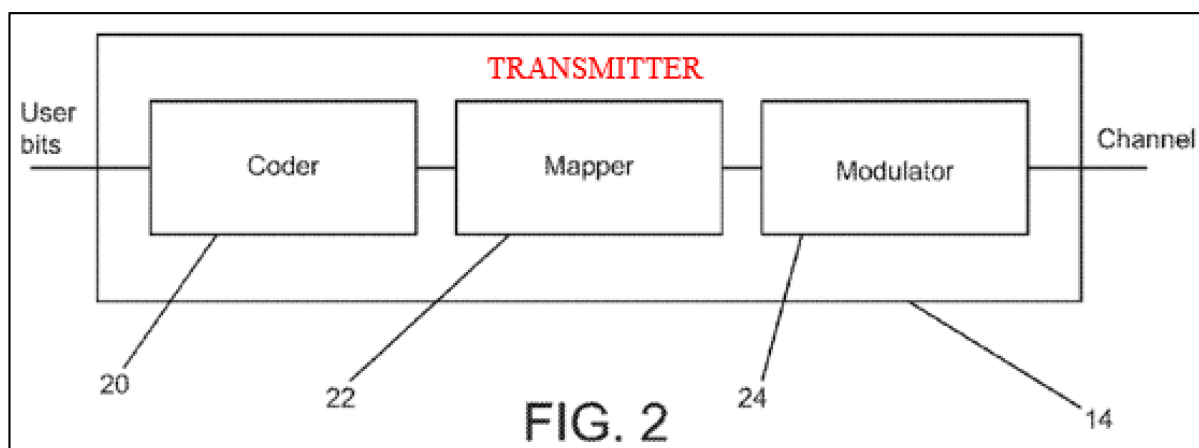
The '700 Patent is directed to communication systems that use geometrically-shaped constellations. LGE1001, Abstract. In communication systems, the term “‘constellation’ is used to describe the possible symbols that can be transmitted by a typical digital communication system.” *Id.*, 1:42-44. When a transmitter transmits data symbols, a “receiver attempts to detect the symbols that were transmitted by mapping a received signal to the constellation.” *Id.*, 1:42-46; LGE1003, ¶¶[0045]-[0049].

Figure 1 (reproduced below) shows a communication system 10 according to the '700 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, 5:32-35. 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.*, 5:33-35; LGE1003, ¶¶[0049]-[0050].



LGE1001, FIG. 1.

FIG. 2 (reproduced below) of the '700 Patent depicts the transmitter 14 and its components, which include a coder 20, a mapper 22, and a modulator 24. LGE1001, 3:45-46, 5:40-51. FIG. 3 (reproduced below) of the '700 Patent depicts the receiver 16 and its components, which include a demodulator 30, a demapper 32, and a decoder 34. LGE1001, 3:47-48, 5:53-59; LGE1003, ¶¶[0050-0051].



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, 5:40-44. 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.*, 2:52-55, 2:56-62, 4:66-5:3. 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.*, 7:52-54. The ’700 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.*, 8:25-29; LGE1003, ¶¶[0051]-[0052].

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, 5:54-58. 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.*, 5:58-60; LGE1003, ¶[0053].

The ’700 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, 5:62-66. 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.*, 5:66-6:1, 6:7-8. The ’700 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.*, 6:8-13. 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.*, 6:25-32; LGE1003, ¶¶[0054]-[0055].

B. Summary of the Prosecution History of the ’700 Patent

The ’700 Patent issued on June 23, 2020 and was filed as a Track 1 application on December 23, 2019. LGE1001, 1; LGE1002, 1,153. Although several IDSs were submitted during prosecution, the Examiner did not rely on any reference cited in an IDS for rejections and did not issue any Office Action during prosecution. *See generally* LGE1002; LGE1003, ¶[0056].

C. Level of Ordinary Skill in the Art

For purposes of this IPR, 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

Petitioner submits no claim constructions are 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.

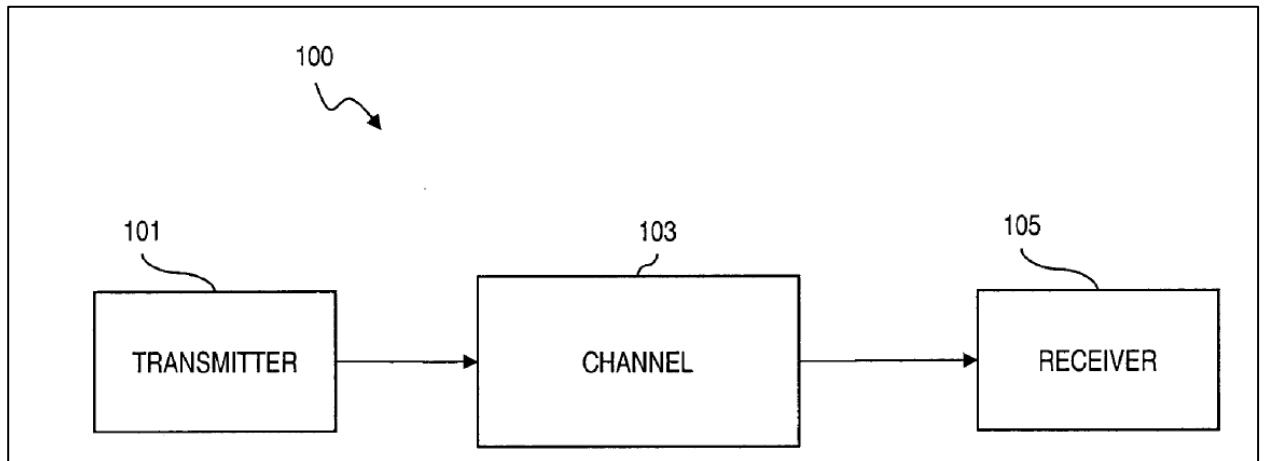
IV. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

A. Ground 1A: Erozi in view of DVB-T render claims 1, 8, 10, 11, 18, 20, 21, 28, and 30 obvious

1. Overview of Erozi³

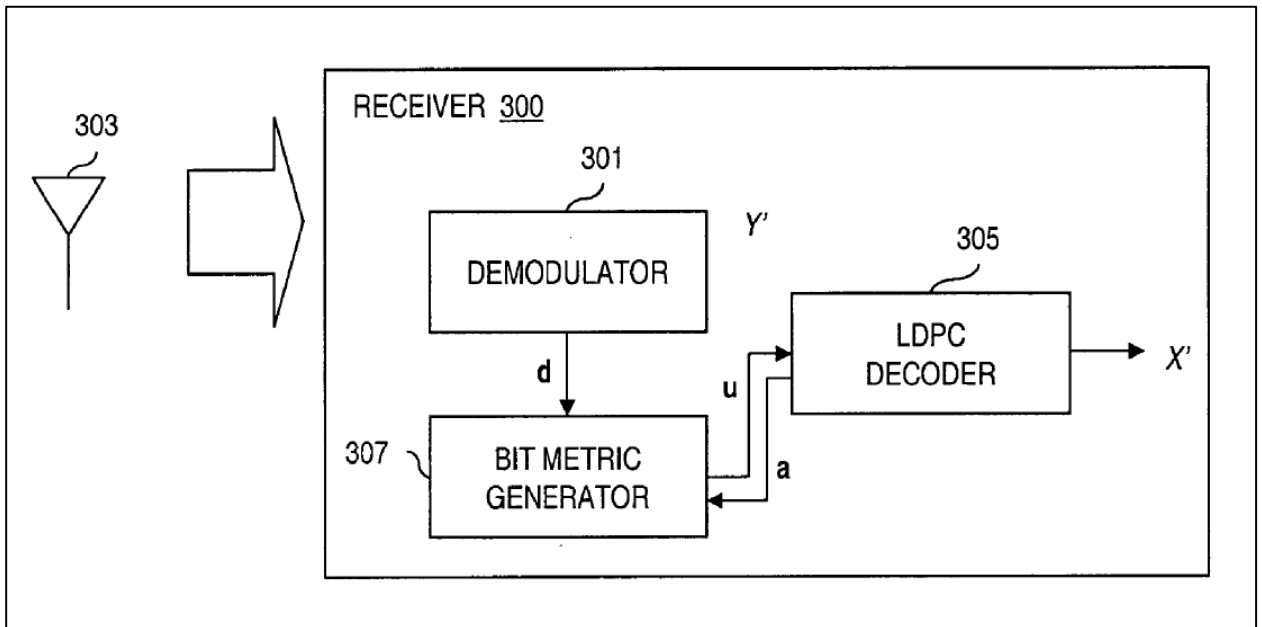
Erozi is a U.S. Patent Publication entitled “Method and System for providing Low Density Parity Check (LDPC) Encoding.” LGE1004, cover. Like the ’700 Patent, Erozi discloses that “a communications system configured to utilize Low Density Parity Check (LPDC) codes,” and that “generates signal waveforms across a communication channel to a receiver.” LGE1004, ¶[0030]; LGE1001, 4:62-5:51. Erozi’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.” LGE1004, ¶[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. LGE1004, ¶¶[0030]-[0058], FIGS. 2A, 2B; LGE1003, ¶¶[0057, 0060].

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.



LGE1004, FIG. 1.

Eroz's FIG. 3 (reproduced below) depicts an example receiver 105/300 receiving signals via antenna 303. LGE1004, 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." LGE1004, ¶[0058]; LGE1003, ¶[0058].



LGE1004, 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.

LGE1004, ¶[0058]; LGE1003, ¶[0059].

2. Overview of DVB-T

DVB-T is a standard document entitled “Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television.” LGE1005, 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.” LGE1005, 8-9; LGE1003, ¶[0061].

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. LGE1005, 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.” LGE1005, 20. Examples of four non-uniform constellations are shown below in

Figures 9b and 9c. LGE1003, ¶[0062]. In particular, Figure 9b illustrates a non-uniform 16-QAM (top) and a non-uniform 64-QAM (bottom) when $\alpha=2$. LGE1005, 22. Figure 9C illustrates a non-uniform 16-QAM (top) and a non-uniform 64-QAM (bottom) when $\alpha=4$. LGE1005, 23. LGE1003 ¶[0062].

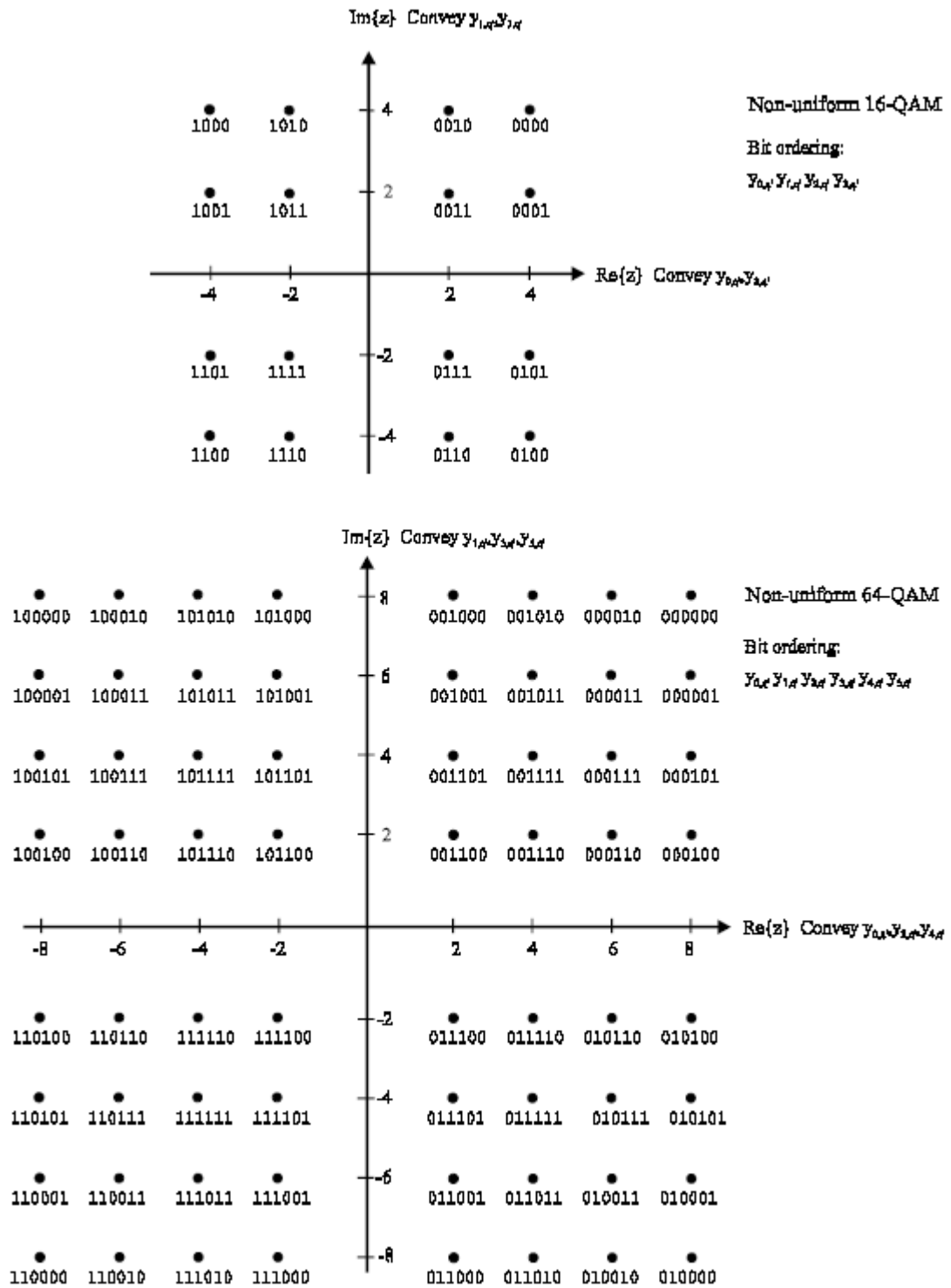


Figure 9b: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 2$

LGE1005, FIG. 9b

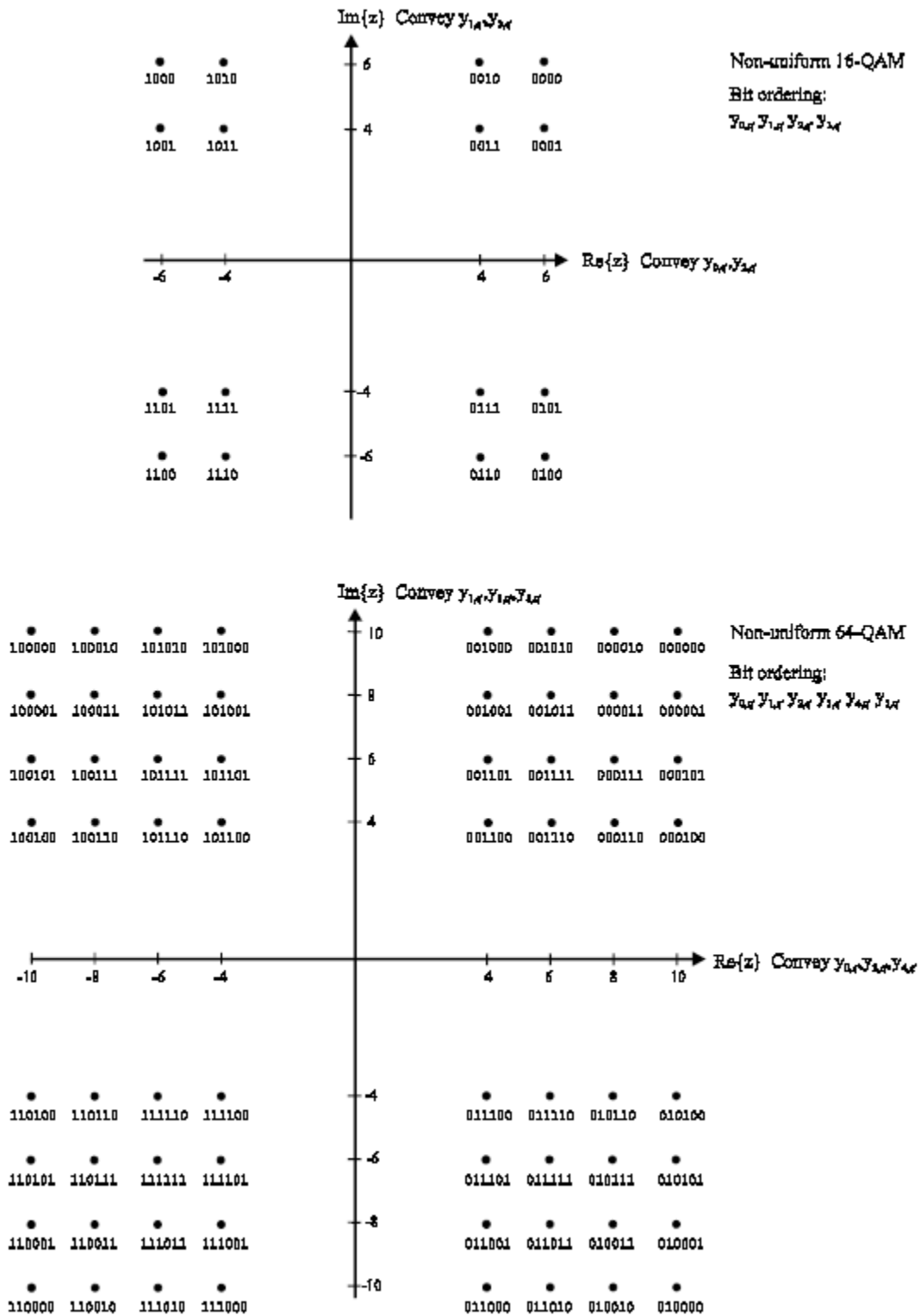


Figure 9c: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 4$

LGE1005, FIG. 9c

Alpha (α) is defined as a “constellation ratio which determines the QAM constellation for the modulation for hierarchical transmission.” LGE1005, 7. The uniformity and shape of a constellation can be affected by the value for α . 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.” *Id.*, 29. For example, as shown in DVB-T’s Figure 9a below, when $\alpha=1$, a uniform constellation can be implemented. *Id.*, 21. However, the spacing between different points in the constellation (and axes) increases when α is increased resulting in non-uniformity, as shown above in Figures 9b and 9c. *Id.*, 22-23. LGE1003 ¶[0063].

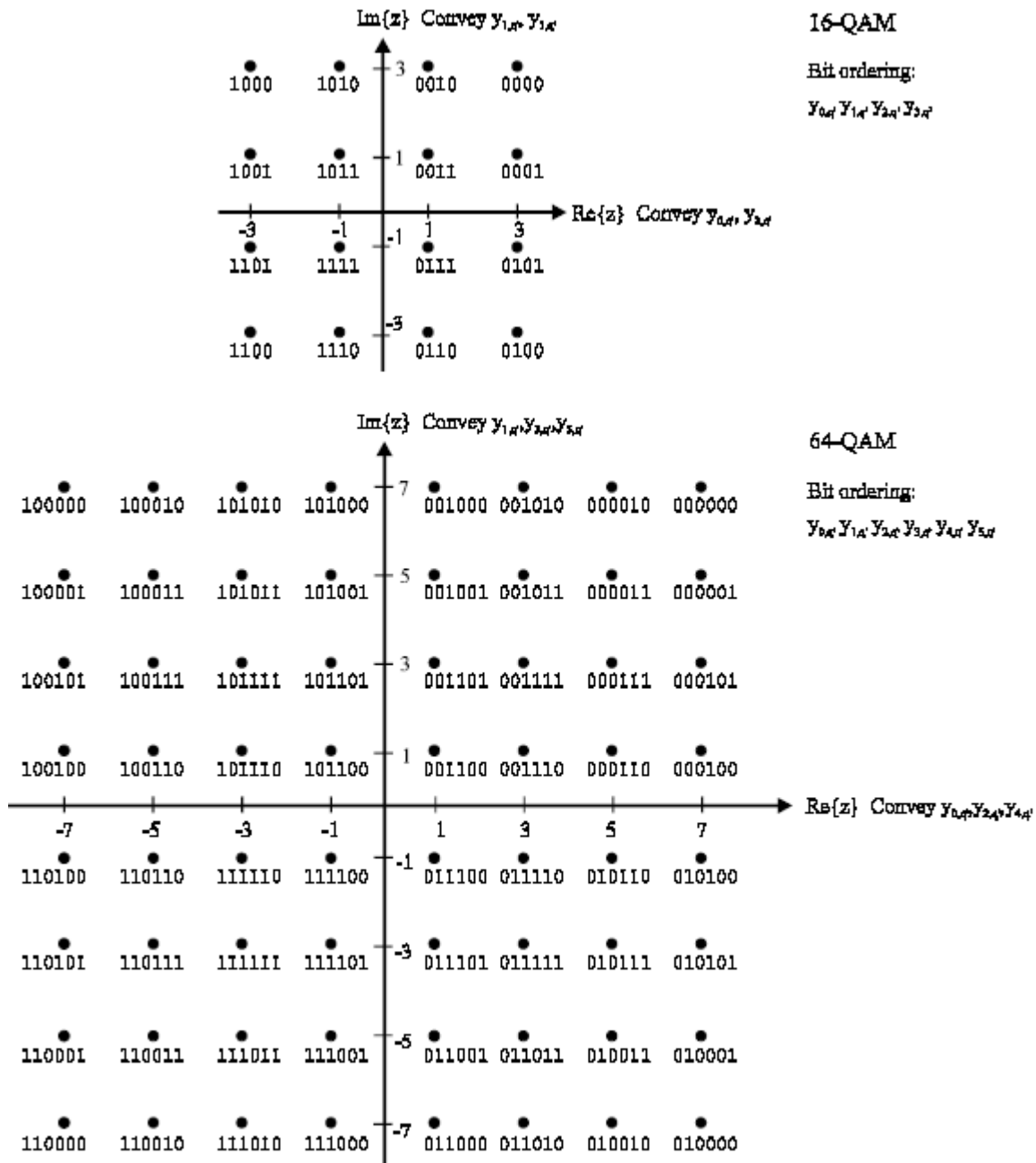


Figure 9a: The QPSK, 16-QAM and 64-QAM mappings and the corresponding bit patterns (non-hierarchical, and hierarchical with $\alpha = 1$)

LGE1005, FIG. 9a.

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. LGE1005, 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.” LGE1005, 29; LGE1003, ¶[0064].

3. Combination of Eroz and DVB-T

As explained above, both Eroz and DVB-T are directed to communication systems in which a transmitter sends encoded data to a receiver over a communication channel. LGE1004, FIGS. 1-3, ¶¶[0029]-[0038], LGE1005, 9-10, 29. Eroz teaches that LDPC codes “can be used [in a] *variety of digital video applications, such as MPEG* (Motion Pictures Expert Group) packet transmission.” LGE1004, ¶[0057]; LGE1003, ¶[0065]. DVB-T discloses a “system directly *compatible with MPEG-2 coded TV signals*.” LGE1005, 9. LGE1003 ¶[0065].

It would have been obvious for a POSITA looking to implement Eroz’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, ¶[0061, 0066]. Combining the teachings of Eroz and DVB-T

would have allowed a POSITA to adopt various coding and modulation schemes disclosed by the standard so that Erož's system could transmit LDPC coded data for digital video broadcasting purposes to other equipment and devices more effectively. LGE1003, ¶[0061].

For example, it would have been obvious for a POSITA to combine the teachings of Erož and DVB-T such that Erož's LDPC communication system, including its transmitter and receiver, are modified to implement teachings of DVB-T, such as (1) non-uniform QAM constellations with $\alpha=2$ or $\alpha=4$ and different coding rates, as described in more detail in DVB-T and below in Sections IV.A.4.[1e]-[1f]; 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. Doing so would have predictably resulted in LDPC-encoded DVB data being communicated from a transmitter to a receiver over a terrestrial digital video broadcasting communication system. EDC would have still used Erož'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; LGE1003 ¶[0065, 0067].

In fact, DVB-T discloses the goal of providing "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.” LGE1005, 6. LGE1003 ¶[0065, 0068].

Combining the teachings of Erož and DVB-T (the combination is hereinafter referred to as “**EDC**”) would have merely involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[0068-0069]. For example, a POSITA would have combined the teachings of Erož and DVB-T such that Erož’s system would have implemented modulations, code rates, constellations, constellation ratios (α), and related details as described in DVB-T, to configure LDPC-encoded DVB data from a transmitter to a receiver over a communication channel. LGE1003, ¶[0068]. For example, 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. LGE1005, 32. In a related DVB standard that incorporates LDPC codes, a similar but expanded code rate range of 1/4 to 9/10 is used. LGE1009, 6. Additionally, non-uniform QAM constellations with $\alpha=2$ or $\alpha=4$ can be used with different coding rates, as described in more detail in DVB-T, so that non-uniform constellation and code rate pairs described in the TPS methodology of DVB-T can be used to transmit LDPC encoded data. LGE1003, ¶[0069-0070]. Indeed, a subsequent DVB standard

eventually released in 2006 used LDPC codes. LGE1009, 6. LGE1003 ¶¶[0069-0070].

A POSITA would have been able to implement EDC for digital video (e.g., television) broadcasting including the various constellation and code rate pairs, described in DVB-T, in Eroz'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. LGE1003, ¶¶[0068-0069, 0071]. Indeed, implementing software code to implement the methods found in DVB-T, would have been foreseeable and predictable for a POSITA interested in implementing teachings of DVB-T such as TPS. LGE1003, ¶¶[0071]. In fact, Ulrich, a book by one of the chairpersons of DVB, explains that manufacturers would create devices for multiple applications and adapt the software. For example, control software could "be adapted, which usually is rather simply done..." LGE1008, 267. 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." LGE1008, 299. LGE1003 ¶¶[0071].

It would have been obvious to a POSITA that the EDC system would have yielded an improved performance even relative to other DVB-T systems because LDPC codes have better performance and capacities that enable a system to operate

closer to the Shannon limit than convolutional codes generally used in the DVB-T standard. LGE1004, ¶[0003], ¶[0058]. LGE1003 ¶[0072].

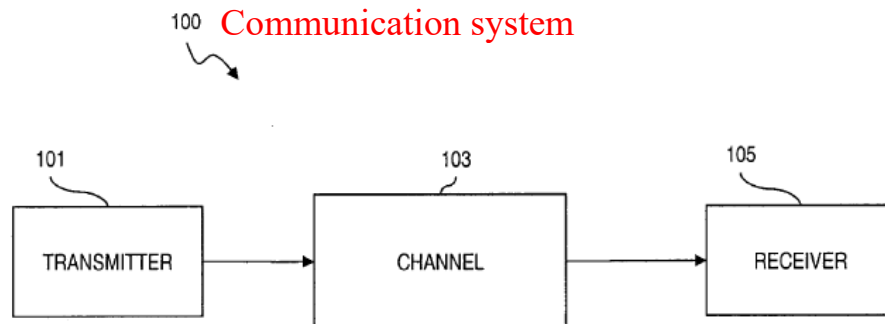
The combination would also have been predictable because elements of the combined system would have performed similar functions that had been known prior to the combination. LGE1008, 299. For example, Erož's communication system (with a transmitter and a receiver) would still perform in the same or similar manner but use the constellation and code rate pairs specified by DVB-T. *Id.*; LGE1003 ¶[0072].

4. Manner in which the EDC renders the Challenged Claims obvious

[1pre]

To the extent the preamble is limiting, EDC renders [1pre] obvious. As indicated by its title, Erož is directed to a system for providing LDPC encoding. LGE1004, cover, ¶[0030]. An example of Erož's communication system is illustrated in Erož's FIG. 1 (reproduced below). LGE1003, ¶[0103].

FIG. 1



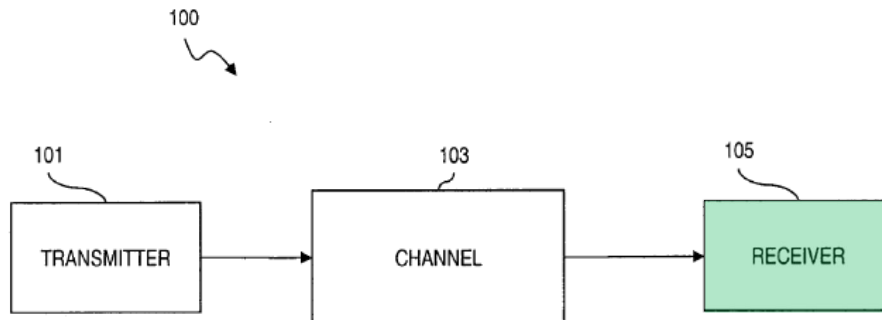
LGE1004, FIG. 1

Eroz’s *communication system* 100 “includes a transmitter 101 that generates signal waveforms across a communication channel 103 to a receiver 105.” LGE1004, ¶[0030]; LGE1003, ¶[0104].

[1a]

As noted above in [1pre] and shown below in FIG. 1, Eroz discloses *a receiver* 105 that is *capable of receiving signals via communication channel* 103 from transmitter 101. LGE1004, ¶[0030]. It is known in the art that a communication channel has a channel signal-to-noise ratio (SNR). LGE1003, ¶[0105]. 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).*” LGE1004, ¶[0003]; *see also* FIG. 7. Accordingly, it would have been obvious to a POSITA that Eroz’s communication channel 103 has a SNR. LGE1003, ¶[0105]

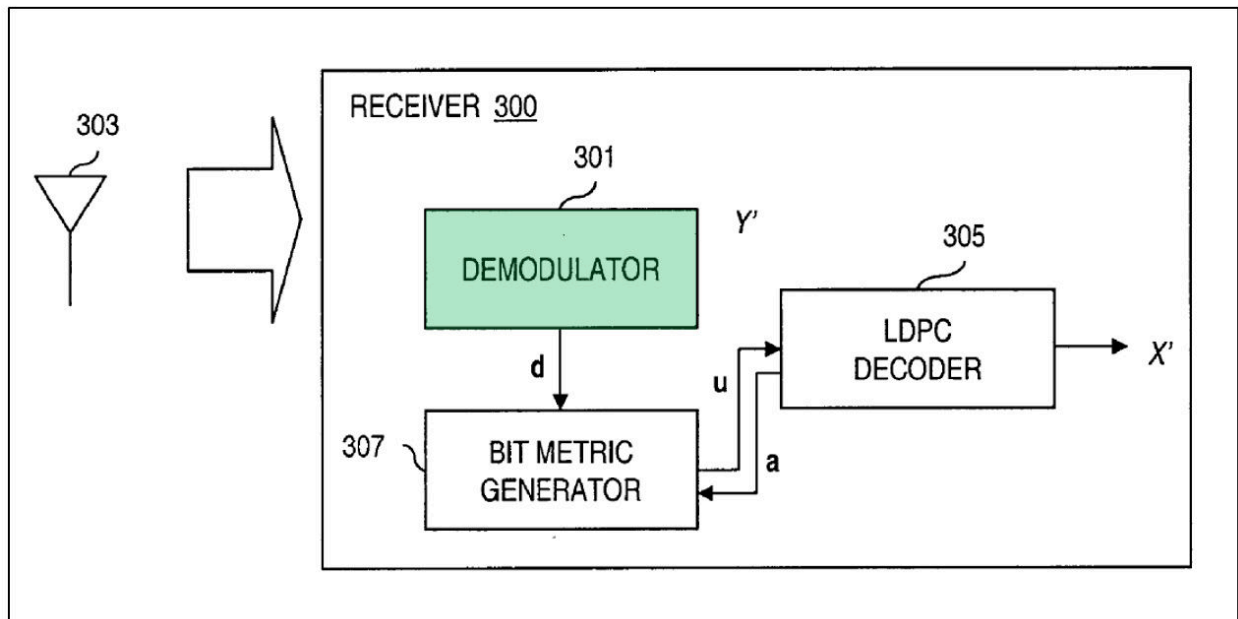
FIG. 1



LGE1004, FIG. 1

[1b]

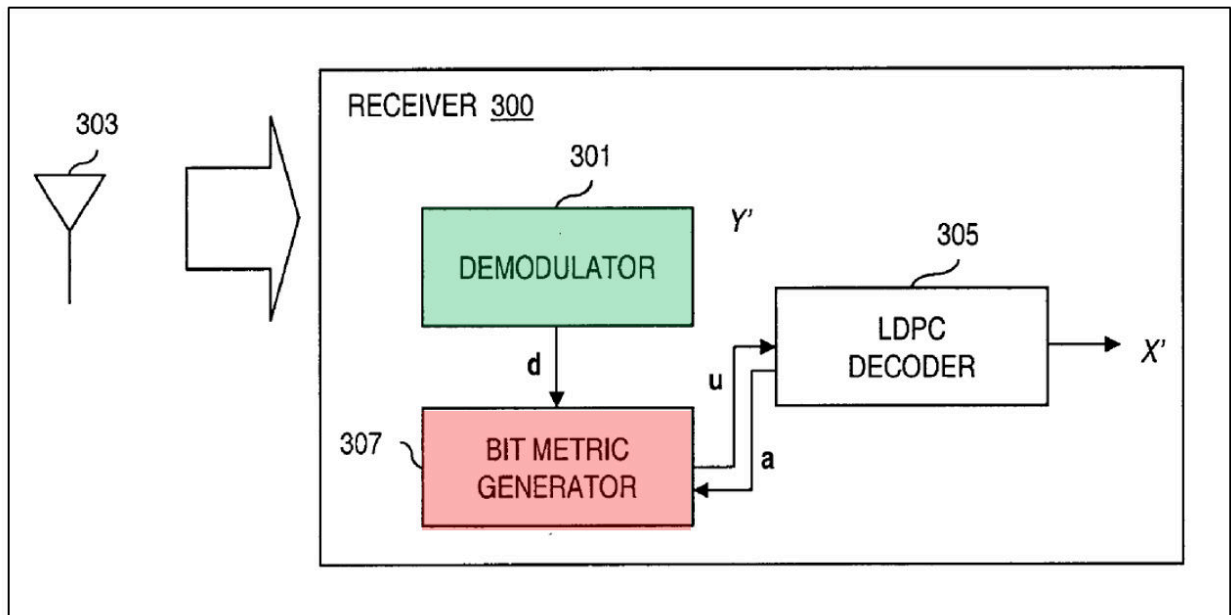
Eroz’s “FIG. 3 is a diagram of an exemplary receiver in the system of FIG. 1.” LGE1004, ¶[0058]. As explained above in §IV.A.1 and shown in Erož’s FIG. 3 below, Erož teaches that “receiver 300 includes a demodulator 301 that performs demodulation of received signals from transmitter” (*demodulator capable of demodulating a received signal into a demodulated signal*). *Id.* A demodulated signal generated by the demodulator 301 is provided to the bit metric generator 307 and LDPC decoder 305. *Id.*; LGE1003, ¶[0106].



LGE1004, FIG. 3.

[1c]

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. LGE1004, ¶[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. LGE1004, ¶[0058], FIGS. 10-11; LGE1003, ¶[0107].



LGE1004, FIG. 3.

In one example of *a multidimensional symbol constellation, an 8-PSK modulation* is used to communicate data, and EroZ'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." LGE1004, ¶¶[0076]-[0077]. LGE1003, ¶[0108].

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. LGE1004, ¶¶[0076]-[0082]; LGE1003, ¶[0109].

More generally (in addition to the 8-PSK modulation example above), Eroz discloses that its system can utilize a plurality of multidimensional symbol constellations. 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." LGE1004, claim 7. Eroz 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." LGE1004, ¶¶[0034]-[0036], FIGS. 2A, 2B. It would have been understood by a POSITA that the modulator 205 would have selected one of the plurality of multidimensional symbol constellations noted above to modulate data to be transmitted, and that the receiver would make a similar selection to ensure it demodulates the data according to the modulation used by the transmitter. LGE1003, ¶[0110].

Indeed, 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." LGE1005, 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 being 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. LGE1005, 31-32; LGE1003, ¶[0111].

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

LGE1005, Table 11

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

LGE1005, Table 12

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

LGE1005, Table 13

Table 9 (reproduced below) lists the transmission parameter information that can be provided by the TPS carriers. LGE1005, 30; LGE1003, ¶[0112].

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

LGE1005, Table 9.

It would have been obvious to a POSITA that tables similar to the ones shown

above would have been generated when using LDPC codes, and communicated in the same or similar manner described by EDC. For instance, the α and code rates values would have been the same or similar for LDPC and non-LDPC codes. Yet, as explained above in §§IV.A.3, the LDPC codes may also include additional α and MODCOD (Modulation and Coding) combinations and values. LGE1003, ¶¶ [0112-0113].

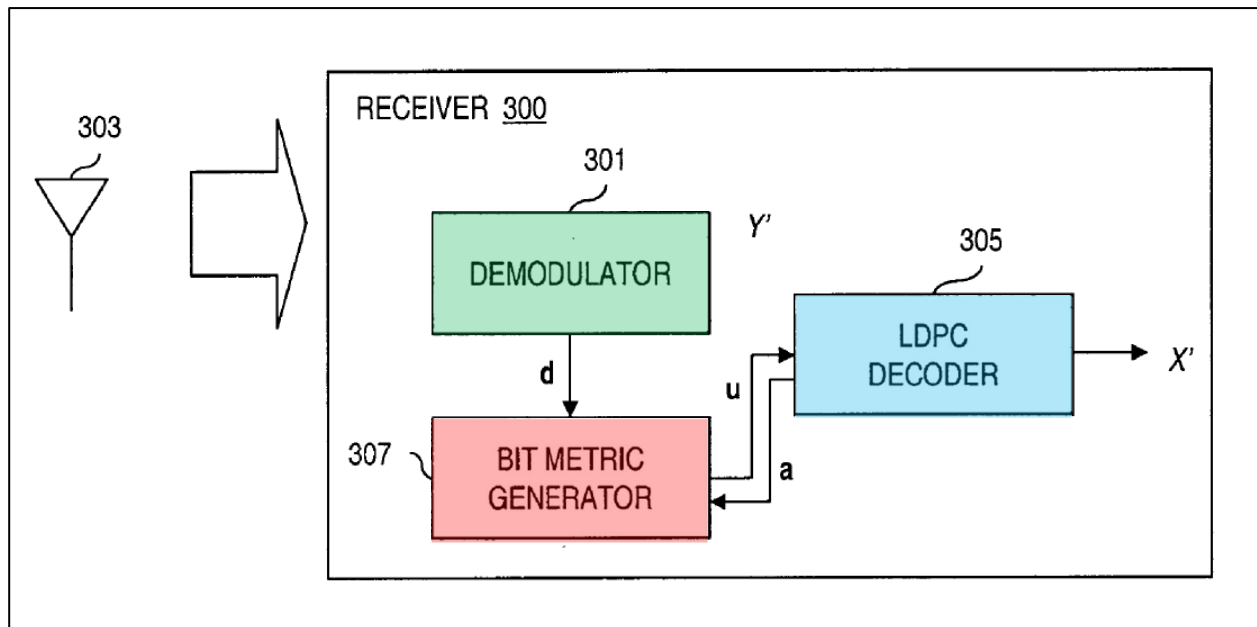
Ulrich, a textbook that describes technical features of digital video broadcasting systems and methods, also explains that at the receiver of a communication system, “processing steps that were carried out at the encoder have to be reversed.” LGE1008, 198. That is, when a particular type of modulation, mapping, and encoding is used on the transmitter, a corresponding modulation, mapping, and decoding is performed at the receiver to recover the information bits. LGE1003, ¶ [0113]. For example, if a 16-QAM modulation with $\alpha=2$ is used to modulate data a transmitter, the receiver would have received transmission parameter information and configured itself to demodulate a received signal using 16-QAM demodulation and $\alpha=2$. LGE1003, ¶¶ [0113-114].

Based on the foregoing, it would have been obvious to a POSITA that EDC teaches “a demapper, coupled to the demodulator, capable of determining likelihoods using the demodulated signal and a multidimensional symbol constellation selected from a plurality of multidimensional symbol constellations.”

LGE1003, ¶[0115].

[1d]

As shown in Eroz's FIG. 3 below, Eroz's receiver 300 includes *a LDPC decoder* 305 that is *coupled to the* bit metric generator 307 (*demapper*). LGE1004, ¶[0058], FIG. 3; LGE1003, ¶[0116].



LGE1004, FIG. 3.

The decoder 305 uses the probability information (*likelihoods*) *determined by the* bit metric generator 307 (*demapper*) to reconstruct the original source messages. LGE1004, ¶[0058]; *see supra* [1c]. 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). LGE1004, ¶¶[0061]-[0063], [0076]; *see also* FIGS. 10-11, ¶¶[0083]-[0107] (describing specifics of decoding non-Gray and Gray codes); LGE1003, ¶¶[0117-0118].

[1e]

As noted above in §§IV.A.4.[1c], Eroze and DVB-T disclose using a constellation from among a plurality of multidimensional symbol constellations. LGE1004, claim 7; LGE1005, 31-32. In particular, DVB-T discloses that the constellations can also include non-uniform-16-QAM or non-uniform-64-QAM, as shown in DVB-T's Figures 9b and 9c below. LGE1005, 20-24. Figures 9B and 9C illustrate non-uniform-16-QAM and non-uniform-64-QAM constellations at α equals to 2 and 4, respectively, resulting in different constellations. LGE1003, ¶[0120]. Two of these *plurality of constellations* have 16 points (“*a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points*”), and the two others have 64 points. Accordingly, EDC renders obvious [1e]. LGE1003, ¶[0119].

Moreover, as shown in Figures 9b and 9c below, “*the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations.*” LGE1003, ¶[0121]. For example, in the non-uniform-QAMs shown in Figure 9b, the constellation points are non-uniformly spaced along the real axis by 2 or 4 (note: $\alpha=2$), and along the imaginary axis by 2

or 4. LGE1003, ¶[0120]. In the non-uniform-QAMs shown in Figure 9c, the constellation points are non-uniformly spaced along the real axis by 2 or 8 (note: $\alpha=4$), and along the imaginary axis by 2 or 8. LGE1003, ¶[0120].

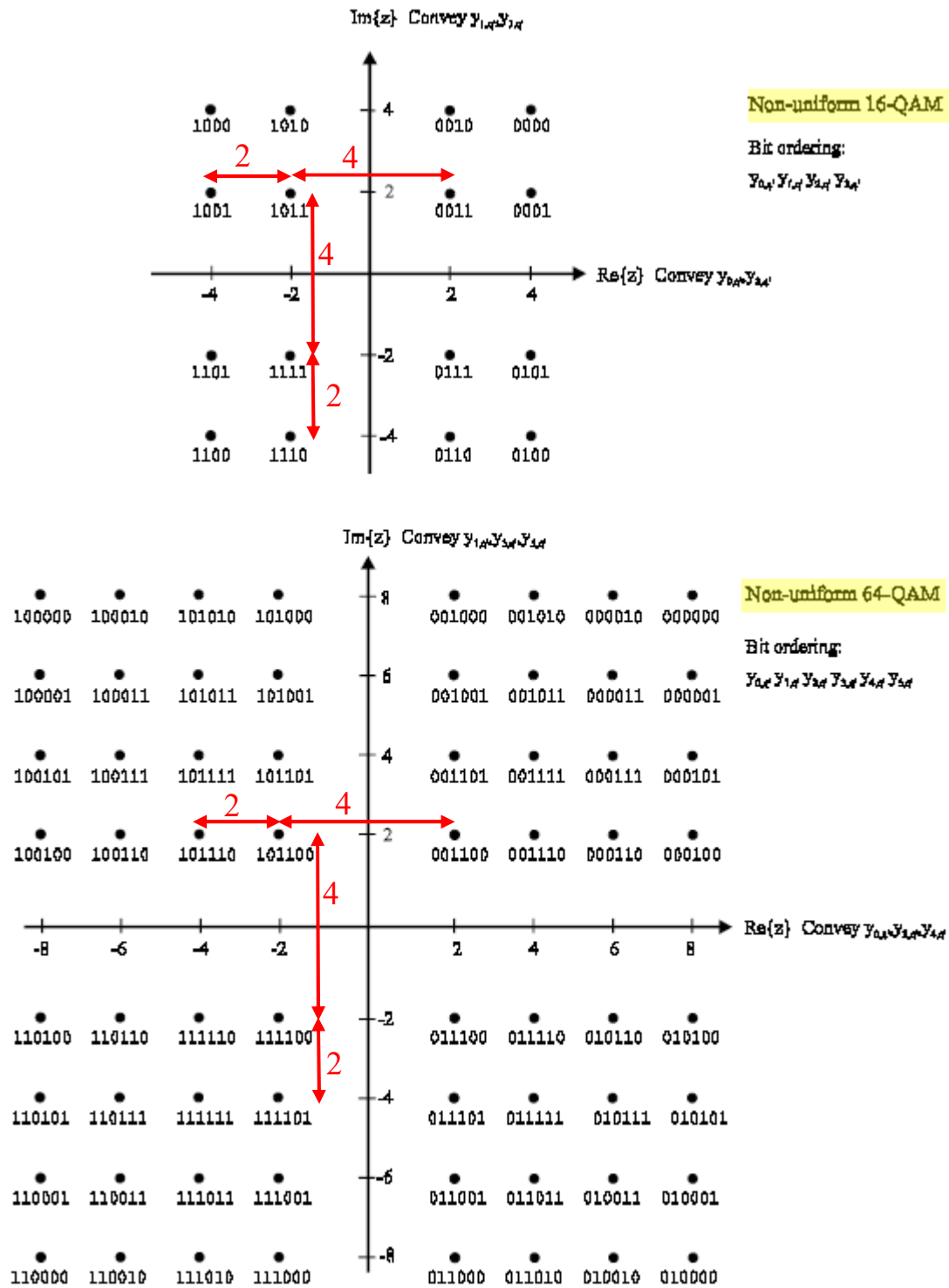


Figure 9b: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 2$

LGE1005, Figure 9b.

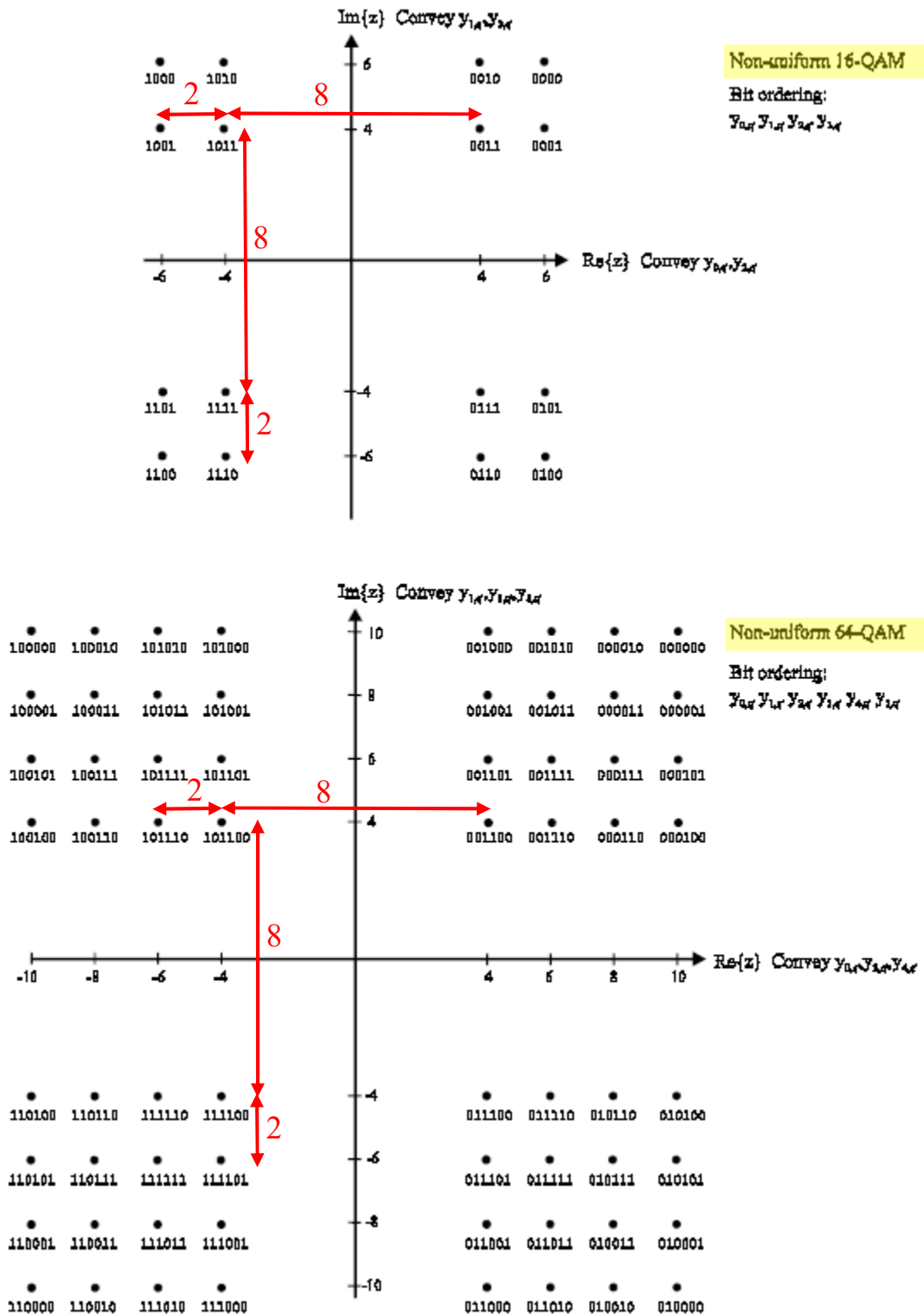


Figure 9c: Non-uniform 16-QAM and 64-QAM mappings with $\alpha = 4$

LGE1005, Figure 9c.

[1f]

As explained in §§IV.A.4.[1c], the receiver receives TPS carriers with transmission parameter information used to configure signals received by the receiver. LGE1005, 29-34. The information includes the modulation type, code rate, and α value, which “allows specification of uniform and non-uniform modulation schemes, covering QPSK, 16-QAM, and 64-QAM.” LGE1005, 29. The receiver selects the same modulation type, code rate, and α value specified in the transmission parameter information to demodulate, demap, and decode the received signal (“the receiver is capable of selecting an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs”). *See supra* §§IV.A.4.[1c]; LGE1008, 198. Recall that EroZ is directed to LDPC encoding and decoding and that EDC also would have performed LDPC encoding and decoding. *See supra* §§IV.A.4.[1pre]-[1b]; LGE1004, Abstract, ¶¶[0029]-[0039], [0058]-[0061]. LGE1003 ¶[0121].

As noted above in §§IV.A.4.[1d], DVB-T’s Figures 9b and 9c disclose examples of four non-uniform constellations, namely non-uniform-16-QAM and non-uniform-64-QAM when α equals 2 or 4. LGE1005, 20-24. These constellations can also be used at different code rates. For example, the TPS carrier 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. LGE1003 ¶[0122].

While a plurality of constellation and code rate pairs can be used in a communication system, in some cases, an optimized set of constellation-code rate pairs would have been obvious and desirable to use. For instance, while it was known in the art that a constellation can be utilized with different code rates and, more generally, can be configured in various suitable ways, configuring constellation and code rate pairs that have been optimized for SNR or spectral efficiency would have been desirable so that inferior SNR or inefficient constellation and code rate pairs are not utilized in EDC's system. Accordingly, it would have been obvious to a POSITA that, in EDC, *each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs*. In this manner, whichever constellation-code rate pair is selected by the EDC system, the selected constellation-code rate pair is one that will perform with the highest efficiency. Such a system would have been obvious to a POSITA because selecting a constellation with optimized configurations (e.g., the best efficiency) would have been desirable to maximize performance of the EDC system. The obviousness of such a system is corroborated in DeGaudenzi, as described in more detail below in §IV.B.3.[1f]. LGE1003, ¶[0123].

Indeed, the '700 Patent concedes in the background section that "Increasing

the dimensionality of a constellation allows larger minimum distance for constant constellation energy per dimension.”LGE1001, 1:50-52. But, since a constraint is the energy per dimension and the power of a transmitter is not unlimited, “[t]herefore, a number of multi-dimensional constellations with good minimum distance properties have been designed.” LGE1001, 1:52-54 These designs are specifically done in order to achieve the maximum capacity with manageable power requirements. The ‘700 Patent concedes that individual constellations are designed and optimized. Therefore, it is obvious that a POSITA would pair each of these individually designed constellations with a coding rate in order to achieve optimized performance. LGE1003 ¶¶[0122-0123].

[8]

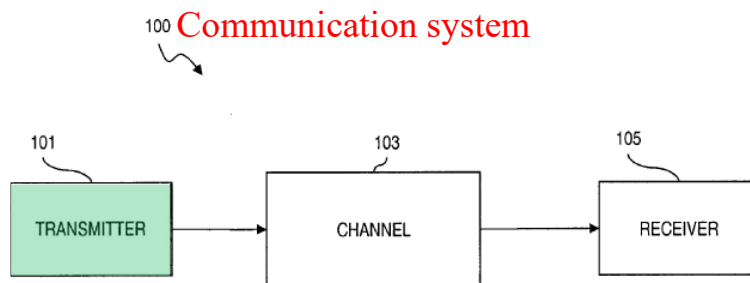
As noted above in §§IV.A.4.[1c], Erozi discloses that its system can utilize a plurality of multidimensional symbol constellations including constellations based on phase shift keying modulation. For example, Erozi’s claim 7 recites “modulating the LDPC coded signal according to a signal constellation 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.” LGE1004, claim 7. Moreover, Erozi discloses two examples of 8-PSK modulated constellations in FIGS. 8A (non-Gray) and 8B (Gray) and explains how

demodulator 301 can receive and demodulate a 8-PSK modulated signal and provide the demodulated signal to the bit metric generator 307 (demapper) and decoder 305. LGE1004, ¶¶[0058], [0068]-[0093]. Accordingly, EDC renders obvious “*the demodulator is capable of using a demodulation scheme that is based on phase shift keying.*” LGE1003, ¶[0125]. It would also have been obvious to a POSITA that “*the degrees of freedom available to the multidimensional symbol constellations are amplitude and phase*” at least because the EDC system can process (modulate and demodulate) APSK constellations. LGE1003, ¶[0125] (explaining that APSK is a digital modulation scheme that, by definition, conveys data by modulating both the amplitude and the phase of a signal). *Id.* LGE1003 ¶[0124].

[10pre]

As explained above in §§IV.A.1 and §§IV.A.3, Erož’s *communication system* 100 *includes a transmitter* 101 that is *capable of transmitting signals via communication channel* 103. LGE1004, ¶[0030], FIG. 1. The “signal waveforms are attenuated, or otherwise altered, by communications channel 103. *Id.*; LGE1003, ¶[0125].

FIG. 1

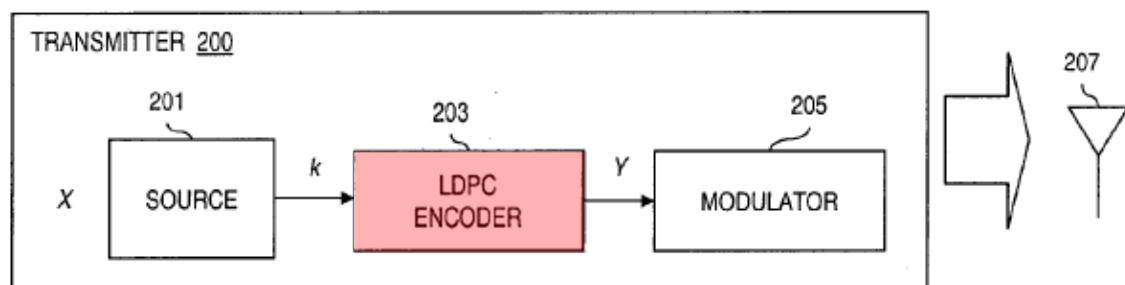


LGE1004, FIG. 1.

[10a]

Details of Erož's transmitter 101/200 are shown in Erož's FIG. 2A (reproduced below). LGE1004, ¶¶[0030], [0034]. Erož's transmitter 200 includes a LDPC encoder 203 ("*coder*") *that is capable of receiving bits* from k signals. LGE1004, ¶[0034]. The bits *are encoded using a LDPC code*. LGE1004, ¶[0034]. LDPC encoder 203 *outputs encoded bits* (using alphabet Y) and provides signals with the encoded bits to modulator 205. LGE1004, ¶[0035]; LGE1003 ¶[0126].

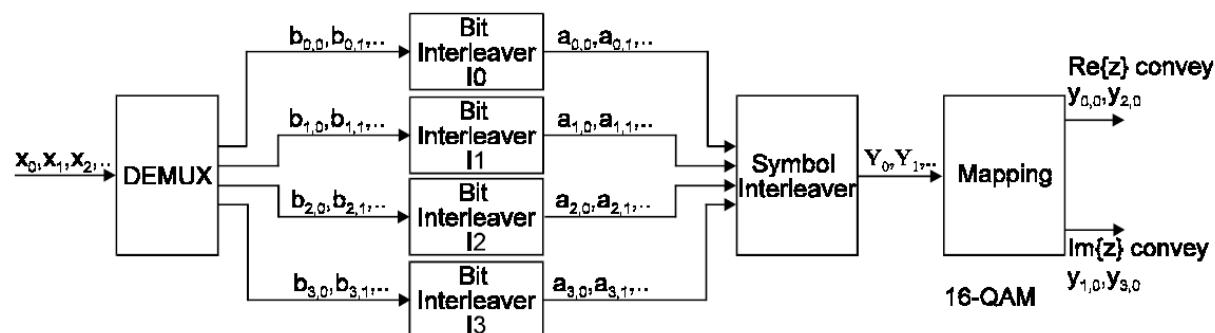
FIG. 2A



LGE1004, FIG. 2A.

[10b]

Eroz generally discloses the use of symbols and provide several examples utilizing 8-PSK symbols. LGE1004, ¶¶[0003], [0071], [0074]-[0075], [0108]. 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 bits can be mapped to symbols in a particular, selected multidimensional symbol constellation. LGE1003 ¶[0128]. DVB-T corroborates this obvious teaching and more explicitly discloses that bitstreams "are mapped onto the signal constellation by the Mapper and Modulator." LGE1005, 9. Several examples of such mappings utilized in 16-QAM uniform and non-uniform constellations are described by DVB-T, and one example of mapping symbols in a 16-QAM is illustrated below in Figure 7a. LGE1005, 14-20; LGE1003 ¶[0128]. The "interleaver" seen in Figure 7a are functionally equivalent to an encoder. LGE1003, ¶[0127].



LGE1005, Figure 7a.

For instance, in Figure 7a above, a bitstream is demultiplexed into 4 substreams for a 16-QAM constellation. LGE1005, 14. The mapper can then select a hierarchical or non-hierarchical scheme to modulate the bits according to the following example:

16-QAM non-hierarchical transmission:	16-QAM hierarchical transmission:
x_0 maps to $b_{0,0}$	x'_0 maps to $b_{0,0}$
x_1 maps to $b_{2,0}$	x'_1 maps to $b_{1,0}$
x_2 maps to $b_{1,0}$	x''_0 maps to $b_{2,0}$
x_3 maps to $b_{3,0}$	x''_1 maps to $b_{3,0}$

LGE1005, 15.

LGE1003 ¶[0128].

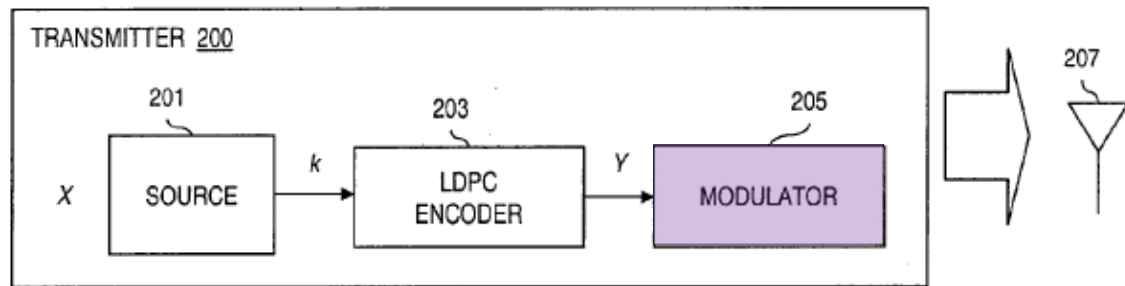
It would have been obvious to a POSITA that Erož's LDPC encoded bits would have been input into a mapper, such as DVB-T's mapper, so that bits-to-symbol mapping may be performed. LGE1003 ¶[0129]. The mapped symbols would have then been used by a modulator to generate signals for transmission to a receiver over a communication channel. LGE1004, ¶¶[0034]-[0036], FIGS. 1-4; LGE1003 ¶[0129].

[10c]

Erož 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"). LGE1004, ¶[0036]; LGE1003 ¶[0130].

FIG. 2A



LGE1004, FIG. 2A.

As explained in [10b], 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 ¶[0131].

[11pre]

See [1pre]; LGE1003, ¶[0132].

[11a]

See [1a]; LGE1003, ¶[0133].

[11b]

See [1b]; LGE1003, ¶[0134].

[11c]

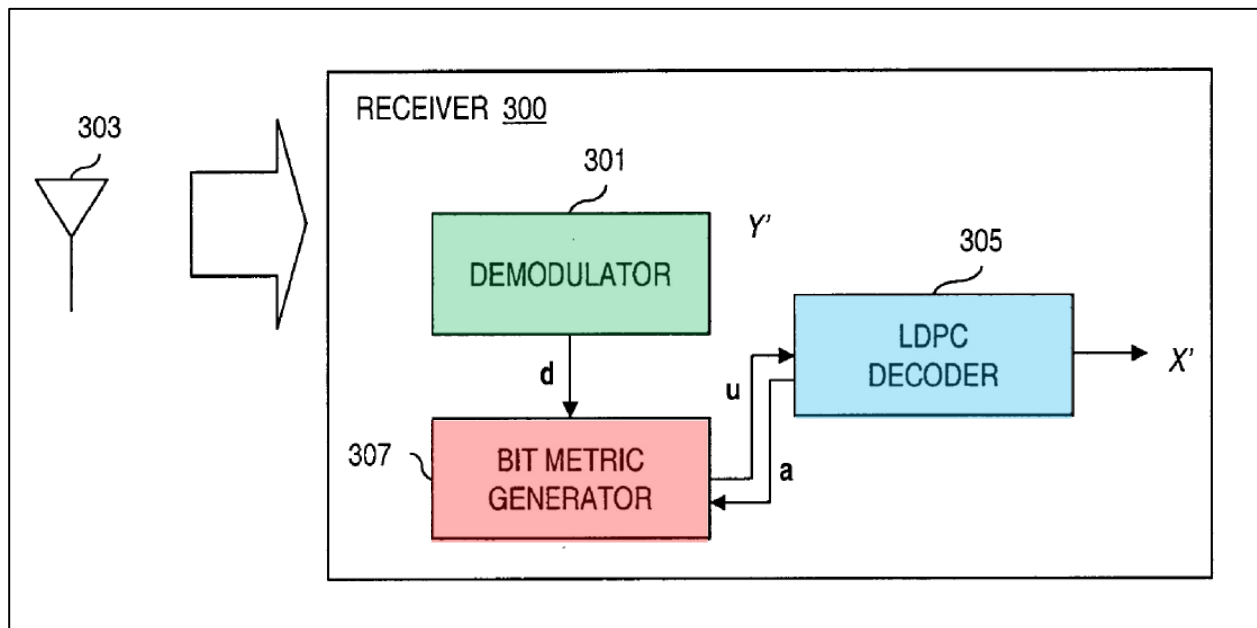
See [1c]; LGE1003, ¶[0135].

[11d]

See [1d]; LGE1003, ¶[0136].

[11e]

As explained above in [1b]-[1d] and shown in Erož's FIG. 3, EDC's bit metric generator 307 (*demapper*) is *interposed between the demodulator 301 and the LDPC decoder 305, receives information from the demodulator 301 and provides information to the LDPC decoder 305*. LGE1004, ¶¶[0058], [0061]-[0063], [0076]-[0077]; LGE1003, ¶[0137].



LGE1004, FIG. 3.

[11f]

See *supra* [1e]; LGE1003, ¶[0138].

[11g]

See *supra* [1f]; LGE1003, ¶[0139].

[18]

See supra [8]; LGE1003, ¶[0140].

[20pre]

See supra [10pre]; LGE1003, ¶[0141].

[20a]

See supra [10a]; LGE1003, ¶[0142].

[20b], [20d]

See supra [10b]; LGE1003, ¶¶[0143,0145].

[20c]

See supra [10c]; LGE1003, ¶[0144].

[21pre]

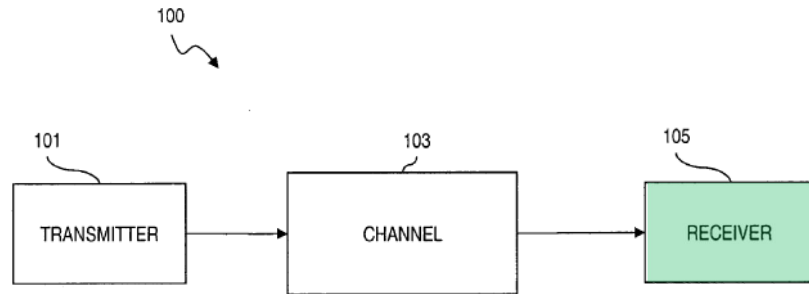
See supra [1pre]; LGE1003, ¶[0146].

[21a]

For the reasons noted above in [1a] and [1c], EDC renders obvious “a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR)” and “the multidimensional symbol constellation is selected from a plurality of multidimensional symbol constellations,” respectively,

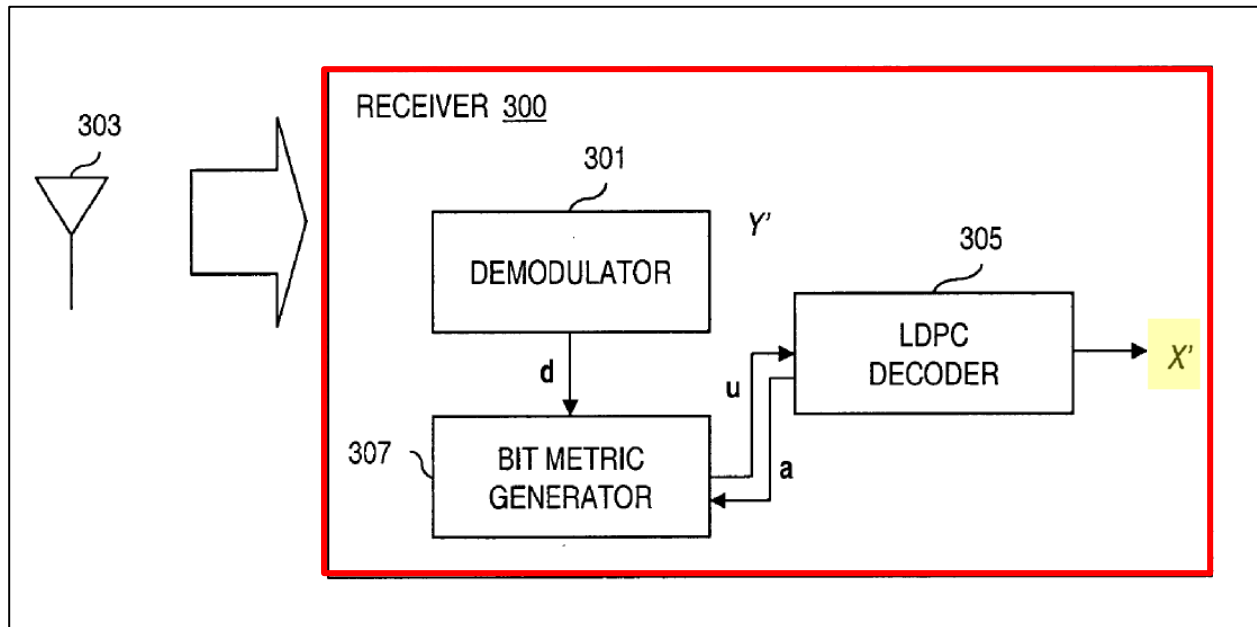
as recited in claim 21. LGE1004, ¶¶[0030]-[0036], [0058] [0076]-[0082], FIGS. 2A, 2B, 3, 10-11, 1 (reproduced below); LGE1003, ¶[0147]..

FIG. 1



LGE1004, FIG. 1.

Moreover, as explained above in [1a]-[1d], EroZ also discloses “wherein the receiver uses a multidimensional symbol constellation to transform the received signals into received bits.” LGE1003, ¶[0148]. For instance, by using its demodulator 301, demapper (bit metric generator 307), and decoder 305 (see EroZ’s FIG. 3 below, which depicts a receiver), EroZ’s receiver “reconstruct[s] the original source messages by generating messages, X'.” LGE1004, ¶¶[0035], [0058]. The messages would have been understood by a POSITA to be composed of the received bits. LGE1003, ¶[0148]. Indeed, EroZ corroborates this understanding by teaching that the LDPC decoder 305 “is considered a message passing decoder, whereby the decoder 305 aims to find the *values of bit nodes*.” LGE1004, ¶¶[0061]-[0063], [0076]; *see also* FIGS. 10-11, ¶¶[0083]-[0107]; LGE1003, ¶[0148]..



LGE1004, FIG. 3.

A POSITA would also have understood that EDC renders obvious “wherein the receiver uses a multidimensional symbol constellation to transform the received signals into received bits” based on the teachings of DVB-T and the understanding a POSITA would have had of how receivers and transmitters in communication systems work. LGE1003, ¶[0149]. For instance, DVB-T discloses that “bitstreams are mapped onto the signal constellation by the Mapper and Modulator.” LGE1005, 9. In this manner, DVB-T’s transmitter, similar to Eroz’s mapper, transforms bits to signals using a constellation. LGE1003, ¶[0149]. And recall that Ulrich explains that operations performed on the transmitter/encoder side have be reversed on the receiver/decoder side. LGE1008, 225. Accordingly, it would have been obvious to a POSITA that in the EDC system in which bits are

transformed to signals using a constellation at the transmitter side, a receiver would have performed the opposite and transformed the received signals to received bits using a multidimensional symbol constellation. LGE1003, ¶[0149].

[21b]

See [1e]; LGE1003, ¶[0150].

[21c]

See [1f]; LGE1003, ¶[0151].

[28]

See [8]; LGE1003, ¶[0152].

[30]

See [10pre]-[10c]; LGE1003, ¶[0153].

B. Ground 1B: EDC and DeGaudenzi render claims 1, 6, 8, 10-11, 16, 18, 20-21, 26, 28, and 30 obvious

1. Overview of DeGaudenzi

DeGaudenzi, *titled Turbo-coded APSK modulations design for satellite broadband communications*, is directed to the optimization of constellations based on the “mutual information” or capacity, thus creating an optimum constellation

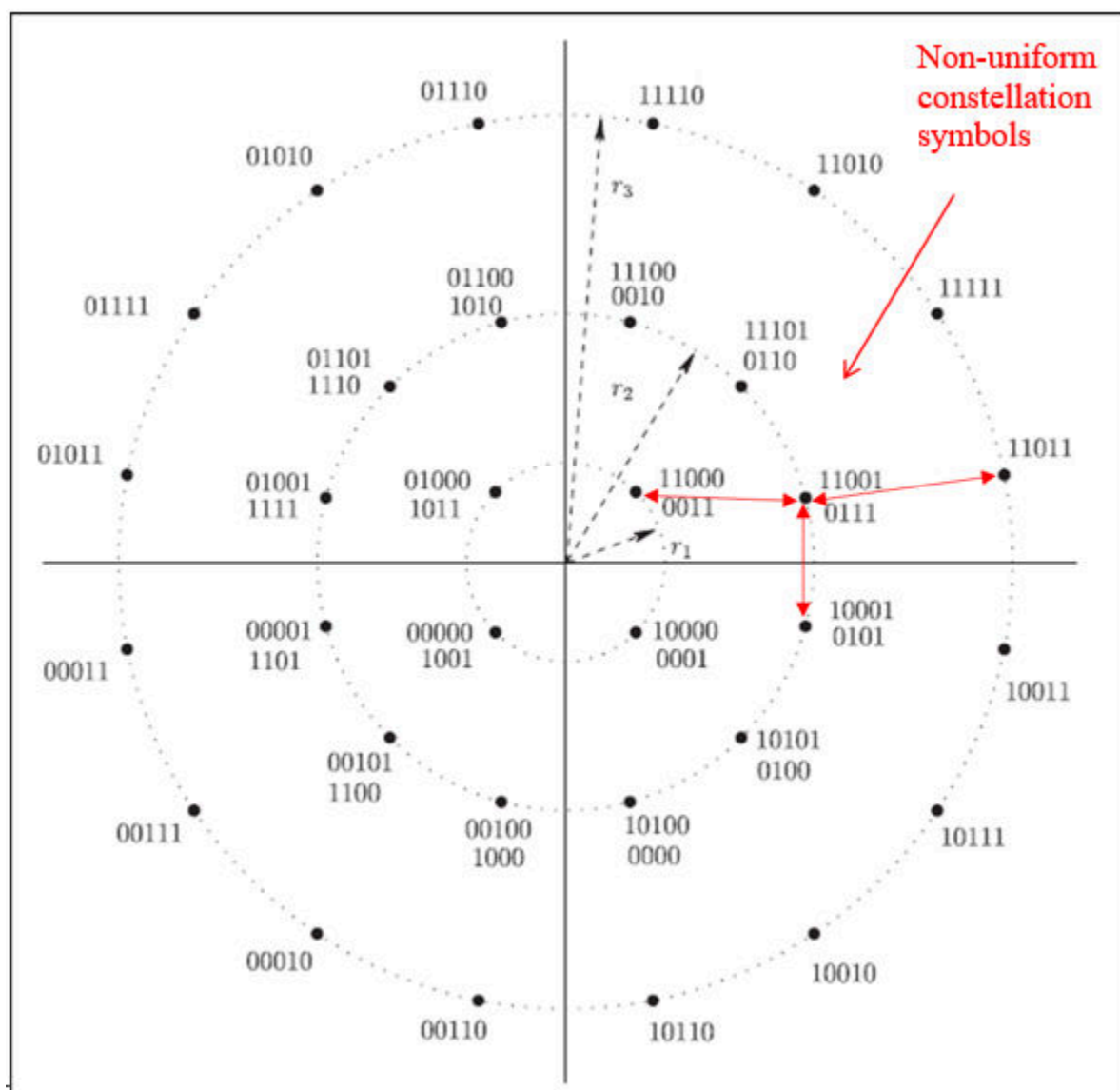
(typically non-uniform) for a given signal to noise ratio (SNR) or spectral efficiency. *Id.*, 261, 266. DeGaudenzi uses Forward Error Correction (FEC) encoding and bit-interleaved coded modulation (“BICM,” also referred to interchangeably in the art with the term “parallel decoding”) because “[a]n additional advantage of BICM is its inherent flexibility, as a single mother code *can be used for several modulations*, an appealing feature for broadband satellite communication systems where a large set of spectral efficiencies is needed.” *Id.*, 262-263; LGE1006, 3; LGE1001, 6:53-67 (“[e]xpressed another way, the PD capacity of a channel can be viewed in terms of the mutual information”); LGE1001, 6:64-65; LGE1014, 262, 272. LGE1003, [0080].

DeGaudenzi “propose[s a] new criteria for the design of digital QAM constellations of 16 and 32 points,” and does so by providing examples of *M*-APSK constellations. LGE1014, 264. In general, “*M*-APSK constellations are composed of n_R concentric rings” with each l th ring having a number of points (n_l), a radius (r_l) and a relative phase shift (θ_l). LGE1014, 264. 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*. Though DeGaudenzi describes *M*-APSK constellations, his goal is the “design of digital QAM constellations” and the teachings are applicable to QAM because QAMs can be considered a subset of APSKs due to the fact that all QAM schemes modulate

both the amplitude and phase of the carrier. LGE1014, 264; LGE1003, [0081].

DeGaudenzi's FIG. 1 (reproduced below) depicts an example of a 16- and 32-APSK constellation. LGE1014, 265. For the 32-APSK, the optimized constellation has 3 rings, with 4, 12, and 16 constellation points, respectively. The 16-APSK has 4 and 12 constellation points in its two rings. *Id.* 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. As depicted in FIG. 1, the numbers of constellation points are unequal and unequally spaced, and the radii of the rings are not multiples of a particular number. LGE1003, [0082].

=



LGE1014, FIG.1.

DeGaudenzi explains that “*for a given SNR, or equivalently, for a given spectral efficiency R ; an optimum constellation* can be obtained, a procedure we apply in the following to 16- and 32-ary constellations.” LGE1014, 266. DeGaudenzi’s “Table I provides the optimized 16- and 32-APSK parameters for various coding rates, giving an optimum constellation for each given spectral

efficiency,” or, in other words, at a given SNR. LGE1014, 268. Table I (reproduced below) lists 11 different constellations having two types of modulation orders, namely 4+12 APSK and 4+12+16-APSK. LGE1014, 271. 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. Because the optimized ρ_2 and ρ_3 have different values, each of the listed constellations has a different shape and size. LGE1003, [0083].

16(4+12) Non-uniform
symbol constellations points

Constellation
and
predetermined
code rate pair

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

Modulation order	Coding rate, r	Spectral eff. (bps/Hz)	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) Non-uniform
symbol constellations points

LGE1014, Table I⁴.

DeGaudenzi achieves this performance improvement by “show[ing] that the degrees of freedom in the design of an APSK modulation can be exploited thanks to the mutual information maximization, and this has been applied to the design of 16- and 32-ary constellations. This technique has been shown to extend the standard minimum Euclidean distance maximization, yielding a small but significant improvement.” LGE1014, 279. As stated earlier, because QAM is a subset of APSK, these advantages extend to QAM. LGE1003, ¶[0084]. Of particular significance, is not just the distance between individual points, but between the concentric rings. “The constellation geometry clearly indicates that the distances to consider are between points belonging to the same ring, or between points in adjacent rings.” LGE1014, 265. DeGaudenzi found that by adjusting the distances between rings, “small but significant improvement” could be achieved. LGE1014, 266, 279. LGE1003, ¶[0084]. Specifically, “the best offset between rings happens when $\phi_2 = \frac{\pi}{n_2}$.” LGE1014, 266. In addition to the improvements made through spacing,

⁴ Table I (shown above) 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_1 , $\rho_l = r_l/r_1$. 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_l always has a unity value. LGE1014, 264.

DeGaudenzi introduces a “new method [that] generates an optimum constellation for each spectral efficiency.” LGE1014, 261. The optimum constellation for each spectral efficiency “can easily be evaluated using the Gauss-Hermite quadrature rules, making numerical evaluations very simple.” LGE1014, 266. As, DeGaudenzi explains, “the two-dimensional optimization can be done by simply finding the ρ^2 that maximizes mutual information” and that “the optimum constellation separates the rings by a distance larger than the number of points in the ring itself, so that the relative phase ϕ has no significant impact in the distance spectrum of the constellation.” LGE1014, 267-268. All of this information can be pre-calculated and formatted into a table, such as Table I. LGE1014, 268. LGE1003, [0084].

DeGaudenzi discloses that “the optimization method based on the mutual information ... can be easily extended to the case of the BICM mutual information [13](sic, [14]) with almost identical results assuming Gray mapping.” LGE1014, 272. Recall that the use of Gray labeling (or mapping) to increase efficiency is disclosed in the EDC combination through Erozi. LGE1004, ¶[0058]. LGE1003, ¶[0085]. The spacing and 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.*, 264, 266, 272-273. In particular, DeGaudenzi discloses “[c]onstellation optimization” in “finding an [optimized]

APSK constellation” via “[m]utual information maximization” or maximization of parallel decoding capacity 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. *Id.*, 264, 266. LGE1003, [0085]

Additionally, DeGaudenzi shows example optimized 16- and 32-APSK constellations with coding “for various coding rates” in Table I. LGE1014, 268, 271, Table I. Although DeGaudenzi provides certain examples of particular types of constellations, its disclosure is broad and can be applied to different types of coding and modulation types. This is also confirmed by DeGaudenzi’s use of BICM, expressly, for its flexibility and ability to be used with several modulations. LGE1014, 262-263. LGE1003, ¶[0085]

For example, although the examples provided in Table I and FIG. 1 related to an APSK, DeGaudenzi’s teachings can be applied to QAMs. LGE1014, 264 (“[w]e propose new criteria for the design of digital QAM constellations of 16 and 32 points”). Recall that QAMs can be considered a subset of APSKs because all QAM schemes modulate both the amplitude and phase of the carrier. The distinction between the two is in their production, e.g., because a QAM is produced from two orthogonal signals. With respect to coding techniques, DeGaudenzi is directed to FEC code designs. LGE1014, 272. It well-known in the art that FEC coding refers to a variety of different coding schemes including LDPC, Polar, Turbo, and

convolutional codes. *See e.g.*, LGE1014, 262. Thus, it would have been obvious to a POSITA that the teachings of DeGaudenzi would have applied to systems using LDPC coding. LGE1003, ¶[0086]

2. Combination of EDC+DeGaudenzi

A POSITA would have combined the teachings of DeGaudenzi with the EDC so that the parallel decoding capacities of EDC's plurality of different non-uniform multidimensional symbol constellations (e.g., EDC's non-uniform-16-QAM constellations) would have been optimized. 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. As described in the previous section and supported by Dr. Hochwald, DeGaudenzi's teachings would have also applied to QAM constellations and LDPC coding. LGE1003, [0087]. Indeed, Eroz mentions the efficiency of Gray labeling by disclosing: "if Gray mapping is used (according to one embodiment of the present invention), one pass of the bit metric generator is sufficient," rather than multiple passes without Gray labeling. LGE1004, ¶[0058] Thus, it would have been obvious for a POSITA to turn to DeGaudenzi's teachings and combine its teachings with EDC's system. LGE1003, ¶[0087]

Advantageously, by maximizing the parallel decoding capacity and optimizing the spectral efficiency/SNR, EDC'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 EDC's terrestrial system to perform better if complemented with satellite communication systems. *Id.* LGE1003, ¶[0088].

A POSITA would have combined EDC and DeGaudenzi as described above by modifying EDC's system, e.g., the constellation designing software, to include code that can implement DeGaudenzi's optimization method and achieve the maximum parallel decoding capacity outcome noted above. Amending the software in EDC'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, codes, and tables for the same/similar types of constellations (e.g., QAM) disclosed by both EDC and DeGaudenzi. As stated earlier, Ulrich disclosed that manufactures would create devices for multiple applications and adapt the software. For example, control software could "be adapted, which usually is rather simply done..." LGE1008, 267. 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." LGE1008, 299. Accordingly, combining the teachings of EDC and DeGaudenzi would have simply involved combining prior art elements according to known methods to yield predictable results. LGE1003 ¶[0089].

Moreover, the combination of EDC and DeGaudenzi would also have been foreseeable. 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. 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 ¶[0090].

**3. Manner in which the EDC+DeGaudenzi render
claims 1, 6, 8, 10-11, 16, 18, 20-21, 26, 28, and 30
obvious**

[1pre]-[1e]

See supra §§X.A.[1pre]-[1e]. LGE1003 ¶[0154].

[1f]

The mapping of claim 1 other than [1f] under Grounds 1A and 1B is the same. Although [1f] would have been obvious in view of the teachings of the EDC system, to the extent the obviousness of such a feature is disputed by the Patent Owner, EDC in combination with DeGaudenzi also renders [1f] obvious. LGE1003 ¶[0155].

In particular, as described above in §IV.B.1, 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, 271. 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 ¶[0156].

16(4+12) Non-uniform
symbol constellations 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	

Constellation and predetermined code rate pair

32(4+12+16) Non-uniform
symbol constellations points

LGE1014, Table I

It would have been obvious to a POSITA that when the teachings of DeGaudenzi (such as Table I) are incorporated into EDC's system, each of the plurality of different non-uniform multidimensional 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. 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 ¶[0157].

As explained above in §IV.B.1, DeGaudenzi's teachings are broad, are not limited to APSKs, and can be applied to LDPC encoded signals and QAM constellations. LGE1014, 262-264 ("[w]e propose new criteria for the design of digital QAM constellations of 16 and 32 points"). Accordingly, in the combination

of EDC 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. 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. Accordingly, EDC-De Gaudenzi renders [1f] obvious. LGE1003 ¶[0158].

[6]

Eroz teaches that signals received by its receiver use Gray mapping, which is a well-known method of coding in which two successive bit values differ by only one bit LGE1004, ¶[0058]. For example, Eroz teaches that “[w]hen Gray labeling is used, bit metrics are advantageously generated only once before the LDPC decoder.” LGE1004, ¶[0093]. It would have been obvious to a POSITA that when Gray labeling is used, points in a constellation would have been assigned labels based on the Gray mapping scheme (e.g., because successive points can only differ

by one bit value). LGE1003 ¶[0159].

It was also known in the art that Gray labeling can be used to maximize parallel decoding capacity. LGE1006, 3 (“Gray labeling maximizes the [parallel decoding] capacity”). Thus, it would have been obvious to a POSITA that by assigning labels to points using Gray labeling, parallel decoding capacity was maximized in EroZ. LGE1003 ¶[0160].

Moreover, as described above in §§IV.A.4.[1pre]-[1f], EDC teaches configuring the constellations by using α , which impacts the uniformity and spacing of the constellations. For example, as noted above in §§IV.A.4.[1e], when $\alpha=2$, the constellation in the EDC system would have been a non-uniform 16-QAM or 64-QAM. Such QAMs would have been labeled based on the Gray labeling. Thus, EDC renders obvious “each of the plurality of different non-uniform multidimensional symbol constellations are characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity.” LGE1003 ¶[0161].

As described above in §§IV.B.1-2 DeGaudenzi also teaches maximizing the parallel decoding capacity of constellations for a given spectral efficiency/SNR. LGE1014, 246, 266. More specifically, DeGaudenzi discloses that the locations and labels of non-uniform constellation points are assigned using Gray labeling and optimized using DeGaudenzi’s optimization technique to maximize parallel

decoding capacity of the symbol constellation at a given SNR. LGE1014, 263, 266-269 (§3.2.2), 279, FIG.1., FIG. 7. For instance, as shown below in DeGaudenzi's Table I, each listed constellation has been optimized at a particular spectral efficiency Furthermore, DeGuadenzi Figure 5 shows the constellations (including their values of radii ρ) that maximize the parallel capacity as a function of SNR and achieves a maximum parallel decoding capacity. As part of the optimization, the spacing of points is determined by the radii ratios (ρ_2 and ρ_3). It would have been obvious to a POSITA, that in a non-uniform QAM constellation, the spacing of points would have similarly been determined (though not necessarily through ρ values) to optimize spectral efficiency/SNR and maximize parallel decoding capacity. LGE1003 ¶[0162].

16(4+12) Non-uniform
symbol constellations 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	

Constellation and predetermined code rate pair

32(4+12+16) Non-uniform
symbol constellations points

LGE1014, Table I

In the EDC-DeGaudenzi system, a table similar to Table I would have been generated and would have listed each of the plurality of different non-uniform multidimensional symbol constellations (e.g., non-uniform 16 QAM), a corresponding coding rate, the specific spectral efficiency or SNR, and the location of the points in the QAM. Gray labeling would have been used to assign labels to each point. In this manner, the EDC-DeGaudenzi combination would have rendered obvious the “plurality of different non-uniform multidimensional symbol constellations are characterized by the assignment of labels and spacing of constellation points so as to maximize parallel decoding capacity at a specific SNR,” as recited in claim 6. LGE1003 ¶[0163].

DeGaudenzi also teaches that its optimization method for maximizing parallel decoding capacity *is subject to at least one constraint*. DeGaudenzi utilizes multiple constraints (e.g., a given SNR, a given constellation size, a number of rings, a number of constellations points in the each ring, mutual information, conditional entropy, peak-to-average power ratio, and an assumption of “equiprobable symbols”) in implementing its optimization method. LGE1014, 266 (Section 3.2.2 Mutual information maximization). DeGaudenzi’s optimization method is also subject to an optimization constraint on average power of the symbol constellation such that $E[|x|^2] = 1$. LGE1014, 263-264. DeGaudenzi expressly states that

“[f]urther work on mutual information for modulations *with average and peak power constraints* is reported in Reference [8].” *Id.*, 262; LGE1003 ¶[0164].

For at least the foregoing reasons, the EDC-DeGaudenzi combination renders [6] obvious. LGE1003 ¶[0165].

[16]

See supra [6]; LGE1003 ¶[0166].

[26]

See supra [6]; LGE1003 ¶[0167].

[8], [10-11], [18], [20-21], [28], and [30]

Claims 8, 10-11, 18, 20-21, 28, and 30 are obvious under Ground 1B for the same reasons noted above in Ground 1A for these claims. LGE1003, ¶[0168].

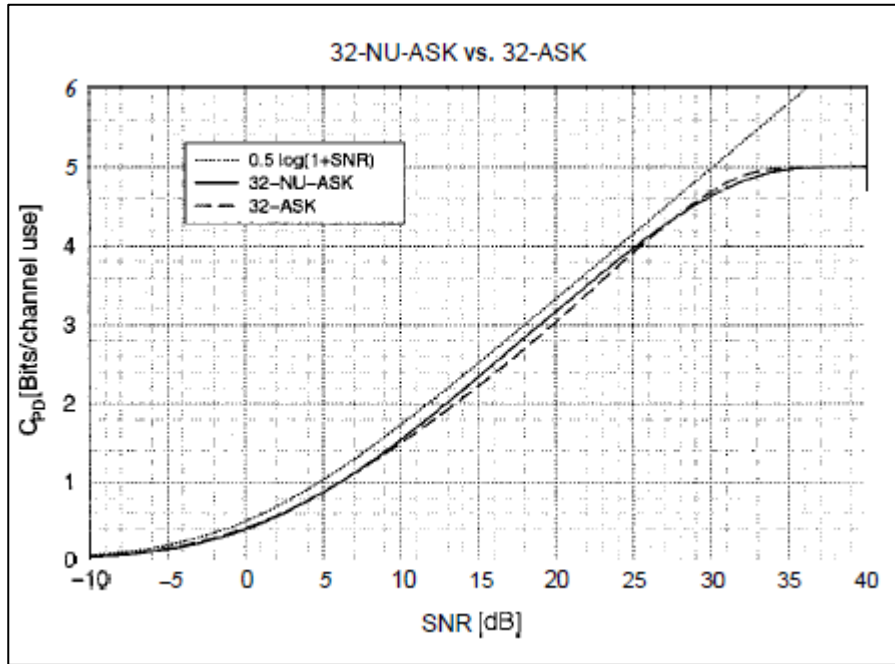
C. Ground 2A: EDC and Sommer render claims 4, 14, and 24 obvious

1. Overview of Sommer

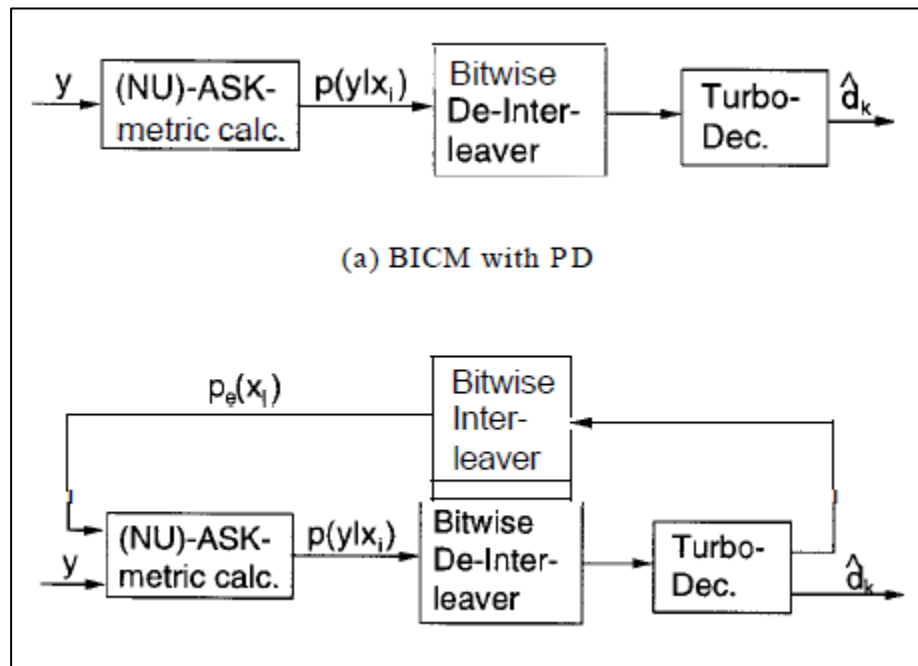
Sommer, titled *Signal Shaping by Non-Uniform QAM for AWGN Channels and Applications Using Turbo Coding*, is directed to a “non-uniform signal set constellation [] used in order to provide shaping gain,” where shaping gain is understood as “the *gain in SNR of a NU-ASK [(non-uniform amplitude shift keying)]*”

compared to a uniform ASK at a certain capacity.” LGE1006, 1, 3 (emphasis in original); LGE1003 ¶[0073]. Sommer further notes that “[n]on-uniform (NU) signal point constellations have a long tradition, e.g., in order to create a signal set for hierarchical (rate adaptive) transmission.” LGE1006, 1; LGE1003 ¶[0073].

Sommer discloses combining “the (NU) signal point constellation” with coding, such as “bit-interleaved coded modulation (BICM) ... in conjunction with Gray labeling,” which “provides similar gain when ... simple parallel decoding of the different bit levels is used.” LGE1006, 1. Sommer also compares the performance of “non-uniform signal set constellation[s]” (e.g., NU-QAM or NU-ASK) over uniform constellations (e.g., classical QAM and ASK), using BICM or parallel decoding (PD) capacity in added white Gaussian noise (AWGN) channels. *See* LGE1006, 1, 3 (“we use the term PD for BICM”). FIG. 3(b) shows the PD capacity for NU-ASK versus ASK constellations. FIG.4(a) explicitly shows, for the PD capacity (C_{PD}), a “Decoder structure” for “BICM with PD” that has no “AFD, additional feedback decoding,” as opposed to the decoder structure of “BICM with AFD” for signal set capacity (C_{PD}) in FIG.4(b). LGE1006, 2-4. LGE1003 ¶[0074].



LGE1006, FIG.3b.



LGE1006, FIG. 4.

2. Combination of EDC+Sommer

As noted in the previous section, Sommer teaches that non-uniform signal constellations with BICM can be used to obtain shaping gain. LGE1006, 1, 3, FIG. 3. Sommer was working in the field of non-uniform APSK and QAM constellations known for utilizing error correction coding (such as LPDC). LGE1006, 1. More specifically, in Sommer, “[a] non-uniform signal set constellation is used in order to provide shaping gain. An approximately Gaussian distribution of the transmitter output signal is achieved by using equally likely signal points with unequal spacing. In this way it is possible to obtain shaping gain without any additional computational effort.” LGE1006, 1. Sommer teaches that “for higher order modulation schemes using these [non-uniform] constellations, shaping gains in the order of 1 dB are possible.” LGE1006, 1, 3; LGE1003, ¶[0075].

It would have been obvious for a POSITA to combine the teachings of EDC with Sommer such that the EDC device would have incorporated 1) using equally likely signal points with unequal spacing in its non-uniform constellations and using more points at the lower power levels and less at higher, and 2) assigning the labeling and spacing of constellation points to achieve a desired shaping gain, as taught by Sommer. LGE1006, 1, 3, 5. The EDC device could utilize Sommer’s teachings by updating the tables of constellation points and code rates and further implementing grey labeling (a feature already disclosed in Erozt’s non-uniform constellations).

LGE1004, ¶[0058]. Such a combination would have simply involved combining prior art elements according to known methods to yield predictable results, and would have been well within the capabilities of a POSITA. For example, a POSITA seeking to improve channel performance, would have implemented the EDC combination and optimized the already non-uniform constellations of EDC, as taught by Sommer, to improve channel performance. LGE1003 ¶¶[0075-0076].

A POSITA would have been able to combine the teachings of EDC and Sommer without much difficulty and in a predictable manner because making such modifications would have merely involved implementing software code for assigning the labeling and spacing of constellation points to achieve a desired shaping gain. LGE1003, ¶[0076]. For example, Sommer discloses that shaping gains do “not entail any additional computational effort. Only the lookup tables for single transmission and metric calculation have to be replaced, so signal shaping with gain s up to about 1dB has been demonstrated without changing the coder/decoder structure.” LGE1006, 5. A POSITA would understand that the updating of these tables can be accomplished through software updates, which, as noted above, Ulrich reveals “is rather simply done” by manufacturers. LGE1008, 257, 299. For example, a POSITA could have created a table similar to those disclosed in DVB-T and utilized for the TPS methodology, then implement this software into the EDC combination, thus creating a device capable of using Gray

labeling (also used in Erozt) to maximize capacity. LGE1004, ¶[0058]; LGE1003, ¶[0076-0077].

In addition, 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, [0077]. For example, EDC's communication system (with a transmitter and a receiver) would still perform in the same or similar manner but using the constellations shaped and labeled according to Sommer's method. *Id.*

In addition to the above, Dr. Hochwald explains that AWGN was commonly used to simulate background noise of a channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self-interference that modern radio systems encounter in terrestrial operation. LGE1003, ¶[0078]. Thus, applying Sommer's teachings (related to non-uniform QAMs in AWGN channels) in EDC would have also allowed a system designer to estimate or determine the background channel noise and interferences in terrestrial operations of the EDC system. LGE1003, ¶[0078].

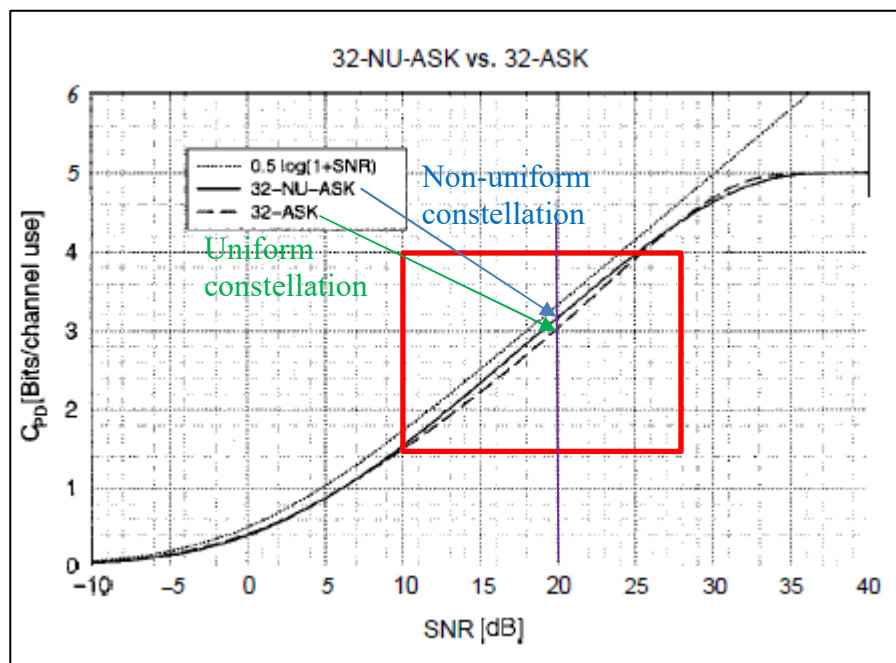
Although Sommer is focused on turbo codes, Dr. Hochwald explains that the teachings of Sommer incorporated into EDC would have also been beneficial for the LDPC encoded data in EDC. LGE1003, ¶[0079]. For instance, a POSITA would have known that the benefits of shaping gains and greater parallel decoding capacity

of non-uniform constellations would have also been achieved in EDC's LDPC coded data system by using equally likely signal points with unequal spacing and more points at the lower power levels and less at higher. LGE1003, ¶[0079]. Accordingly, it would have been obvious for a POSITA to implement Sommer's teachings in EDC's system. LGE1003, ¶[0079].

**3. Manner in which the EDC+Sommer renders the
Claims 4, 14, and 24 obvious**

[4]

Sommer teaches that the parallel decoding capacity of a non-uniform constellation is greater than a similar uniform constellation at the same SNR. For example, Sommer compares the performance of “non-uniform signal set constellation[s]” (e.g., NU-QAM or NU-ASK) with uniform constellations (e.g., classical QAM and ASK), using BICM or parallel decoding (PD) capacity. *See* LGE1006, 3 (“we use the term PD for BICM”). FIG. 3(b) shows the PD capacity for 32-NU-ASK versus 32-ASK constellations. LGE1006, 2-4; LGE1003 ¶[0169].



LGE1006, FIG.3b

As shown above in FIG. 3B, the parallel decoding capacity of the non-uniform constellation (32-ASK / 1024-QAM) is greater than the parallel decoding capacity of a similar uniform constellation at the same SNR. For example, at a SNR of 20 dB, the non-uniform constellation has a greater parallel decoding capacity than the uniform constellation. Relatedly, Sommer's Table 3 also explains that the required SNR for non-uniform constellations is almost 0.5-1 dB less than the required SNR for uniform constellations, confirming that non-uniform constellations can provide better SNR and parallel decoding capacity performance compared to their uniform constellation counterparts. LGE1003, ¶[0170].

SNR (dB)	$C_{SS}(\text{NU-ASK})$	$C_{SS}(\text{ASK})$
16-ASK (256-QAM)	11.94	12.53
32-ASK (1024-QAM)	15.05	15.87
64-ASK (4096-QAM)	18.10	19.10
	$C_{PD}(\text{NU-ASK})$	$C_{PD}(\text{ASK})$
16-ASK (256-QAM)	12.75	13.25
32-ASK (1024-QAM)	15.96	16.77

Table 3. Capacity at $R = 0.5$

LGE1006, FIG. 4.

In view of the foregoing, it would have been obvious to a POSITA that in the EDC-Sommer system in which constellations can be further optimized for shaping gains consistent with Sommer's teachings, *"each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than a similar multidimensional symbol constellation at the same SNR, where the similar multidimensional symbol constellation differs only in that the constellation points in the similar multidimensional symbol constellation are uniformly spaced in each degree of freedom."* LGE1003, ¶[0171].

[14]

See supra [4]; LGE1003 ¶[0172].

[24]

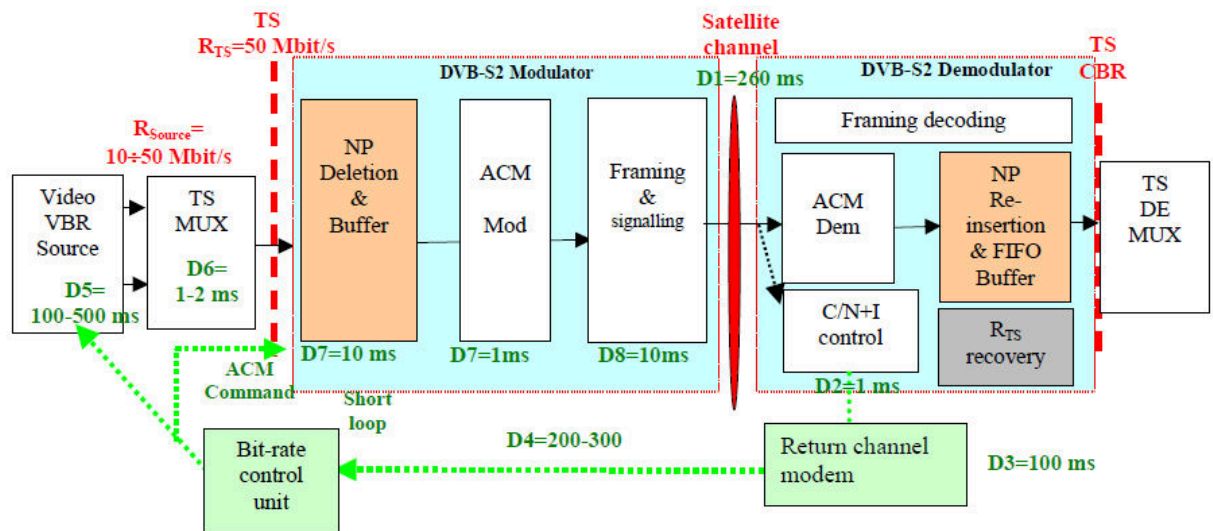
See supra [4]; LGE1003 ¶[0173].

D. Ground 3A: EDC and DVB-S2 render claims 7, 17, and 27 obvious

1. Overview of DVB-S2

DVB-S2 is a standard document entitled “Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications.” LGE1009, 1. DVB-S2 is in the same family of standards and produced by the same committee as the DVB-T standard of the EDC combination (*see Supra IV A.3*). LGE1005, 1, LGE1008, 1. DVB-S2 teaches a method of transmitting digital television signals using variable coding and modulation, adaptive coding modulation, Forward Error Correction (FEC), and Low-Density Parity Checks (LDPC) codes. For example, DVB-S2 describes the use of Quadrature Amplitude Modulation (QAM), and spectrum shapes for non-uniform constellations, along with a wide range of code rates. LGE1009, 6, 9; LGE1003 ¶[0091].

DVB-S2 employs *Variable Coding Rate* (VCM), which “may be combined *with the use of return channels*, to achieve *Adaptive Coding and Modulation* (ACM).” *Id.*, 6. An example of ACM is provided in DVB-S2’s Figure H.6 (reproduced below), which depicts a DVB-S2 communication system including a receiver that receives a signal from a transmitter over a channel. The receiver can transmit information regarding the channel conditions including (C/N+I), via a return channel, back to the transmitter. LGE1009, 6, 66-69; LGE1003 ¶[0092].



LGE1009, 67

ACM utilizes receivers to provide feedback on signal quality. *Id.*, 6. “This technique provides more exact channel protection and dynamic link adaptation to propagation conditions, targeting each individual receiving terminal. ACM systems promise satellite capacity gains of up to 100 %-200 %. In addition, service

availability may be extended compared to a constant protection system (CCM) such as DVB-S or DVB-DSNG. Such *gains are achieved by informing the satellite up-link station of the channel condition* (e.g. C/N+I) of each receiving terminal *via* the satellite *or terrestrial return channels.*” *Id.*, 6; LGE1003 ¶[0093].

2. Combination of EDC+DVB-S2

As noted above, DVB-S2 and DVB-T belong to the same family of ETSI DVB standards. LGE1009, 1-5; LGE1005, 1-5. DVB-S2 is directed to satellite communications whereas DVB-T is directed to terrestrial communications. LGE1009, 1; LGE1005, 1. Ulrich, a book by one of the chairpersons of the DVB standard, explains that DVB-T receivers were used in various devices and would “often have to be ‘world receivers’” when used in certain types of devices such as handheld devices, PDAs, and car receivers. LGE1008, 257-258, v-x (“I have the pleasure of being chairman of the Technical Module of the DVB Project”). “World receivers” refers to receivers that “allow[] reception in all possible environments (frequency range, channel arrangement, bandwidth)” and “features other reception standards, like analogue TV, ATSC or ISDB-T.” LGE1008, 258. Indeed, a technology referred to as Network Interface Module (NIM) technology was developed to receive all types of DVB signals including DVB satellite and DVB terrestrial signals. LGE1008, 267. Ulrich explains that some of advantages of NIM were that “[i]t has all the technology and the related know-how ‘on board’, in one

module,” and “exactly the same receiver [can be used] for all DVB systems.” LGE1008, 267-268; LGE1003, ¶[0094].

As can be appreciated from the foregoing, it would have been obvious for a POSITA to combine and implement the DVB-T and DVB-S2 standards in a single device, such as Erož’s receiver, so that Erož’s receiver could operate as a “world receiver” and be configured to receive communications over terrestrial and satellite communication networks. LGE1003, ¶[0094]. Indeed, not only would this have been obvious, but, as evidenced by Ulrich, it was already being practiced. LGE1003, ¶¶[0094-0095].

Combining the teachings of EDC and DVB-S2 would have merely involved combining prior art elements according to known methods to yield predictable results. LGE1003, ¶[0097]. Here, the predictable and foreseeable result would have been that Erož’s receiver would operate as a world receiver capable of communicating using both the DVB-T and DVB-S2 standards, which were well-known communication standards. LGE1003, ¶[0096]; LGE1008, 258. Such a world receiver would have incorporated the teachings of EDC and DVB-S2 such that EDC’s system would have implemented various, if not all, the features of the DVB-S2 standard, such as the return channel that provides feedback communication from the receiver to the transmitter. LGE1003, ¶¶[0096-0097].

In addition to the reasons noted above, incorporating the return channel

feature would have been beneficial because the channel feedback information would have provided the transmitter with configuration information, such as modulations, code rates, constellations, constellation ratios (α), and related details as described in DVB-S2, to configure LDPC-encoded DVB data from a transmitter to a receiver over a communication channel. LGE1003, ¶[0094]. By configuring the transmission based on information related to the quality of the communication channel, communication performance between the transmitter and receiver would have improved, for example, by reducing data loss, increasing data throughput, increasing capacity gains, and using code rate and constellations that are more suitable for the existing channel conditions. LGE1003, ¶[0094-0095].

A POSITA would have been able to implement combine EDC and DVB-S2 without much difficulty and in a predictable manner because such technology was already being implemented (e.g., the NIM technology described above) and similar products were already in the market (*see e.g.*, NIM chip from Phillips shown below in FIG. 11.14). LGE1008, 268; LGE1003, ¶[0096-0097].

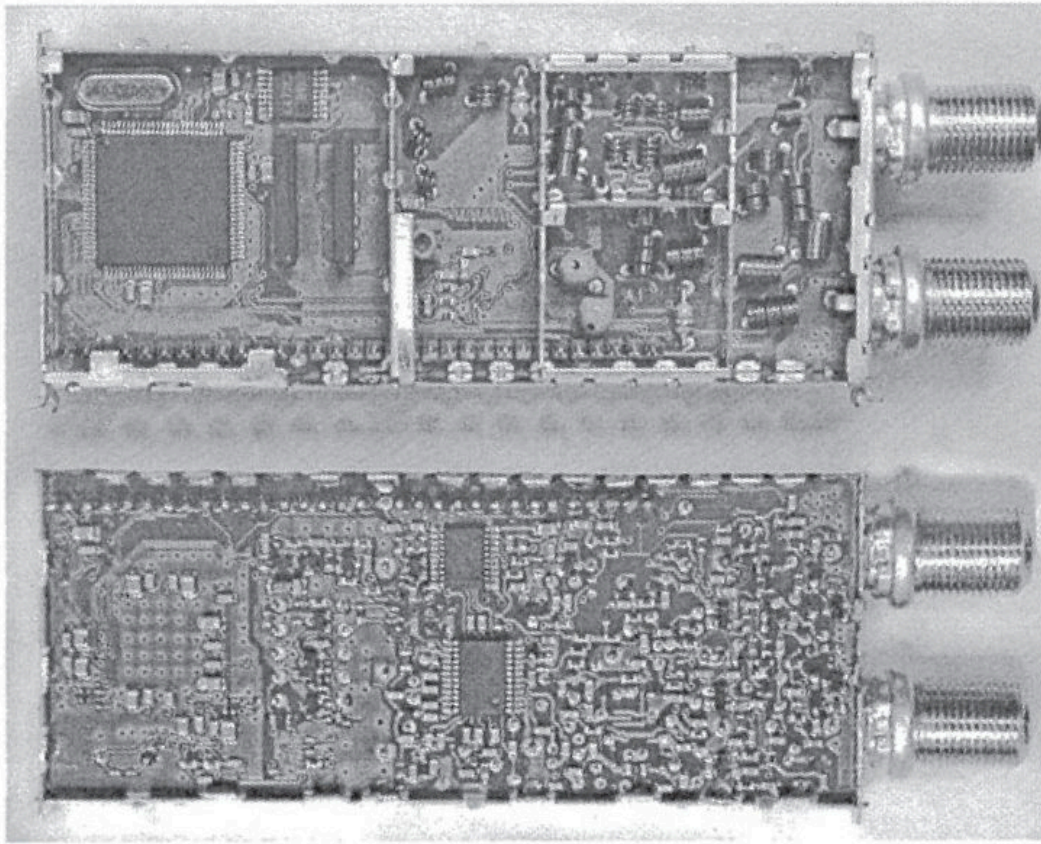


Fig. 11.14 Network Interface Module (NIM) from Philips ⁴ (top and bottom view)

LGE1008, 268.

**3. Manner in which the EDC+DVB-S2 renders the
Claims 7, 17, and 27 obvious**

[7a]

DVB-T explains that data received by the receiver includes scattered pilot cells, continual pilot carriers, TPS carriers, and that these pilots can be used for various purposes, including, channel estimation. LGE1005, 24. Similarly, DVB-S2 states that when utilizing “ACM modes, the *receiver shall signal the reception*

quality via an available return channel...” LGE1009, 52. A POSITA would have understood that channel estimation is one method of *measuring the quality of the communication channel*. LGE1003, ¶[0174]. This understanding is corroborated by Ulrich, a textbook on Digital Video Broadcasting, which explains that “the receiver will be able to perform a nearly continuous analysis of the frequency and the temporal plane, which can be used for the evaluation of the current channel condition (‘channel estimation’)” using pilots. LGE1003, ¶[0174]; LGE1008, 253, 255-256, 265. For example, Ulrich explains that various estimation techniques can be used to measure “the channel frequency response for attenuation and phase ... on the basis of the continual pilots and on the scattered pilots.” *Id.*; LGE1003, ¶[0174].

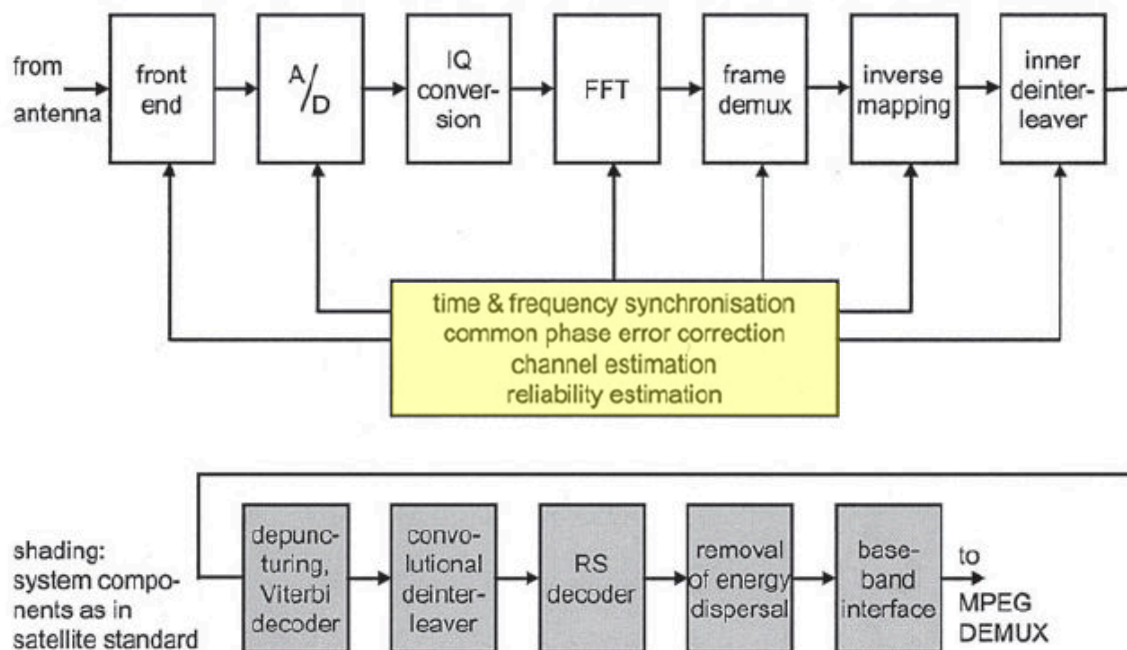
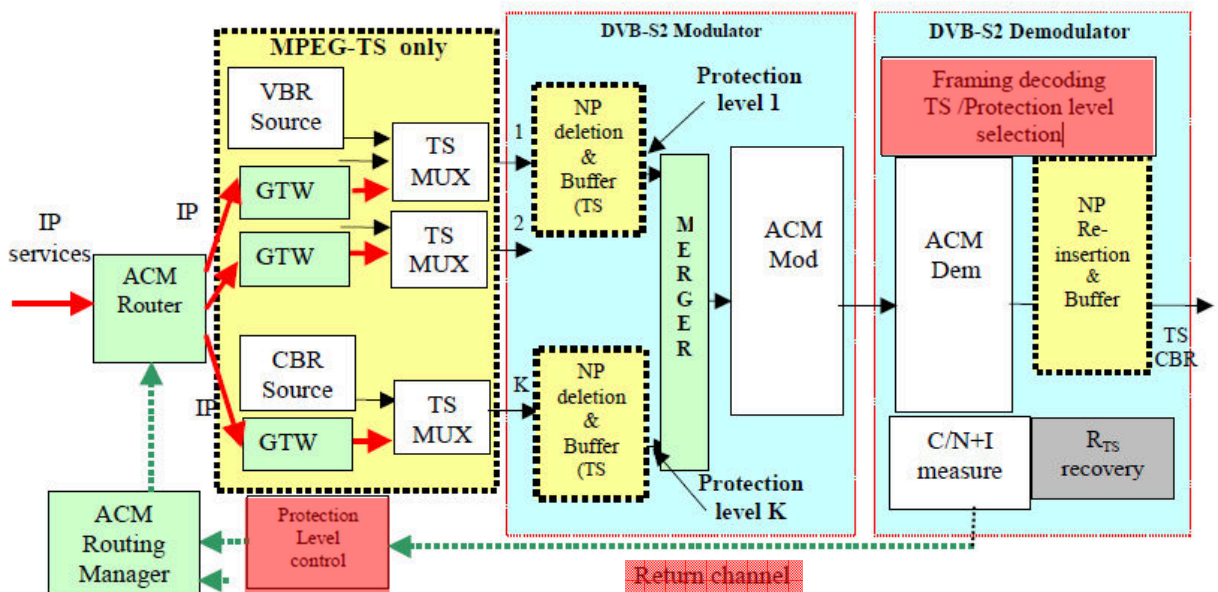


Fig. 11.6. Block diagram of signal processing at the receiving end

LGE1008, 255.

[7b]

DVB-T explain that TPS signaling information is used by the receiver to configure itself to receive data from the transmitter. LGE1008, 254, LGE1005, 29-31. For instance, the receiver uses bits $s_{25}-s_{32}$ to select a modulation type, α value, and code rate. LGE1005, 29-32. As noted above in [7a], the receiver also performs channel estimation to determine channel frequency response for attenuation and phase. LGE1008, 253, 255-256, 265. DVB-S2 teaches the use of Variable Coding Rate (VCM) and a return channel (as shown in DVB-S2's Figure H.8 below) to create Adaptive Coding and Modulation (ACM). *Id.*, 6. The ACM method utilizes the received signal quality to affect the coding and modulation scheme of the channel. *Id.*, 69; LGE1003, ¶[0175].



LGE1009, 69 (Figure H.8).

“In ACM modes, the receiver shall signal the reception quality via an available return channel.” LGE1009, 52. “The receiver shall evaluate quality-of-reception parameters, in particular carrier to noise plus interference ratio in dB available at the receiver.” LGE1009, 53. “CNI and other optional reception quality parameters (such as for example the BER on the channel”) can be evaluated. *Id.* The receiver then selects MODCOD information and sends the MODCOD information (in a request message MODCOD_RQ) along with the CNI through an ACM command to a transmitter (gateway). LGE1009, 53, 48. The MODCOD information includes 5 bits set according to Table 12 (reproduced below) that “identify[] code rates in the set $\eta_C = [1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9, 9/10]$ and modulations in the set of spectrum efficiencies $\eta_{MOD} = [2, 3, 4, 5]$.” *Id.*, 29; LGE1003, ¶[0176].

Table 12: MODCOD coding

Mode	MOD COD	Mode	MOD COD	Mode	MOD COD	Mode	MOD COD
QPSK 1/4	1 _D	QPSK 5/6	9 _D	8PSK 9/10	17 _D	32APSK 4/5	25 _D
QPSK 1/3	2 _D	QPSK 8/9	10 _D	16APSK 2/3	18 _D	32APSK 5/6	26 _D
QPSK 2/5	3 _D	QPSK 9/10	11 _D	16APSK 3/4	19 _D	32APSK 8/9	27 _D
QPSK 1/2	4 _D	8PSK 3/5	12 _D	16APSK 4/5	20 _D	32APSK 9/10	28 _D
QPSK 3/5	5 _D	8PSK 2/3	13 _D	16APSK 5/6	21 _D	Reserved	29 _D
QPSK 2/3	6 _D	8PSK 3/4	14 _D	16APSK 8/9	22 _D	Reserved	30 _D
QPSK 3/4	7 _D	8PSK 5/6	15 _D	16APSK 9/10	23 _D	Reserved	31 _D
QPSK 4/5	8 _D	8PSK 8/9	16 _D	32APSK 3/4	24 _D	DUMMY PLFRAME	0 _D

LGE1009, 29.

It would have been obvious to a POSITA that to signal MODCOD

information to the transmitter, the receiver would have to select a constellation and code rate pair first. In the EDC-DVB-S2 combination, it would have been obvious to a POSITA that *the receiver is capable of selecting* parameters, such as *the constellation and LDPC code rate pair based on* the signaling information and channel estimation (“*at least in part on a quality measurement*”). As explained above in §§IV.A.4.[1c] and §§IV.A.4.[1f] (and §§IV.B.3.[1f]), *the selection* of the constellation and LDPC code rate pair in the EDC system would have been made *from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs*. LGE1005, 29-32, 40; LGE1003, ¶¶[0177]-[0178].

[7c]

DVB-S2 teaches that “the receiver shall signal the reception quality via an available return channel, according to the various DVB interactive systems.” LGE1009, 52. As explained above, DVB-S2 teaches that “[t]he receiver shall evaluate quality-of-reception parameters, in particular carrier to noise plus interference ratio in dB available at the receiver, indicated as CNI,” and that MODCOD and other parameter information would be sent to a transmitter (gateway device). LGE1009, 53; *see supra* [7b]. “As a minimum, the CNI and MODCOD_RQ parameters shall be sent to the satellite network operator Gateway every time the protection on the DVB-S2 channel has to be changed. When no modification of the protection level *is requested*, the optional message from the

terminal to the Gateway shall indicate MODCOD_RQ = actual MODCOD and pilot configuration of the frames received by the terminal.” *Id.*; *see also* LGE1009, 67, 69. “[T]he gateway may acknowledge the reception of the message and the execution of the command by a message containing the new adopted MODCOD, coded according to table 12” (reproduced below). LGE1009, 53; LGE1003, ¶[0179].

Accordingly, it would have been obvious to a POSITA that EDC-DVB-S2’s *receiver is capable of* determining the quality of the received signal, determining a level of protection required (modulation and code rate), and *sending a request* (MODCOD_RQ) *to a remote transmitter to use a selected LDP code rate and multidimensional constellation pair*. LGE1009, 48, 66-69; LGE1003, ¶[0180].

[17], [27]

See supra [7]; LGE1003, ¶¶[0181]-[0186].

E. Ground 4A: EDC and DVB-TS, render claims 9, 19, and 29 obvious

1. Overview of DVB-TS

DVB-TS is a technical specification in the family of DVB Standards. It “defines agreements on which to base interoperability for system software update services and receivers.” LGE1013, 5. DVB-TS “specifies a standard mechanism

for signalling a software update service and the means to carry the data for such a software update service.” *Id*, 7. Among its various features and teachings, DVB-TS:

- “defines the signalling information that can be used to locate the transport stream containing the system software update service”;
- “defines the options for transmitting the actual system software update service in either a proprietary data transfer format, or a standardized 2-layer DVB data carousel”; and
- “defines a recommended format for exchanging the system software update data from receiver manufacturer to the network (or multiplex) operator for subsequent transmission.” LGE1013, 5-6; LGE1003, ¶[0098].

2. Combination of EDC+DVB-TS

DVB-TS is part of a family of DVB standards that relate to digital video broadcasting. LGE1013, 1-5. DVB-TS describes how system software can be updated in services and receivers. *Id*, 7. As stated in DVB-TS: “[i]n order to guarantee the functionality of a receiver as well as increasing its functionality once deployed in the field a software update service is required.” *Id*, 7. It would have been obvious to a POSITA to incorporate the teachings of DVB-TS into EDC, which already contains one of the DVB standards, so that software updates are made to

communication network devices such as the receiver. LGE1003, ¶[0099].

Combining the teachings of EDC and DVB-TS would have merely involved combining prior art elements according to known methods to yield predictable and foreseeable results. LGE1003, ¶¶[0100-0101]. Here, combining the teachings of EDC and DVB-TS would have predictably allowed a device, such as EDC's receiver, to receive updates so that it continues to increase its functionality as necessary based on technological progress. LGE1003, ¶[0100]. For example, when a system is initially designed for a particular terrestrial network and environment and overtime the network technologies advance, it would have been obvious to update the receiver's software to adapt to the network and environmental changes. LGE1003, ¶¶[0099-0101].

3. Manner in which the EDC+DVB-TS renders the Claims 9, 19, and 29 obvious

[9]

DVB-TS discloses that “[r]eceiver software is increasingly complex. In order to guarantee the functionality of a receiver as well as increasing its functionality once deployed in the field a software update service is required. The present document specifies a standard mechanism for signalling a software update service and the means to carry the data for such a software update service.” LGE1013, 7; LGE1003, ¶[0187].

A POSITA would have understood that to keep the receiver software updated

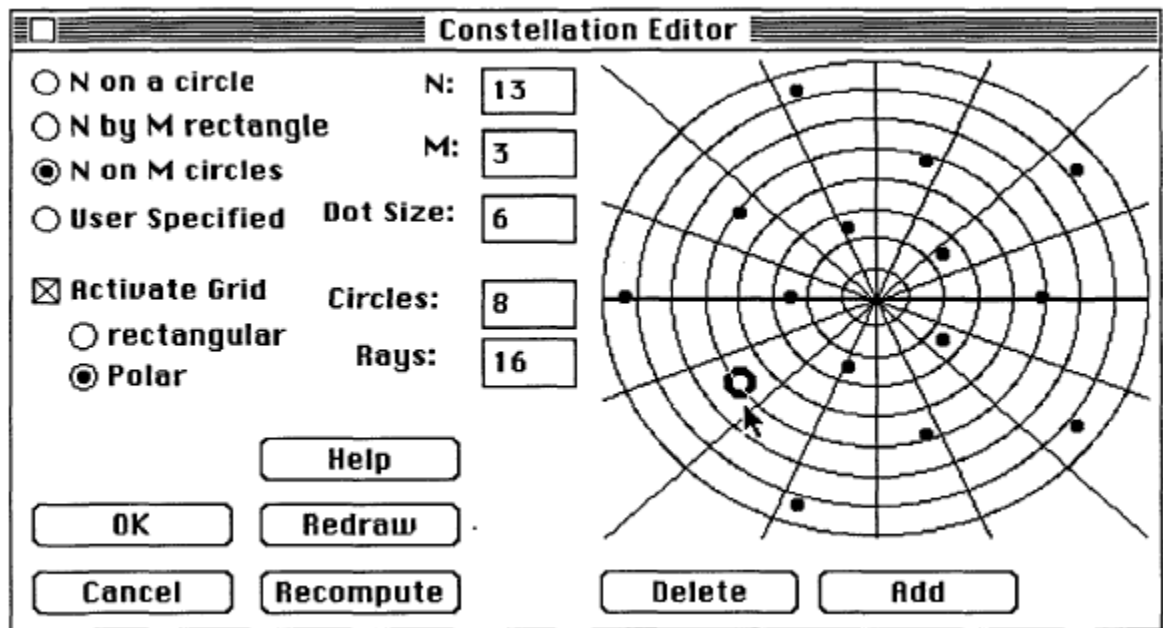
and continue to “increase[e] its functionality” (*see* LGE1013, 7), various aspects of the receiver software would have been continuously or periodically updated. LGE1003, ¶[0188]. A POSITA would have been understood that with the progression of technology over time, higher modulation rates, bit rates, code rates, and different constellation types would be introduced or used in the network to increase the receiver’s functionality and keep it updated. LGE1003, ¶[0188]. In addition, changes in network configuration, devices, and environment may also require different constellations to be used. LGE1003, ¶[0188]. Thus, a POSITA interested in increasing the functionality and use of the receiver in EDC’s communication system would have incorporated the teachings of DVB-TS to allow the receiver to update software over time to remain consistent with current technology and operating conditions. LGE1003, ¶[0188].

It would also have been obvious to a POSITA that a receiver’s software includes various programs and files including programs and files used to configure the constellations that the receiver is capable of receiving and processing. LGE1003, ¶[0189]. Accordingly, it would have been obvious to a POSITA that that an update to software in a receiver would have also included an update of the constellations used by the receiver. LGE1003, ¶[0189]. For example, as previously-used constellations (“*the plurality of multidimensional symbol constellations*”) become out of date or are no longer used, such constellations would have been substituted

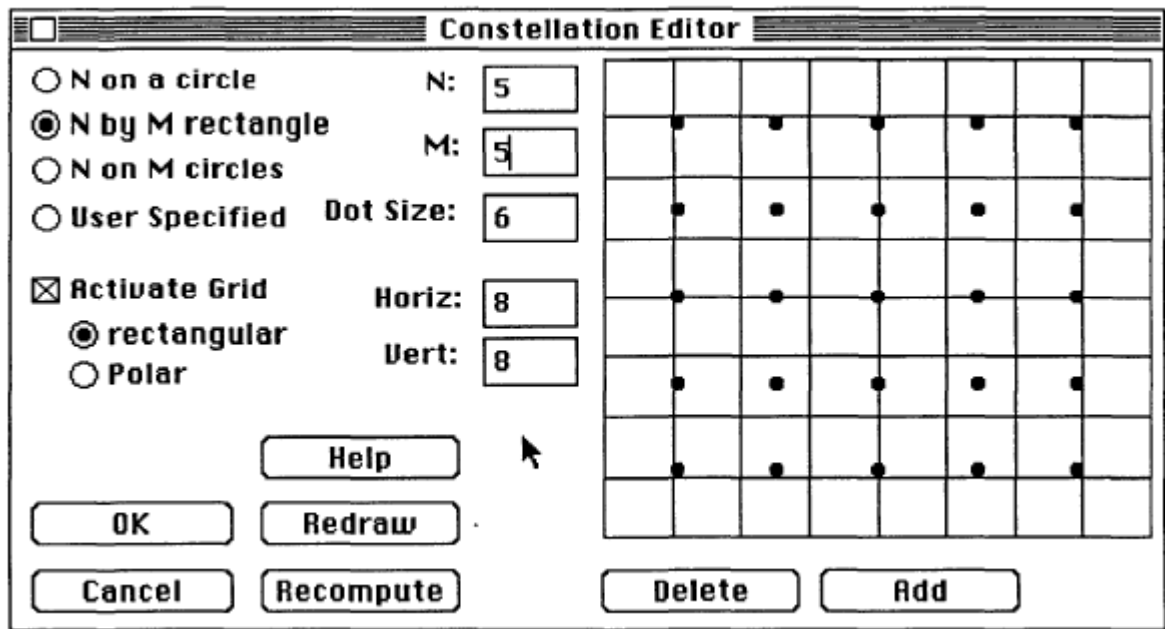
by other, newer, or more suitable constellations “*by an upgrade to at least one of the receiver software and firmware.*” LGE1003, ¶[0189].

Although it is well known that software can be used to configure and design constellations, to the extent such knowledge in the art is challenged as known by the Patent Owner, Robins, a published conference paper, explicitly discloses that constellations can be configured and designed through software. LGE1016, 1. Robins explains that “the actual code that simulates signal constellations is rather trivial.” LGE1016, 1; LGE1003, ¶[0190].

According to Robins, “[s]ignal constellation design is a major part of constructing an efficient communication system. This task essentially entail trading off error frequency against information throughput...” LGE1016, 1. In particular, Robins “signal constellation design tool” can be used to design constellations of various shapes and sizes. *Id.*, 5. Robins discloses “an interactive [software] tool for designing and simulating arbitrary signal constellations.” *Id.*, 1; LGE1003, ¶[0191]. Robins explains that constellations can be designed to address concerns about the “...effects of noise and other kind of interference on the system... .” *Id.*, 2. As noted above, Robins explains that “the actual code that simulates signal constellations is rather trivial.” *Id.*, 1. The figures represented below depict portions of Robins’ user interface used to design constellations. LGE1003, ¶[0191].



LGE1016, 5.



LGE1016, 6.

As shown by Robins' figures, software can be used to control the type of constellation, the number of points, and various other design aspects of

constellations. Robins discloses that constellation design changes are made by software. LGE1003, ¶[0192]. And because constellation design would have been an obvious part of a receiver's software, the combination of EDC and DVB-TS (and its teachings of software updates in receivers) would have rendered obvious *a receiver that is capable of substituting the plurality of multidimensional symbol constellations by an upgrade to at least one of the receiver software and firmware.* LGE1003, ¶[0192].

[19], [29]

See supra [9]; LGE1003, ¶¶[0193-0194]

F. Ground 2B-4B:

Grounds 2B-4B render claims [4], [7], [9], [14], [17], [19], [24], [27], and [29] obvious for the same reasons noted under Grounds 2A-4A. LGE1003, ¶[0192]. In particular, Grounds 2B-4B address dependent claims that depend from the independent claims that have been mapped to the prior art references under Grounds 1A and 1B. *Id.* Relative to Ground 1A, Ground 1B additionally addresses claims 6, 16, and 26, and also relies on DeGaudenzi to map to feature [1f], [11g], and [21c]. *Id.* And because the claims addressed under Grounds 2A-4B include claims depending from the independent claims challenged in Grounds 1A and 1B, Grounds 2B-4B are similar to Grounds 2A-4A but additionally include DeGaudenzi as part of the asserted combination. LGE1003, ¶[0195].

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.

An earlier version of DVB-S2 (version 1.1.1 issued in 2005) was cited in an IDS submitted on December 31, 2019. LGE1002, 103-106. The Examiner indicated that the filed IDS had been considered. LGE1002, 1089-1092. A review of the prosecution history reveals that not a single Office Action was issued. *See generally* LGE1002. Thus, during prosecution, the Examiner did not rely on DVB-S2 for any rejection, and furthermore 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* LGE1020 (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. LGE1019.

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.” LGE1018, 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 claims 1, 4, 6-11, 14, 16-21, 24, and 26-30 of 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. LGE1012; *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 '700 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 (LGE1020).

Petitioner is not aware of any disclaimers, reexamination certificates, or *inter partes* review petitions for the '700 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 IPR19688-0196IP1@fr.com (referencing No. 19688-0196IP1 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 13,957 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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