

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Maged F. Barsoum et al.
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Title: RECEIVERS INCORPORATING NON-UNIFORM
CONSTELLATIONS WITH OVERLAPPING CONSTELLATION
POINT LOCATIONS

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

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EXHIBITS

LGE1001	U.S. Patent No. 11,019,509
LGE1002	Prosecution History for U.S. Patent No. 11,019,509
LGE1003	Expert Declaration of Dr. Bertrand Hochwald
LGE1004	RESERVED
LGE1005	RESERVED
LGE1006	RESERVED
LGE1007	RESERVED
LGE1008	RESERVED
LGE1009	RESERVED
LGE1010	RESERVED
LGE1011	RESERVED
LGE1012	RESERVED
LGE1013	RESERVED
LGE1014	De Gaudenzi et al., <i>Turbo-coded APSK modulations design for satellite broadband communications</i> , Int. J. Satell. Commun. Network. 2006; 24:261–281, Published online 19 May 2006 in Wiley InterScience (“DeGaudenzi”)
LGE1015	U.S. Provisional application No. 60/933,319 (“’319 Provisional”)
LGE1016	RESERVED

LGE1017	RESERVED
LGE1018	RESERVED
LGE1019	RESERVED
LGE1020	First Declaration of June Munford
LGE1021	Stipulation by Petitioner, LGE, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1022	Complaint, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1023	Complaint Exhibit, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1024	RESERVED
LGE1025	Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (USPTO June 21, 2022) (“Interim Procedure”)
LGE1026	Docket Control Order, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1027	U.S. Patent No. 7,978,777 (“the ’777” or “the ’777”)
LGE1028	ATSC Recommended Practice: Guidelines for the Physical Layer Protocol, Document no. A/327:2018
LGE1029	ATSC 3.0 Standard: Physical Layer Protocol, Document no. A/322:2017
LGE1030	Nabil Sven Loghin, Jan Zöllner, Belkacem Mouhouche, Daniel Ansorregui, Jinwoo Kim, and Sung-Ik Park, <i>Non-Uniform Constellations for ATSC 3.0</i> , IEEE Transactions on Broadcasting, vol. 62, no. 1, March 2016 (“Loghin”)

LGE1031	Second Declaration of June Munford
LGE1032	Third Declaration of June Munford
LGE1033	Fourth Declaration of June Munford

LIST OF CLAIMS

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

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

[2c]	the receiver is capable of selecting an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs; and
[2d]	each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs.
Claim 3	
[3a]	The communication system of claim 2, wherein the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs includes: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $1/3$ and a sixty-four-point unequally spaced symbol constellation of the first type;
[3b]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $5/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the first type; and

[3c]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $7/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the first type.
Claim 4	
[4a]	The communication system of claim 3, wherein the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is:
[4b]	equal to or less than 5.27 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate that is below $1/3$ and a sixty-four-point unequally spaced symbol constellation of the first type;
[4c]	equal to or less than 15.42 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below $5/8$ and a two-hundred-fifty-six-point unequally spaced symbol constellation of the first type; and

[4d]	equal to or less than 21.52 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 7/10 and a one-thousand-twenty-four-point unequally spaced symbol constellations of the first type.
Claim 5	
[5a]	The communication system of claim 4, wherein: the plurality of unequally spaced symbol constellations include a plurality of unequally spaced symbol constellations of a second type that comprises multiple different sixteen-point symbol constellations, multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations;
[5b]	no two constellation points within an unequally spaced symbol constellation of the second type share locations that are the same;
[5c]	the demapper is also capable of determining likelihoods using the demodulated signal and an unequally spaced symbol constellation of the second type; and

[5d]	the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs include: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[5e]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[5f]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and
[5g]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $8/10$ and less than or equal to $9/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type;

[5h]	the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is: between 3.11 dB and 9.25 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[5i]	between 9.00 dB and 15.93 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[5j]	between 18.72 dB and 22.13 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and

[5k]	between 24.79 dB and 28.20 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 8/10 and less than or equal to 9/10 and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type.
Claim 6	
[6a]	The communication system of claim 1, wherein: the non uniform symbol constellation is selected from a plurality of unequally spaced symbol constellations; and
[6b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that each of the plurality of unequally spaced symbol constellations is capable of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR.

Claim 7	
[7]	The communication system of claim 6, wherein the symbol constellation operating SNR is a channel SNR where the receiver is capable of using the respective unequally spaced symbol constellation to receive data at a frame error rate (FER) of 10^{-2} or lower.
Claim 11	
[11pre]	A communication system, comprising:
[11a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver comprises:
[11b]	a demodulator that demodulates a received signal into a demodulated signal;
[11c-1]	a demapper that determines likelihoods using the demodulated signal and a symbol constellation that includes constellation points at a plurality of unique point locations, where:
[11c-2]	the plurality of unique point locations are unequally spaced;
[11c-3]	the constellation points each have a location and a different label; and

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

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

Claim 13	
[13a]	The communication system of claim 12, wherein the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs includes: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $1/3$ and a sixty-four-point unequally spaced symbol constellation of the first type;
[13b]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $5/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the first type; and
[13c]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $7/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the first type.

Claim 14

[14a]	The communication system of claim 13, wherein the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is: equal to or less than 5.27 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate that is below 1/3 and a sixty-four-point unequally spaced symbol constellation of the first type;
[14b]	equal to or less than 15.42 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 5/8 and a two-hundred-fifty-six-point unequally spaced symbol constellation of the first type; and
[14c]	equal to or less than 21.52 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 7/10 and a one-thousand-twenty-four-point unequally spaced symbol constellations of the first type.

Claim 15

[15a]	The communication system of claim 14, wherein: the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a second type that comprises multiple different sixteen-point symbol constellations, multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations;
[15b]	no two constellation points within an unequally spaced symbol constellation of the second type have locations that are the same;
[15c]	the demapper also determines likelihoods using the demodulated signal and an unequally spaced symbol constellation of the second type; and

[15d]	the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs includes: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[15e]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[15f]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and
[15g]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $8/10$ and less than or equal to $9/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type;

[15h]	the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is: between 3.11 dB and 9.25 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[15i]	between 9.00 dB and 15.93 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[15j]	between 18.72 dB and 22.13 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and

[15k]	between 24.79 dB and 28.20 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 8/10 and less than or equal to 9/10 and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type.
Claim 16	
[16a]	The communication system of claim 11, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations; and
[16b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that each of the plurality of unequally spaced symbol constellations provides greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR.

Claim 17	
[17]	The communication system of claim 16, wherein the symbol constellation operating SNR is a channel SNR where the receiver uses the respective unequally spaced symbol constellation to receive data at a frame error rate (FER) of 10^{-2} or lower.
Claim 21	
[21pre]	A communication system, comprising
[21a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR),
[21b]	wherein the receiver uses a symbol constellation to transform the received signals into received bits, and the symbol constellation includes constellation points at a plurality of unique point locations, where:
[21c-1]	the plurality of unique point locations are unequally spaced;
[21c-2]	the constellation points each have a location and a different label; and
[21c-3]	the locations of at least two of the constellation points are the same.

Claim 23	
[23a]	The communication system of claim 21, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations;
[23b]	the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a first type that comprise multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations, where unequally spaced symbol constellations of the first type include at least two constellation points having identical locations and different labels;
[23c]	the receiver selects an LDPC code rate and the unequally spaced symbol constellation as a pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs; and
[23d]	each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs.

Claim 24	
[24a]	The communication system of claim 23, wherein the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs includes: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $1/3$ and a sixty-four-point non-uniform symbol constellation of the first type;
[24b]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $5/8$ and a two-hundred-and-fifty-six-point non-uniform symbol constellation of the first type; and
[24c]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate below $7/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the first type.

Claim 25	
[25a]	The communication system of claim 24, wherein the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is: equal to or less than 5.27 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate that is below 1/3 and a sixty-four-point unequally spaced symbol constellation of the first type;
[25b]	equal to or less than 15.42 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 5/8 and a two-hundred-fifty-six-point unequally spaced symbol constellation of the first type; and
[25c]	equal to or less than 21.52 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 7/10 and a one-thousand-twenty-four-point unequally spaced symbol constellations of the first type.

Claim 26

[26a]	The communication system of claim 25, wherein: the plurality of unequally spaced symbol constellations includes a plurality of unequally spaced symbol constellations of a second type that comprises multiple different sixteen-point symbol constellations, multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations;
[26b]	no two constellation points within an unequally spaced symbol constellation of the second type have locations that are the same;
[26c]	the receiver also transforms received signals into received bits using an unequally spaced symbol constellation of the second type; and

[26d]	the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs include: multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[26e]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[26f]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and
[26g]	multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $8/10$ and less than or equal to $9/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type;

[26h]	the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is: between 3.11 dB and 9.25 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type;
[26i]	between 9.00 dB and 15.93 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type;
[26j]	between 18.72 dB and 22.13 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type; and

[26k]	between 24.79 dB and 28.20 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 8/10 and less than or equal to 9/10 and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type.
Claim 27	
[27a]	The communication system of claim 22, wherein: the symbol constellation is selected from a plurality of unequally spaced symbol constellations; and
[27b]	each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that each of the plurality of unequally spaced symbol constellations provides greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR.

Claim 28

[28]	The communication system of claim 27, wherein the symbol constellation operating SNR is a channel SNR where the receiver uses the respective unequally spaced symbol constellation to receive data at a frame error rate (FER) of 10^{-2} or lower.
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LG Electronics, Inc. (“**Petitioner**” or “**LGE**”) petitions for *Inter Partes* Review (“**IPR**”) of claims 3-7, 13-17, and 24-28 (“**the Challenged Claims**”) of U.S. Patent 11,019,509 (“**the ’509 Patent**”). As explained below, the Challenged Claims are unpatentable.

I. REQUIREMENTS FOR IPR

A. Standing

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

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the grounds¹ identified in the table below. Accompanying explanations and support are provided in Dr. Hochwald’s Declaration (LGE1003). LGE1003, ¶¶[1]-[239].

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

Ground	Claims	35 U.S.C. § 103 Ground
1	3-7, 13-17, 24-28	§103 – '777 patent in view of ATSC327 (“ATSC327” or LGE1028)

The '509 Patent was filed on Dec. 27, 2019 and claims priority from U.S. Provisional Application No. 60/933,319 (“**319 Provisional**” or LGE1015), which was filed on June 5, 2007. However, as explained in Section II(A) below, claims 3-7, 13-17, and 24-28 are not entitled to the June 5, 2007 priority date. Instead, claims 3-7, 13-17, and 24-28 should be awarded a priority date of no earlier than the filing date of the '509 patent - December 27, 2019. Each of the references relied upon in this Petition are prior art when claims 3-7, 13-17, and 24-28 are awarded the December 27, 2019 priority date.

The declarations of June Munford (LGE1020) provide information regarding the public availability of the non-patent literature references listed in the table.

Reference	Publication Date	Section
U.S. Patent 7,978,777 ('777 patent or LGE1027)	July 12, 2011	102(a)(1)
ATSC Recommended Practice: Guidelines for the Physical Layer Protocol, Document no. A/327:2018Standard” or LGE1028)	March 26, 2019	102(a)(1)

II. THE CHALLENGED CLAIMS ARE NOT ENTITLED TO JUNE 5, 2007 PRIORITY DATE

Legal Standard for Priority

In evaluating whether a disclosure provides a sufficient written description, the Federal Circuit has held that “one cannot disclose a forest in the original application, and then later pick a tree out of the forest and say here is my invention. In order to satisfy the written description requirement, **the blaze marks directing the skilled artisan to that tree must be in the originally filed disclosure.**”

Purdue Pharma, 230 F.3d at 1326-1327 (emphasis added); *see also Indivior UK Limited v. Dr. Reddy’s Laboratories S.A.*, 18 F.4th 1323, 1328-29 (2021)

The Challenged Claims were not “original claims” of any priority application, and the claimed subject matter was not included in the ’319 provisional or the ’777 (collectively referred to herein as the “Barsoum Patents”). LGE1015; LGE1027.

1. The Barsoum Patents Do Not Contain Written Description Support For the Claimed Code Rate Ranges of Claims 3-5, 13-15, and 24-26

The Barsoum Patents lack written description support for the limitations of claims 3-5, 13-15, and 24-26, which are directed towards respective constellation pairs having an LDPC code rate within a specific range of LDPC code rates.

Claims 3-4, 13-14, and 24-25 are directed towards unequally spaced constellation and LDPC code rate pairs, wherein:

- an unequally spaced constellation having an *LDPC code rate that is below 1/3*;
- an unequally spaced constellation having an *LDPC code rate that is below 5/8*; and
- an unequally spaced constellation having an *LDPC code rate below 7/10*.

Claims 5, 15, and 26 further claim multiple a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs, wherein:

- *multiple* LDPC code rates and unequally spaced symbol constellation pairs that each include an LDPC code rate is *equal to or greater than 3/8 and less than or equal to 6/8*;
- *multiple* LDPC code rates and unequally spaced symbol constellation pairs that each include an LDPC code rate is *equal to or greater than 3/6 and less than or equal to 5/6*;
- *multiple* LDPC code rates and unequally spaced symbol constellation pairs that each include an LDPC code rate is *equal to or greater than 6/8 and less than or equal to 7/8*;
- *multiple* LDPC code rates and unequally spaced symbol constellation pairs that each include an LDPC code rate is *equal to or greater than 8/10 and less than or equal to 9/10*;

- an SNR of the communication channel is between 3.11dB and 9.25dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is *equal to or greater than 3/8 and less than or equal to 6/8*;
- an SNR of the communication channel is between 9.00 dB and 15.93 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is *equal to or greater than 3/6 and less than or equal to 5/6*;
- an SNR of the communication channel is between 18.72 dB and 22.13 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is *equal to or greater than 6/8 and less than or equal to 7/8*;
- an SNR of the communication channel is between 24.79 dB and 28.20 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is *equal to or greater than 8/10 and less than or equal to 9/10*. LGE1003,[65].

The Barsoum Patents do not have sufficient written description to show that

the Patent Owner had possession of the Challenged Claims as of the priority dates of the Barsoum Patents. LGE1003,[66]-[68].

**2. The Text of the Barsoum Patents Do Not Contain Any
Blaze Marks Directing a POSITA to the Claimed
Code Rate Ranges**

There is nothing in the Barsoum Patents that demonstrates that the claimed *code rate ranges* and constellations were part of their invention. LGE1015, 1-6; LGE1027; LGE1003. To contrary, the '319 provisional explains that there is “link margin to be gained by tailoring the design of a constellation *for a specific code rate.*” LGE1015, 2 (emphasis added). LGE1003,[69].

To achieve the link margin gain, the '319 provisional seeks to parameterize constellation design based on a *target code rate*. *Id.* Indeed, the '319 provisional explains that “optimal design of a constellation depends on the *target code rate* to be used with it.” LGE1015, 2. To this end, the '319 provisional found that “[t]he number of user bits per dimension, η , is related to code rate, R , and the total number of real signaling dimensions, N_{dim} ,” using the following equation:

$$\eta = \frac{R(\log_2(M))}{N_{dim}},$$

wherein M is, as best understood by Petitioner, the number of constellation points. LGE1015, 2. Thus, though '319 provisional suggests optimizing the design of a constellation based on a *target code rate*, there is nothing in the '319 provisional

that suggests, or otherwise identifies, the code rate ranges of the challenged claims. LGE1003, [70].

Determination of a *code rate range* requires determination of one or more particular features of the *code rate range* depending upon the claimed range. For example, determination of the *code rate ranges* of claims 3 and 4 requires determination of a *maximum code rate* as an upper bound to the *code rate range* and determining whether the *maximum code rate* is included in the code rate range (or not). However, none of these aspects of the code rate ranges of 3-4 are found in the '319 provisional. LGE1015, 1-6; LGE1003, [71].

Petitioner further submits that mere disclosure of a single code rate (or an equation for calculating said single code rate) such as, e.g., $1/2$ on pg. 5 of the '319 application is not sufficient disclosure to claim a *code rate range* such as an “LDPC code rate below $5/8$ ” or “an LDPC code rate below $7/10$ ” in claims 3 and 4 that encompasses the single disclosed code rate. LGE1015, 1-6; LGE1002, 14:13-27; LGE1003, [72]. Instead, these *code rate ranges* of claims 3 and 4 are not supported by the '319 provisional. LGE1015, 1-6; LGE1003, [72].

For example, determination of the *code rate ranges* of claim 5 requires determination of a *minimum code rate* as a lower bound to the code rate range (e.g., $3/8$ in claim 5), determination of a *maximum code rate* as an upper bound to the code rate range (e.g., $6/8$ in claim 5), and determination, e.g., as to whether

minimum code rate, maximum code rate, or both, are included in the code rate range (e.g., $3/8$ is included in the range of claim 5, as the language recites equal to or greater than). *Id.* Moreover, multiple limitations of claim 5 also require a similarly unsupported determination of an SNR communication channel that is between a particular dB range that is paired with a ***code rate range***. LGE1015, 1-6; LGE1002, 15:20-50; LGE1003, [73]. However, nothing in the '319 provisional supports any of these claim features. LGE1015, 1-6.

The '777 also does not have written description support for the claimed ***code rate ranges***. The '777 describes “[p]rocesses for selecting capacity optimized constellations to achieve increased coding gains based upon a ***specific coding rate***...” and that these processes are “for use in a communication system having a ***fixed code rate*** and modulation scheme.” LGE1027, 5:4-7, 9:3-8. In line with this objective, the '777 provides constellation design tables shown in FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b with each column of each design table corresponding to a constellation optimized with a ***specific coding rate*** calculated using the above equation from the '319 provisional. LGE1027, 3:61-4:21, 10:25-11:13, FIGS. 10a-17b; LGE1003, ¶[74].

For example, FIGs. 11a and 11b of the '777 show design tables of parallel decoding (PD) Capacity and joint capacity optimized PAM-4 constellations, with each column of the design table corresponding to a particular single dimensional

PAM-4 constellation optimized for a *specific code rate*. LGE1003, ¶[75] (explaining that each column in the table is a different constellation). The *specific code rate* for each single dimensional PAM-4 constellation of FIGs. 11a and 11b and determined using the equation of '319 provisional identified above is $R = 1/4$ for the first column / constellation, $R = 3/8$ for the second column / constellation, $R = 1/2$ for the third column / constellation, $R = 5/8$ for the fourth column / constellation, and $R = 3/4$ for the fifth column / constellation. LGE1027, 10:35-55, FIGs. 10a-11b; LGE1003, ¶[75]. Thus, the constellation design tables of FIGs. 11a and 11b describe a plurality of single dimensional PAM-4 optimized to a *specific code rate* resulting in a set of discrete code rates of $R = \{1/4, 3/8, 1/2, 5/8, 3/4\}$ - i.e., *one specific code rate for each constellation of the design table respectively*. LGE1027, 10:35-55, FIGs. 10a-11b; LGE1003, ¶[75].

By way of another example, FIGs. 13a and 13b of the '777 show design tables of PD Capacity and joint capacity optimized single dimensional PAM-8 constellations, with each column of the design table corresponding to a particular single dimensional PAM-8 constellation optimized for a *specific code rate*. LGE1003, ¶[76]. The *specific code rate* for each PAM-8 constellation of the design tables in FIGs. 13a and 13b and determined using the equation of '319 application identified above is $R = 1/6$ for the first column / constellation, $R = 1/3$ for the second column / constellation, $R = 1/2$ for the third column / constellation, $R =$

2/3 for the fourth column / constellation, and $R = 5/6$ for the fifth column / constellation. LGE1027, 10:56-11:7, FIGs. 12a-13b; LGE1003, ¶[76]. Thus, the constellation design tables of FIGs. 13a and 13b describe a plurality of single dimensional PAM-8 constellations that are each optimized to a *specific code rate* resulting in a set of discrete code rates of $R = \{1/6, 1/3, 1/2, 2/3, 5/6\}$ - i.e., *one specific code rate for each constellation of the design table respectively*.

LGE1027, 10:56-11:7, FIGs. 12a-13b; LGE1003, ¶[76]. The *specific code rate* of each single dimensional PAM-16 constellation of the single dimensional PAM-16 constellations design tables of FIGs. 15a-15b and *specific code rate* of each single dimensional PAM-32 constellation of the single dimensional PAM-32 constellation design tables of FIGs. 17a-17b do not explicitly list the respective code rate for each constellation of the design tables. LGE1027, 11:1-7.

Nonetheless, the resulting analysis is the same. Via application of the equation from the '319 provisional, a list of discrete code rates can be determined.

LGE1003, ¶[76].

In claiming priority benefit of the Barsoum Patents, Patent Owner appears to contend that one can determine, in hindsight, *specific code rate ranges* for particular unequally spaced constellations, particular SNR communication channels, or both. LGE1003, [77]. To be clear, the Barsoum Patents do not provide a single statement explaining how these particular *code rate ranges* (or

characteristics thereof) were determined for particular constellations, SNR communications channels, or both. As explained in *Purdue*, the Barsoum Patents themselves must provide sufficient “blaze marks” directing POSITAs to teachings within the Barsoum Patents that support the claimed *code rate ranges* of the challenged patents. Here, no blaze marks exist. *Id.*

Therefore claims 3-5, 13-15, and 24-26 are not entitled to the priority date of the Barsoum Patents. LGE1003 ¶[78].:

3. The Written Description of the Barsoum Patents Do Not Contain Written Description Support for “Multiple” LDPC Code Rate and Unequally Spaced Constellation Pairs That Include a Code Rate Below $1/3$

Claim 3 (and similarly claims 13 and 24) recites “*multiple* LDPC code rate and unequally spaced symbol constellation *pairs that each include an LDPC code rate below $1/3$* and a sixty-four-point unequally spaced symbol constellation of the first type.” LGE1001, 14:15-20 (emphasis added). The ’319 Provisional includes description of code rates (*see, e.g.*, pg. 2, col. 2; pg. 5), but does not include any description of *multiple* LDPC code rate-constellation *pairs that include a code rate below $1/3$* . LGE1003, [79]. Similarly, the ’319 provisional fails to provide any description of the other code rate-constellation pairs, code rates, and SNRs that are recited in claims 3-5, 13-15, and 24-26. Accordingly, these claims should not be awarded the priority date of the ’319 Provisional. LGE1003, ¶[79].

The '777 does not remedy the deficiencies of the '319 provisional.

LGE1003, [80]. The '777 includes a few paragraphs related to QAM constellations. LGE1027, 3:15-19, 12:12-37. In these paragraphs, the '777 discloses that “[q]uadrature amplitude modulation (QAM) constellations can be constructed by orthogonalizing PAM constellations into QAM inphase and quadrature components.” LGE1027, 12:12-14, FIG. 21. Presumably, it is such disclosure combined with the description of PAM-4, PAM-8, PAM-16, and PAM-32 constellations (*see, e.g.*, FIGS. 6A-17B and corresponding descriptions) that Patent Owner relies upon to claim 64-, 256-, and 1024-point constellations in claims 2-6, 12-15, and 23-27 (note that there is no explicit disclosure of the claimed 256- and 1024-point constellations in the '777). LGE1003, [80]. For example, the '777 discloses set of discrete code rates $R=\{1/6, 1/3, 1/2, 2/3, 5/6\}$ with respect to the PAM-8 constellation. LGE1027, 10:56-62 (“each of these slices correspond to systems with code rate $R=\eta \text{ bps}/\log_2(8)$, resulting in $R=\{1/6, 1/3, 1/2, 2/3, 5/6\}$ ”), FIGS. 13A, 13B; LGE1027, 10:58-62, FIG. 13A, 13B. But such disclosure does not support *multiple* LDPC code rate-constellation *pairs that include a code rate below 1/3*, as claimed in claims 3, 13, and 24. Instead, at best, only one code rate below 1/3 is disclosed. LGE1027, 10:56-11:7; LGE1003, ¶[80].

Moreover, the '777 provides no disclosure that the claimed 256 and 1024 point unequally spaced constellations would have the *same characteristics* such as

code rate or SNRs as purported corresponding PAM constellations would. For instance, the '777 does not teach that the claimed code rate range (below 7/10) for a 1024-point unequally spaced symbol constellation (as in claim 3) would be the same as the coding rate range or SNRs alluded to in the corresponding 32-PAM constellation described in FIGS. 17A and 17B. Indeed, a POSITA would have understood that the capacities, coding rates, and SNRs for one-dimensional (PAM) and corresponding two-dimensional constellations are not the same. LGE1003, ¶[81]. For example, Ungerboeck, an IEEE Transactions paper from 1982, provides a comparison of the channel capacities of one-dimension and two-dimension constellations. LGE1003, ¶[81].

4. The Written Description of the Barsoum Patents Do Not Demonstrate that the Patent Owner Was “In Possession” of the Communication System Claimed by claims 3-5, 13-15, and 24-26

As explained in Section II(A)(1) above, the Barsoum Patents do not include sufficient written description of the ***code rate ranges (and other claim features claimed in relation thereto)*** of the Challenged Claims. Moreover, the Barsoum Patents fail to provide any “blaze marks” that would direct a POSITA to the ***code rate ranges*** of the challenged claims in the Barsoum Patents. Lack of such disclosure means that the Patent Owner did not possess a communication system that uses the claimed ***code rate ranges*** as of the priority dates of the Barsoum

Patents. LGE1003 ¶¶[82-83].:

Claims 3-5, 13-15, and 24-26 impart a *code rate range* limitation on particular constellations, SNR communications channels, or both, used by the receiver of the claimed communication system. LGE1003, ¶[83]. However, the *code rate ranges* are not supported by the written description of the Barsoum Patents for the reasons set forth in Section II(A)(1). Accordingly, a POSITA would not be able to discern that the Patent Owner had possession of a communication system imparts particular *code rate ranges* on particular constellations, SNR communications channels, or both, used by the receiver of the claimed communication system. For at least the reasons set forth in Section II(A)(1) and Section II(A)(2), the written description of the Barsoum Patents is not sufficient to show possession of claims 3-5 and 13-15. LGE1003, ¶[83]. Therefore, the claims 3-5, 13-15, and 24-26 are not entitled to priority date of the Barsoum Patents. LGE1003, ¶[83].

5. The Written Description of the Barsoum Patents Do Not Demonstrate that the Patent Owner Was “In Possession” of the Communication System of claims 6, 16, and 26

Claim 6 recites:

“each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that each of the plurality of unequally spaced symbol constellations is

capable of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR.” LGE1001, 15:55-62.

These features do not find support in the written description of the Barsoum Patents. LGE1003, ¶[85].

This limitation defines a very specific relative relationship between two groups of unequally spaced constellations that is not supported by the ’777. Claim 6 recites an observation of a relative relationship between a first group of ***unequally spaced symbol constellations***² to a second group of ***unequally spaced space symbol constellations***³ when the two groups are ***operated at the same SNR***. LGE1003, [86]. Nothing in the ’777 provides sufficient written description for the relative evaluation

² i.e., the first group of constellations in claim 6 is narrowly claimed as “***each of the plurality*** of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that ***each of the plurality*** of unequally spaced symbol constellations ***is capable of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR***”

³ i.e., the second group of constellations in claim 6 is narrowly claimed as “other plurality of ***unequally*** spaced symbol constellations”

of these two groups of *unequally spaced symbol constellations*. LGE1003, [86]. To the contrary, the '777 only describes determining a relative relationship between *a* geometrically shaped (i.e., unequally spaced) constellation and a constellation optimized for $d_{\min}$. LGE1027, 6:14-20, 2:56-63; LGE1003, [86]. This disclosure of the '777 *does not* support the specific groups or the relationship claimed between the groups. LGE1003, [86]. No other portions of the '777 provide support that a POSITA would understand as showing Patent Owner had possession of claim 6 as of the priority date of the '777. The '319 provisional similarly lacks written description for claim 6. LGE1003, [86]. Thus, the subject matter of claim 6 is not entitled to the priority date of the '777.

Claims 16 and 26 include features that correspond to claim 6. Thus, the subject matter of claims 15 and 26 are likewise not entitled to the priority date of the '777. LGE1003, ¶[87].

6. The Written Description of the Barsoum Patents Do Not Demonstrate that the Patent Owner Was “In Possession” of the Communication System where “each of the plurality” of Multidimensional Symbol Constellations have a Greater Parallel Decoding Capacity than Other Symbol Constellations at the “same SNR” as recited by claims 6, 16, and 26

Claim 6 recites:

“each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points such that *each of*

the plurality of unequally spaced symbol constellations is capable of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR.” LGE1001, 15:55-62.

These features do not find support in the written description of the Barsoum Patents. LGE1003, ¶[88].

The ’777 specifies that:

“Not all geometrically shaped constellations have a greater capacity than that of a constellation maximized for $d_{\min}$. One approach to selecting a geometrically shaped constellation having a greater capacity than that of a constellation maximized for $d_{\min}$ is to optimize the shape of the constellation with respect to a measure of capacity of the constellation for a given SNR. Capacity measures that can be used in the optimization process can include, but are not limited to, joint capacity or parallel decoding capacity. LGE1027 6:13-22.

A POSITA would have understood this passage of the ’777 as specifying that *at least some* geometrically shaped (i.e., unequally spaced) constellations used by the ’777 *do not* have a greater capacity than other constellations used by the the ’777. LGE1027 6:13-22; LGE1003, ¶[89]. A POSITA would have understood the ’777 as explaining that operations can be performed on an unequally spaced constellation so that the unequally spaced constellation *can be optimized* for joint capacity optimization or parallel decoding optimization in order to have greater capacity. LGE1027 6:13-22; LGE1003, ¶[89]. Thus, though some unequally spaced

constellations do not have a greater capacity than other constellations maximized for $d_{\min}$, the '777 *explains how to optimize a geometrically shaped constellation so that it can be capable* of having a greater capacity such as a greater parallel decoding capacity. LGE1027 6:13-22; LGE1003, ¶[89].

Regarding claim 6, the Barsoum Patents fail to disclose that *each of the plurality* of different unequally spaced symbol constellations *have been optimized* to be *capable* of having greater parallel decoding capacity. LGE1003, ¶[90]. Indeed, neither the language of claim 6 nor the language of parent claim 1 indicate that *each of the plurality* of different unequally spaced symbol constellations have been optimized for parallel decoding capacity. LGE1003, ¶[90]. Moreover, nothing in the '777 or '509 patent provides any indication that *each of the plurality of* different unequally spaced symbol constellations of claim 6 have been optimized for parallel decoding capacity. LGE1003, ¶[90]. To the contrary, the '777 and the '509 patent reveal that “*[n]ot all geometrically shaped constellations have a greater capacity than that of a constellation maximized for $d_{\min}$.*” LGE1001, 6:33-35; LGE1027, 6:13-15; LGE1003, ¶[90] (emphasis added).

Claim 6 is not supported by the '777 because “[n]ot all” *of the plurality of* different unequally spaced symbol constellations are *capable of providing a greater parallel decoding capacity when operated at a symbol constellation operating SNR* than the other plurality of unequally spaced symbol constellations when operated at

the same SNR recited by claim 6. Thus, claim 6 is not entitled to the priority date of the '777. LGE1003, ¶[91].

To the extent Patent Owner argues that a constellation not optimized for parallel decoding capacity, as described by col. 6, 15-23 of the '777, *is capable* of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other plurality of unequally spaced symbol constellations when operated at the same SNR, such an assertion further proves that the claim feature of the “*each of the plurality of unequally spaced symbol constellations is characterized by the assignment of labels and spacing of the constellation points*” includes unequally spaced constellations that are not optimized for parallel decoding capacity, of which, “[n]ot all” have a greater capacity than that of other plurality of unequally spaced symbol constellations when operated at the same SNR. LGE1003, ¶[92]. In other words, a non-uniform constellation is only *capable* of providing greater parallel decoding capacity at a specific SNR than other symbol constellations in the plurality multidimensional symbol constellations at the same SNR *after* the non-uniform constellation has been optimized for parallel decoding capacity. LGE1027 6:13-22; LGE1003, ¶[92].

For such an argument to prevail, the Patent Owner would need to show that the each of the plurality of unequally spaced symbol constellations of claim 6 have been optimized for parallel decoding capacity – which brings us right back to where

we started. LGE1003, ¶[93]. Ultimately, claim 6 is not supported by the specification of the '777 in sufficient detail to convey to a POSITA that Patent Owner had possession of claim 6 as of the priority date of the '777. LGE1003, ¶[93]. Nothing else in the Barsoum Patents does anything to change the calculus of this analysis. LGE1003, ¶[93].

Thus, the Barsoum Patents fail to support subject matter of claim 6. Claims 16 and 26 include claim features that correspond to the features of claim 6. Therefore, claims 6, 16, and 26 are not entitled to priority date of the Barsoum Patents. LGE1003 ¶¶[94-96].:

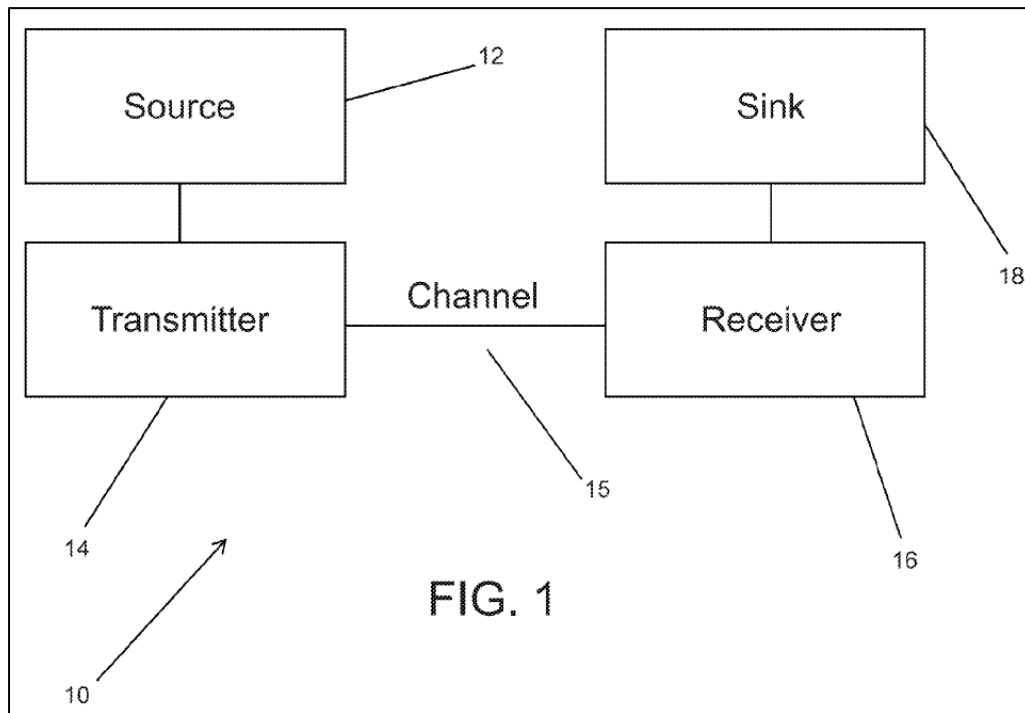
III. OVERVIEW OF THE '509 PATENT

A. Brief Description of the '509 Patent

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

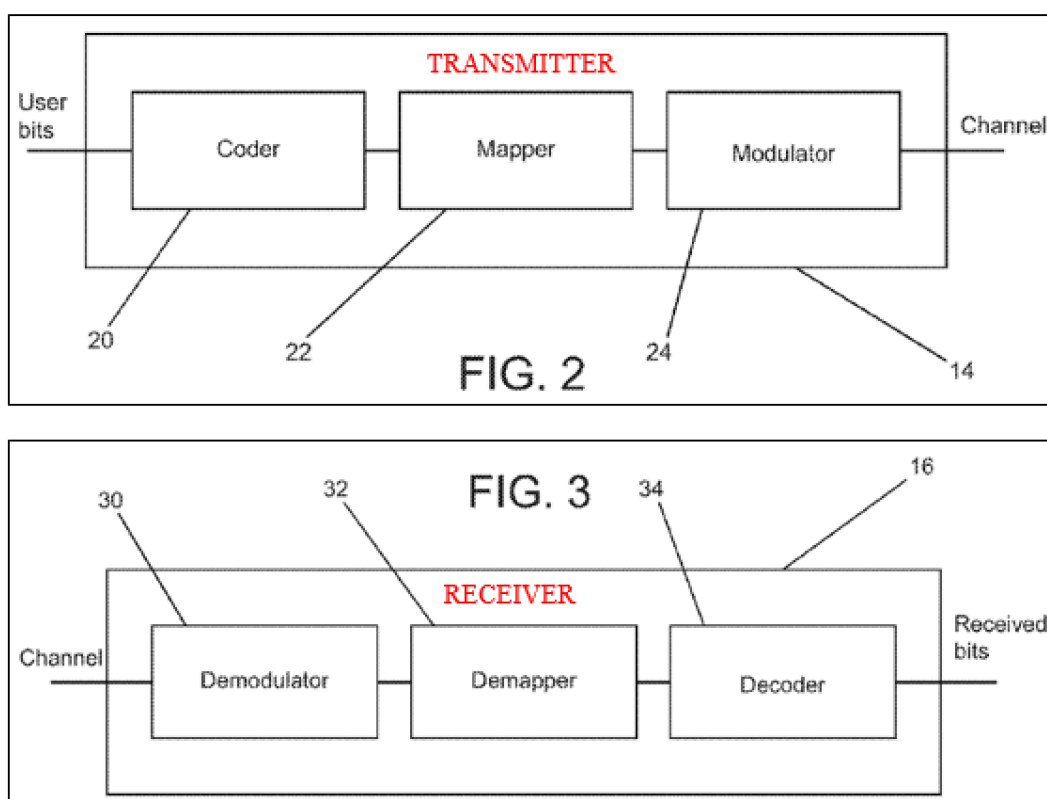
mapper of transmitters and the demapper of receivers within a communication system.” *Id.*, 6:8-12; 6:24-33; LGE1003, ¶[48].

Figure 1 (below) shows a communication system 10 according to the ’509 Patent LGE1003 ¶[49-50].::



LGE1001, FIG. 1.

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



LGE1001, FIGS. 2-3.⁴

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

⁴ Annotations to this and other figures in this petition are indicated by colored text and/or marks.

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

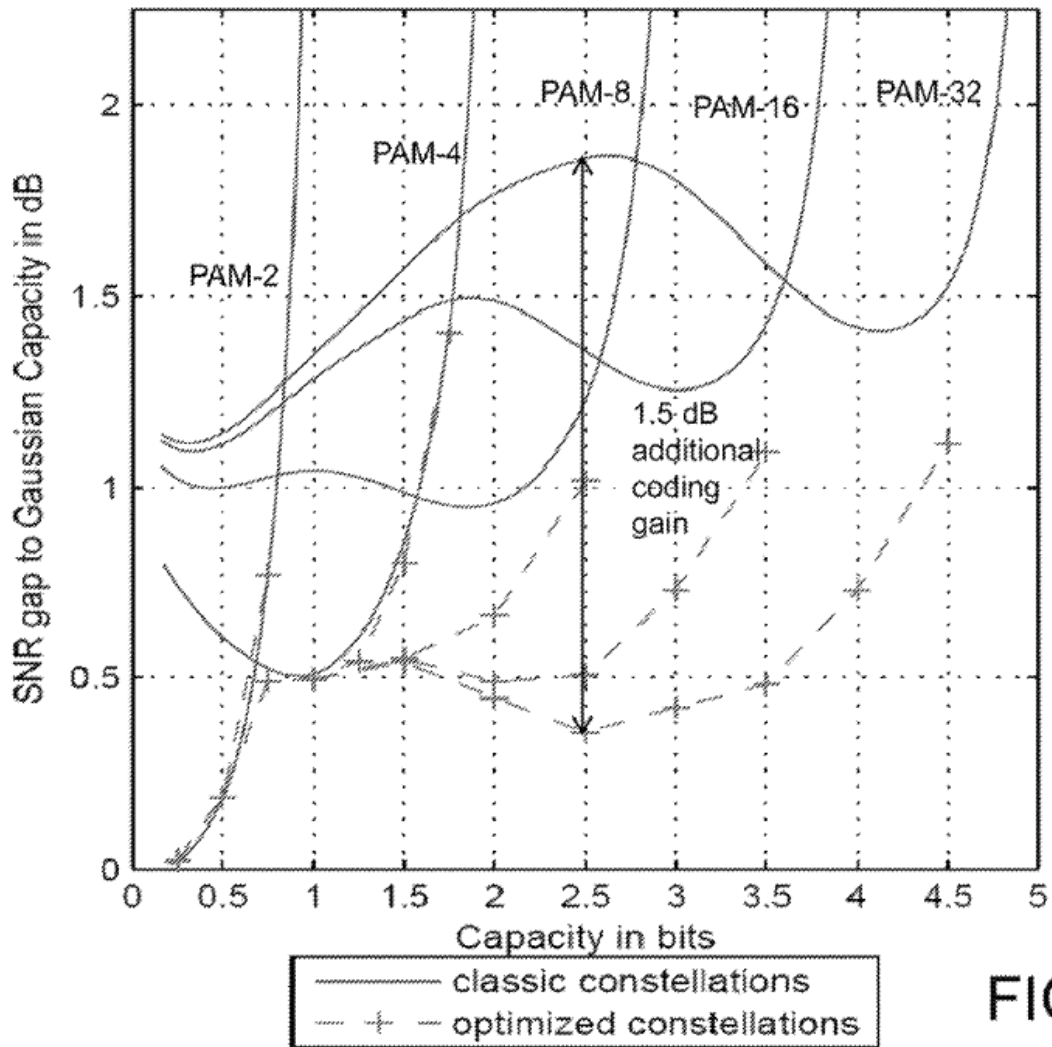


FIG. 8a

LGE1001, FIG. 8a.

PAM-4 constellations optimized for joint capacity at different rates

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

FIG. 11a

LGE1001, FIG. 11a.

PAM-4 constellations optimized for parallel decoding capacity at different

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

FIG. 11b

LGE1001, FIG. 11b.

B. Level of Ordinary Skill in the Art

Petitioner submits that a person of ordinary skill in the art at the time of the alleged invention (a “POSITA”) would have had at least a Master’s degree in an academic area emphasizing electrical engineering or a similar discipline, and at least two years of experience in the field working with, teaching, or researching communication systems including the use of constellations in transmitting signals between devices. LGE1003, ¶¶[21]-[23]. Superior education could compensate for a deficiency in work experience, and *vice-versa*. *Id.*

IV. CLAIM CONSTRUCTION

For the purposes of this petition, no claim construction is necessary. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Petitioner reserves the right to respond to any constructions offered/adopted by Patent Owner or the Board.

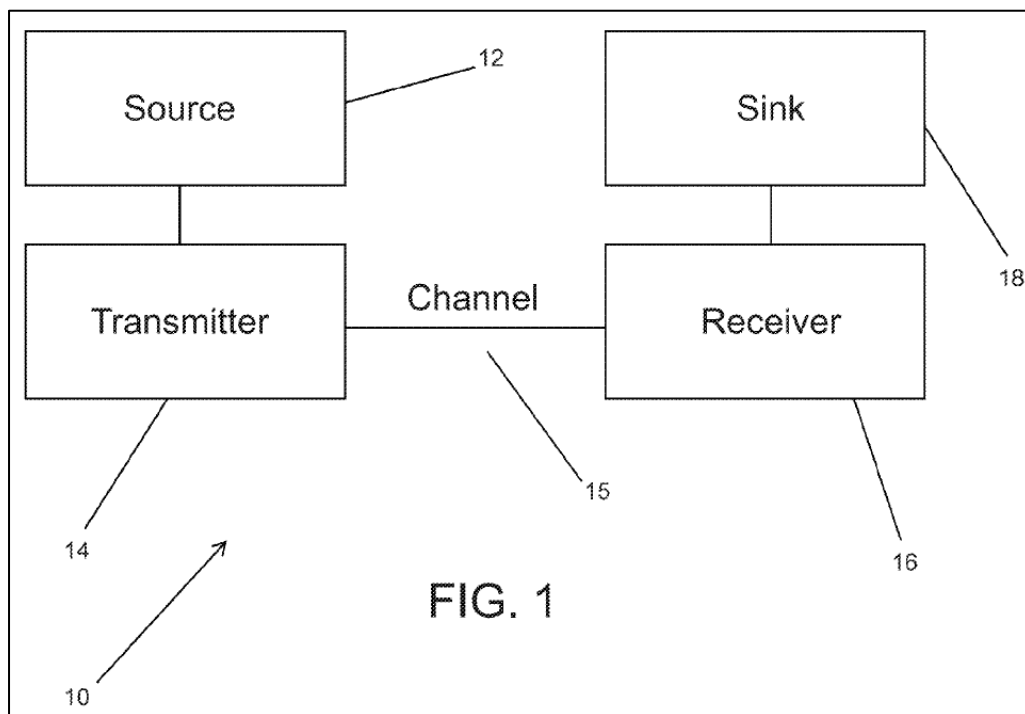
V. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

A. Ground 1: the ’777 in view of ATSC327 render claims 3-7, 13-17, and 24-28 obvious

1. Overview of the ’777⁵

⁵ 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.

Figure 1 (below) of the '777 shows a communication system 10 according to the '777, 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.” LGE1027, 5:16-18. 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.*, 5:18-21; LGE1003, ¶[98-99].

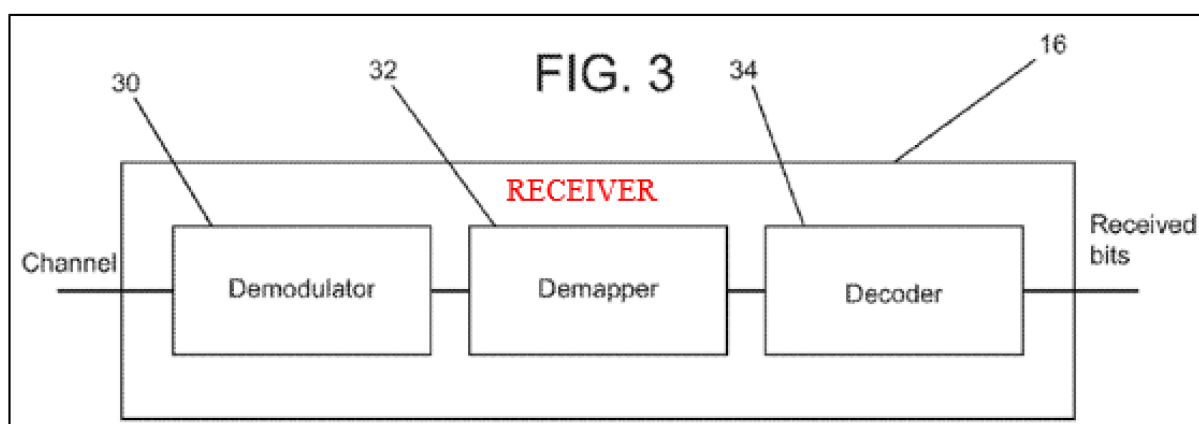
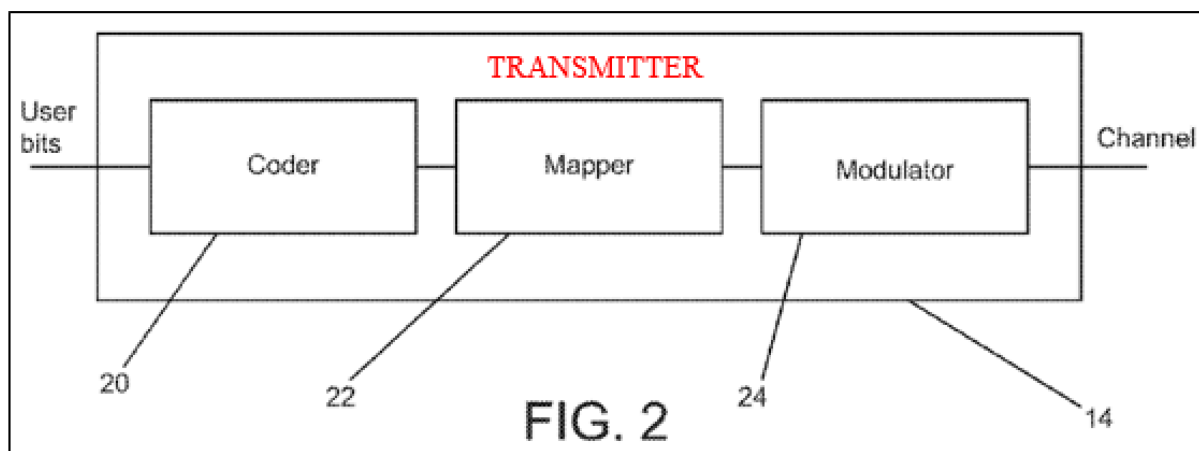


LGE1027, FIG. 1.

FIG. 2 (below) of the '777 depicts the transmitter 14 and its components, which include a coder 20, a mapper 22, and a modulator 24. LGE1027, 3:30-31, 5:22-34.

FIG. 3 (below) of the '777 depicts the receiver 16 and its components, which include

a demodulator 30, a demapper 32, and a decoder 34. LGE1027, 3:32-33, 5:35-43; LGE1003, ¶[100].



LGE1027, FIGS. 2-3.⁶

FIG. 11a and 11b also disclose an example of a concept that the '509 patent will call types. LGE1001, claims 2b, 5b; LGE1003, [101]. The first type (annotated in a red box below) “includes at least two constellation points having location that

⁶ Annotations to this and other figures in this petition are indicated by colored text and/or marks.

are the same and different labels.” LGE1001, claim 2b. That is, the constellation has at least two points that coincide (annotated in red circles). The second type (annotated in blue box below) contains “no two constellation points...share locations that are the same.” LGE1001, claim 5b. That is, no two constellation points in a second type coincide. LGE1003, ¶¶ [101-106].

PAM-4 constellations optimized for joint capacity at different rates

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

FIG. 11a

LGE1027, FIG. 11a.

PAM-4 constellations optimized for parallel decoding capacity at different

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

FIG. 11b

LGE1027, FIG. 11b.

The features of the '509 patent are the same as the '777 described above in Section III(A), as the '509 patent and the '777 share the same specification and drawings. LGE1003, ¶¶ [105-106]

2. Overview of the ATSC327

ATSC327 is a supplement to the ATSC322 reference LGE1029. LGE1003, ¶[107].

“This document provides recommended practices for the ATSC 3.0 physical layer protocol standard specified by A/321 [2] and A/322 [3]. The intent of this document is to make recommendations for physical layer operating modes so that readers can make informed decisions about physical layer configurations. Also,

this document provides some implementation guidelines to aid with flexible configurations of physical layer design resources in transmitter and receiver manufacturers' equipment." LGE1028, 1. ATSC327 seeks "to provide a toolbox of technology that allows flexible operating modes for a variety of harsh channel conditions..." and "[i]t also contains detailed guidelines for transmitter and receiver design implementations based on engineering studies of the latest technologies in the ATSC 3.0 physical layer." LGE1028, 1. Where ATSC322 "provides distinct features and description of the physical layer technologies," the ATSC327 teaches the implementation of those technologies. LGE1028, 6; LGE1003 ¶[108].

As ATSC327 teaches channel coding methods that include optimized constellations, Low Density Parity Check (LDPC) codes (2/15-13/15 code rates), and Non-Uniform Constellations (QAM) to "achieve near Shannon Limit performance of channel error mitigation across a wide range of SNR values." LGE1028, 6. LGE1003 ¶[109].

ATSC327 uses a fixed number of these channel coding schemes by limiting the modulation and code rate (ModCod) combinations to 120. LGE1028, 18. Specifically, when implementing a ModCod scheme, ATSC327 teaches that "[t]here is one non-uniform constellation (NUC) defined for each ModCod combination" and that "for implementation, a look-up table with defined

constellation mapping for each ModCod combination can be used.” LGE1028, 32.

LGE1003 ¶[110].

ATSC327 teaches these ModCod tables in two ways. First in Tables 4.7 and 4.8, the mandatory ModCod combinations are shown, which are the minimum requirements for receiver and transmitter implementation in the ATSC 3.0 architecture. LGE1028, 19. LGE1003 ¶[111].

Table 4.7 Mandatory ModCod Combinations for Long Codes (64800 bits)

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	✓	✓	✓	✓	✓	✓	✓	✓		✓		
16QAM			✓	✓		✓	✓	✓		✓		
64QAM		✓	✓	✓	✓	✓	✓	✓	✓	✓		
256QAM			✓	✓		✓	✓	✓	✓	✓	✓	✓
1024QAM				✓		✓	✓	✓	✓	✓	✓	✓
4096QAM						✓		✓		✓	✓	✓

Table 4.8 Mandatory ModCod Combinations for Short Codes (16200 bits)

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	✓	✓	✓	✓	✓	✓	✓	✓				
16QAM				✓	✓	✓	✓			✓		
64QAM				✓	✓	✓	✓	✓	✓	✓		
256QAM				✓		✓	✓	✓	✓	✓	✓	✓

LGE1028, Table 4.7-4.8, 19

Tables 4.3 and 4.4 show “the required SNRs for AWGN and i.i.d. Rayleigh channels, respectively, in long code (64800 bits) cases. In these tables, capacity-equivalent ModCods are marked by the same color, and for each color, the ModCods that show the lowest required SNRs are marked in bold.” LGE1028, 18. LGE1003 ¶[112].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

3. The '777-ATSC327 Combination

The '777-ATSC327 combination includes a communication system comprising a receiver that is capable of demapping and decoding non-uniform multidimensional constellations that have been optimized to have a specific code rate at a specific SNR. LGE1027, 4:60-5:11, 5:35-43, FIG. 3; LGE1028, 18-19. LGE1003 ¶[113].

In the combination, the '777 discloses a communication system comprising “[t]ransmitters and receivers ... [that] utilize geometrically shaped symbol constellations” and how the geometrically shaped symbol constellation can be “used that optimizes the capacity of the constellation.” LGE1027, 5:45-49. The

'777 explains that PAM constellations can be paired with specific code rates to optimize capacity. LGE1027, 9:52-10:3; LGE1003, ¶[114].

Also in the combination, the '777 describes “[p]rocesses for selecting capacity optimized constellations to achieve increased coding gains based upon a specific coding rate.” LGE1027, 5:4-7. In addition, the '777 provides a number of one dimensional constellation design tables. LGE1027, 3:61-64, 4:5-8, 4:12-14, 4:19-21, 9-21 FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b. In the combination, the '777 teaches that a specific code rate can be calculated for each one dimensional constellation, with the one-dimensional constellations comprising a PAM-4 constellation, a PAM-8 constellation, a PAM-16 constellation, or a PAM-32 constellation. LGE1027, 5:4-7; 10:25-11:13. For PAM-4 constellation and the PAM-8 constellations, the '777 explicitly provides a discrete list of respective code rates, with each specific code rate in the list of code rates corresponding to a constellation of a constellation design table. LGE1027, 10:47-55, FIGs. 11a, 11b, 10:58-62, FIGs. 13a, 13b. The '777 also explains to a POSITA that **QAM** constellations can be derived from **PAM** constellations. LGE1027, 3:9-19, 12:11-16.; LGE1003 ¶[115].

Also in the combination, the system of the '777 is modified with the teachings of ATSC327 to pair multidimensional **QAM** constellations with specific code rates and compare the SNR. LGE1028, 18-19. In the communication system

of the combination, ATSC327 is used to enable the communication system to have “a look-up table with the defined constellation mapping for each ModCod combination can be used.” LGE1028, 32. In this table, “There is one non-uniform constellation (NUC) defined for each ModCod combination.” LGE1028, 32. LGE1003 ¶[116].

In the combination, the communication system of the ’777 is configured to have a look-up table of non-uniform multidimensional constellations and code rate (ModCod) pairs that are capable of maximizing the channel capacity at a given SNR as seen in Tables 4.2 and 4.3 from ATSC327 (reproduced below) LGE1003 ¶[117]:

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

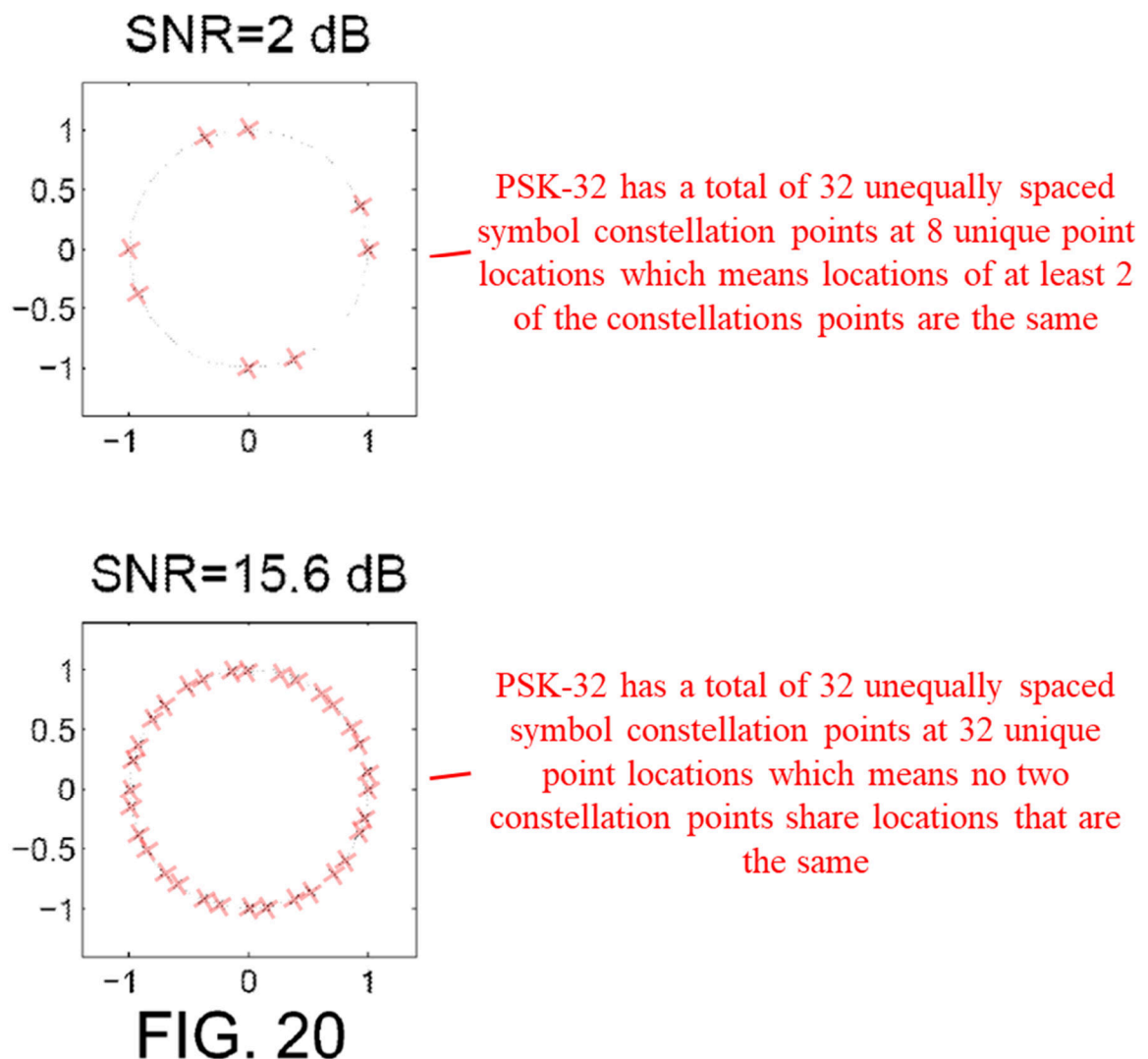
Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

As the '777 clearly teaches “a geometrically shaped constellation is selected in conjunction with a code rate to meet specific performance requirements, which can for example include such factors as a specified bit rate, a maximum transmit power.” LGE1027; 5:64-6:1. The '777 suggests that “the receiver could implement a quality of performance based optimized constellation/code rate pair control mechanism. Such an approach would include some form of receiver quality measure. This could be the receiver's estimate of SNR or bit error rate.” LGE1027, 11:66-12:3. A POSITA armed with the teachings of ATSC327 would have found it obvious to implement a look-up table of ModCod combinations associated with given SNRs into both the transmitter and receiver. LGE1028, 19; LGE1003, ¶[118].

Further, based on the teachings in the '777-ATSC327, a POSITA would have been motivated to implement different types of unequally spaced symbol constellation in the ModCod combinations. As the '777 discloses two types of unequally spaced symbol constellation - first type includes at least two constellation points having locations that are the same and the second type includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. For example, illustrates in FIG. 20 (reproduced below), illustrates different configurations of PSK-32 symbol constellation with optimized locations of

constellation points based on SNR values. LGE1027, FIG. 20; LGE1003, ¶[119]. For example, at SNR=2dB, PSK-32 has 32 unequally spaced symbol constellation points at 8 unique point and at SNR=15.6dB, PSK-32 has 32 unequally spaced symbol constellation points at 32 unique points locations. LGE1027, FIG. 20; LGE1003, ¶[119].



LGE1027, FIG. 20 (annotated and magnified view showing PSK-32 unequally spaced symbol constellations at unique point locations, at SNR=2dB and 15.6dB).

4. Reasons to Combine the '777 with ATSC327

It would have been obvious for a person of ordinary skill in the art (POSITA) to modify the teachings of the '777 with the teachings of ATSC327 for a number of reasons. LGE1003, ¶[120]. First, ATSC327 is a technical standards document that seeks to “to provide a toolbox of technology that allows flexible operating modes for a variety of harsh channel conditions...” and “[i]t also contains detailed guidelines for transmitter and receiver design implementations based on engineering studies of the latest technologies in the ATSC 3.0 physical layer.” LGE1028, 1. Thus, a POSITA working with a communication system such as the communication system of the '777 would have looked to ATSC327 to identify solutions to problems in the field. LGE1003, ¶[120].

Second, a POSITA would have looked to the teachings of the ATSC327 standard for “implementation guidelines to aid with flexible configurations of physical layer design resources in transmitter and receiver manufacturers’ equipment.” LGE1028, 1; LGE1003, ¶[120]. For example, ATSC327 provides a finite list of multiple different non-uniform multidimensional QAM constellation-code rate pairs as listed in, for example, Tables 4.3 and 4.4. LGE1028, 18. A POSITA would have found it obvious to try each of the solutions in this finite list of multiple different non-uniform multidimensional QAM constellation-code rate pairs and select the particular non-uniform

multidimensional QAM constellation-code rate pair that best suites the needs of the system designed by the POSITA. LGE1003, ¶[121].

Third, a POSITA would have been motivated to design a system that uses the particular operating modes of ATSC327 to achieve the benefits that comes with being standard compliant. For example, having a system that is standards compliant would result in a system that is interoperable with communications systems in the industry and likely to achieve greater adoption in the market. LGE1003, ¶[122].

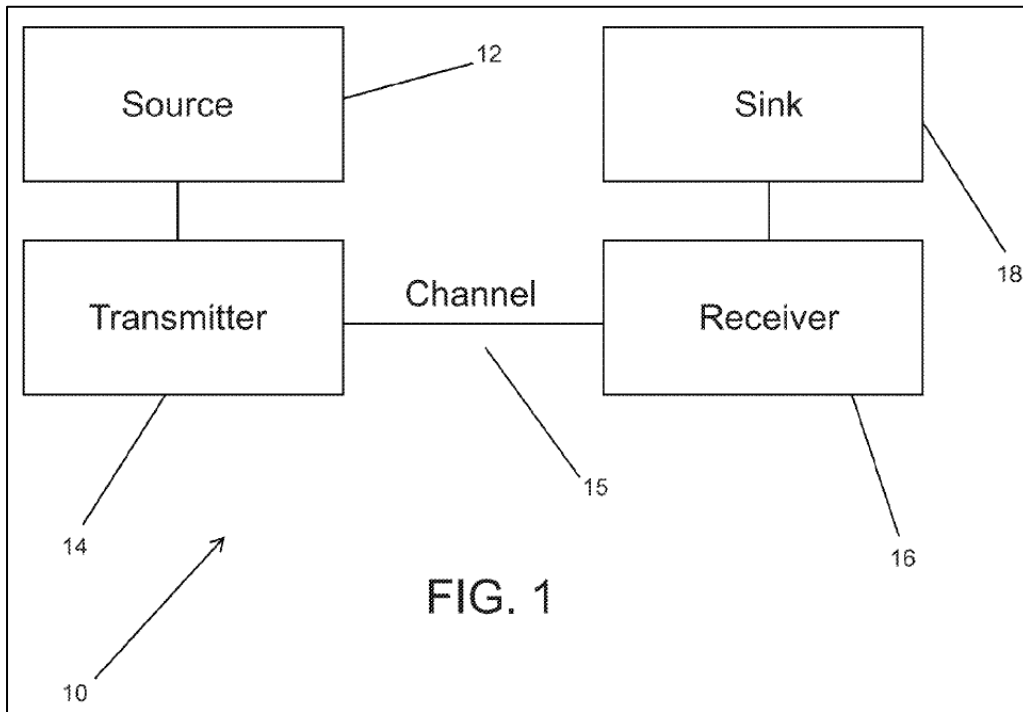
5. Ground 1 Prior Art Mappings

Claim 1

[1pre]⁷

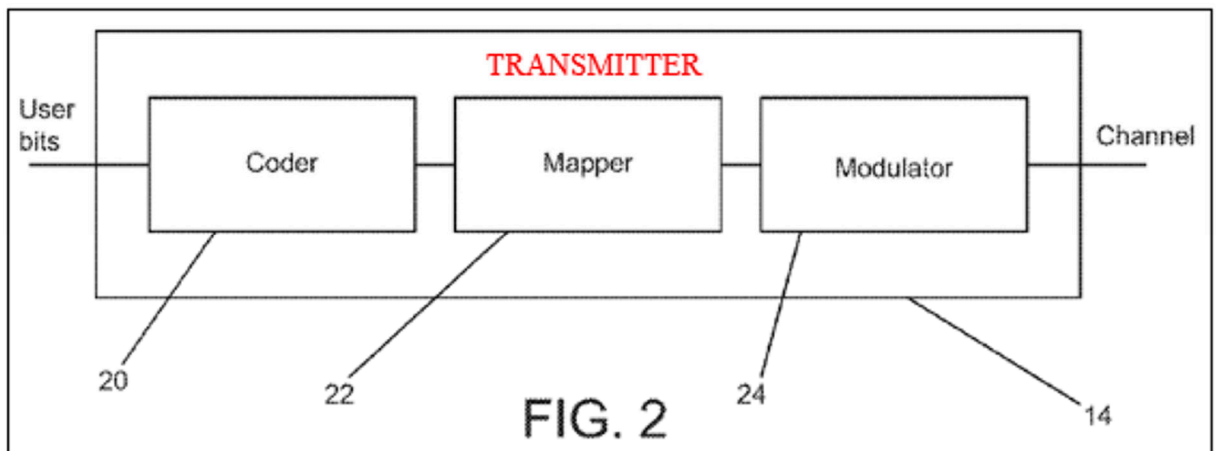
The '777 **discloses a communication system**. LGE1027, 5:16-21, abstract, FIGs. 1-3. For example, see the digital communication system of '777 FIG. 1 (reproduced below) LGE1003 ¶[123].:

⁷ Because claim 3 depends from claim 1 and 2, this Petition also includes a mapping of the prior art references against claims 1 and 2 (and similarly other independent claims). [In Ground 1, petitioner relies on the '777 as disclosing all the features of claim 1.](#)



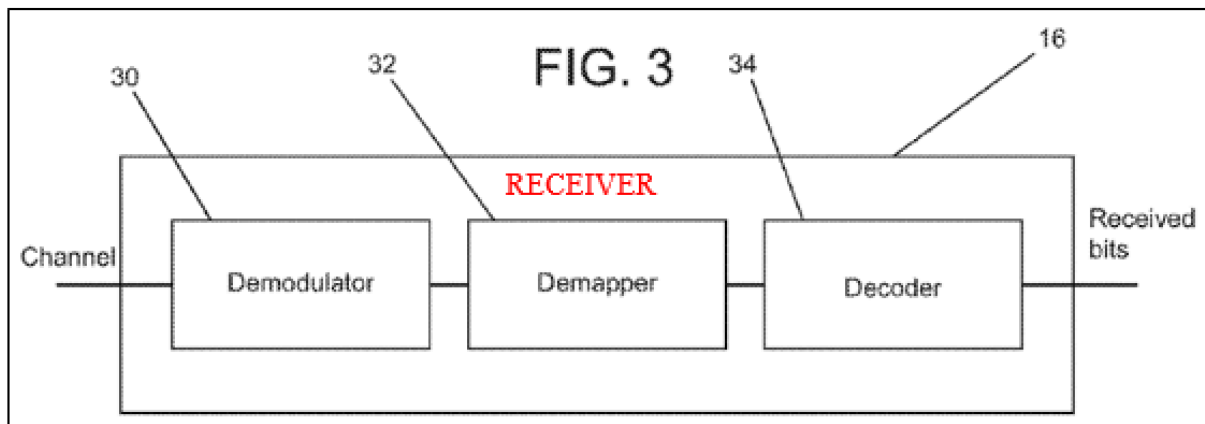
LGE1027, FIG. 1.

The transmitter 14 of the patent communication system 10 includes a coder 20, a mapper 22, and a modulator 24. LGE1027, 3:30-31, 5:22-34. The transmitter 14 is shown in FIG. 2 of the '777 (reproduced below) LGE1003 ¶[124].:



LGE1027, FIG. 2.⁸

The receiver 16 of the communication system 10 includes a demodulator 30, a demapper 32, and a decoder 34. LGE1027, 3:32-33, 5:35-43; LGE1003, ¶[125]. The receiver 16 of the communication system 10 is shown in FIG. 3 of the '777 (reproduced below) LGE1003 ¶¶[125-126]::



LGE1027, FIGS. 3.

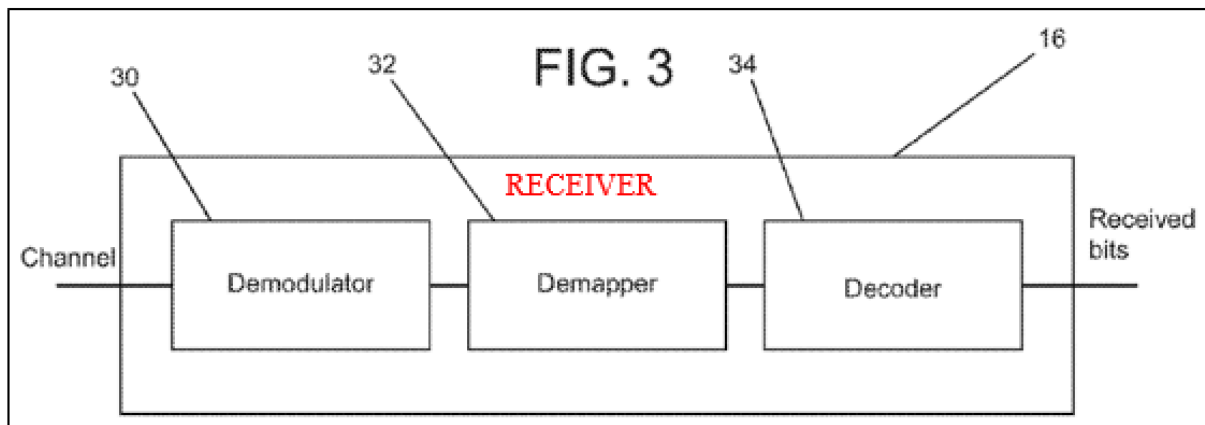
[1a]

In the combination, the '777 discloses *a receiver 16 that is capable of receiving signals via a communication channel*. LGE1027, 5:35-43; 13:37-38. For example, the “receiver 16 includes a demodulator 30 that demodulates a signal received via the channel to obtain symbol or bit likelihoods.” *Id.* The receiver 16

⁸ Annotations to this and other figures in this petition are indicated by colored text and/or marks.

of the communication system 10 is shown in FIG. 3 of the '777 (reproduced below)

LGE1003 ¶[127].:



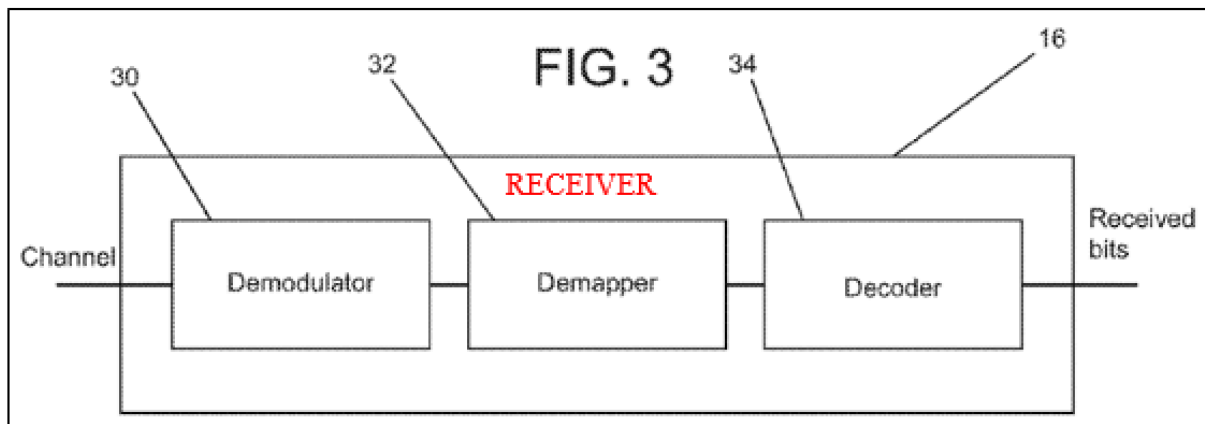
LGE1027, FIGS. 3.

A POSITA understands that a communication channel has a channel signal-to noise ratio (SNR). LGE1003, ¶[128]. The '777 alludes to this, for example, in explaining that the receiver 16 is configured to select a constellation “to provide increased capacity *at a predetermined range of channel signal-to-noise ratios (SNR).*” LGE1027:4:54-56; 7:26-33; 7:47-49; 13:34-38. Thus, the features of [1a] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[128].

[1b]

The '777 discloses *a demodulator capable of demodulating a received signal into a demodulated signal.* LGE1027, 5:35-43; 13:37-38. For example, the “receiver 16 includes a demodulator 30 that demodulates a signal received via the

channel to obtain symbol or bit likelihoods.” *Id.* The receiver 16 then uses the demapper 32 to estimate likelihoods from the demodulated signal. LGE1027, 2:32-36, 2:52-543; 15:4-6; 16:14-15. The receiver 16 of the communication system 10 is shown in FIG. 3 of the ’777 depicts a demodulator 30 (reproduced below). LGE1003, ¶[129].

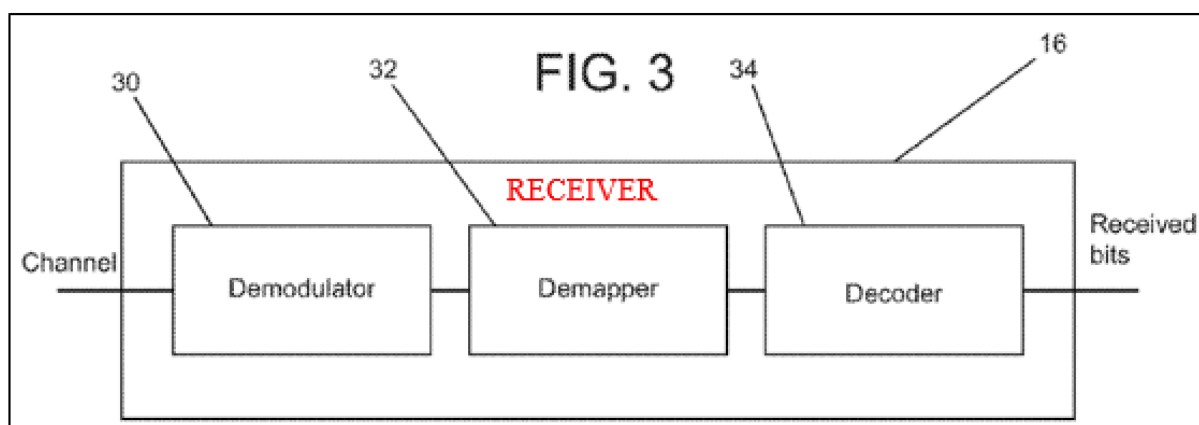


LGE1027, FIGS. 3.

Thus, the features of [1b] above would have been obvious to a POSITA in view of the ’777. LGE1003, ¶[130].

[1c-1]

The ’777 discloses *a demapper coupled to the demodulator*. LGE1027, 3:32-33, 5:35-43; FIG. 3; LGE1003, ¶[131]. The ’777s coupling of the demapper 32 to the demodulator is shown, for example, in FIG. 3 of the ’777 (reproduced below) LGE1003 ¶[131].::



LGE1027, FIGS. 3.

The '777 discloses *a demapper that is capable of determining likelihoods using the demodulated signal and a symbol constellation*. LGE1027, 2:52-55; 5:35-43, 6:24-51 FIG. 3; LGE1003, ¶[132]. For example, the '777 discloses that “the demapper uses knowledge of the geometrically shaped symbol constellation used by the transmitter to determine likelihoods.” LGE1027, 5:35-43. The '777 discloses that the geometrically shaped symbol constellation. LGE1027, 3:11-19; 4:29-31; 12:12-16; 12:38-49, FIGs. 20, 21; LGE1003, ¶[132].

The '777 discloses *a symbol constellation that includes constellation points at a plurality of unique point locations*. LGE1027, 2:52-55; 3:20-25, 5:35-43, 6:24-51, 10:36-11:13, FIGs. 11b, 13b, 15b, 17b. For example, the '777 broadly suggests that “the communication systems can adapt location of points in a constellation in response to channel conditions, changes in code rate and/or to change the target user data rate.” LGE1027, 5:7-11. In FIGs. 11b, 13b, 15b, and 17b, the '777 exemplifies

PAM based symbol constellations that include constellation points at unique points locations. LGE1027, 3:65-67, 4: 5-7, 4:12-14, 4:19-21, 10:25-11:13, FIGs. 11b, 13b, 15b, and 17b; LGE1003, ¶[133]. For PAM symbol constellation, “[l]ocus plots of PAM-4, 8, 16, and 32 constellations [are] optimized for PD capacity and joint capacity”. LGE1027, 10:29-30. In one instance, optimization of locations of constellation points are performed based on SNR values, wherein, “[a]t low SNRs, the PD capacity optimized **PAM-4 constellations have only 2 unique points, while the Joint optimized constellations have 3**. As SNR is increased, **each optimization eventually provides 4 unique points.**” LGE1027, 10:45-47; FIGs. 10a-d, 11a-d. LGE1003, ¶[133].

PAM-4 constellations optimized for joint capacity at different rates

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

3 unique
point
locations

4 unique
point
locations

FIG. 11a

LGE1027, 11a.

PAM-4 constellations optimized for parallel decoding capacity at different

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

2 unique point locations
4 unique point locations

FIG. 11b

LGE1027, 11b.

PAM-8 constellations optimized for parallel decoding capacity at different

(bps)	0.5	1.0	1.5	2.0	2.5
(SNR)	0.19	5.27	9.00	12.42	15.93
x_0	-1.00	-1.36	-1.72	-1.64	-1.60
x_1	-1.00	-1.36	-0.81	-0.97	-1.03
x_2	-1.00	-0.39	1.72	1.64	-0.19
x_3	-1.00	-0.39	-0.62	-0.58	-0.58
x_4	1.00	1.36	0.62	0.58	1.60
x_5	1.00	1.36	0.02	0.15	1.03
x_6	1.00	0.39	0.81	0.97	0.19
x_7	1.00	0.39	-0.02	-0.15	0.58

2 unique point locations
 4 unique point locations
 8 unique point locations

FIG. 13b

LGE1027, 13b.

PAM-16 constellations optimized for parallel decoding capacity at different

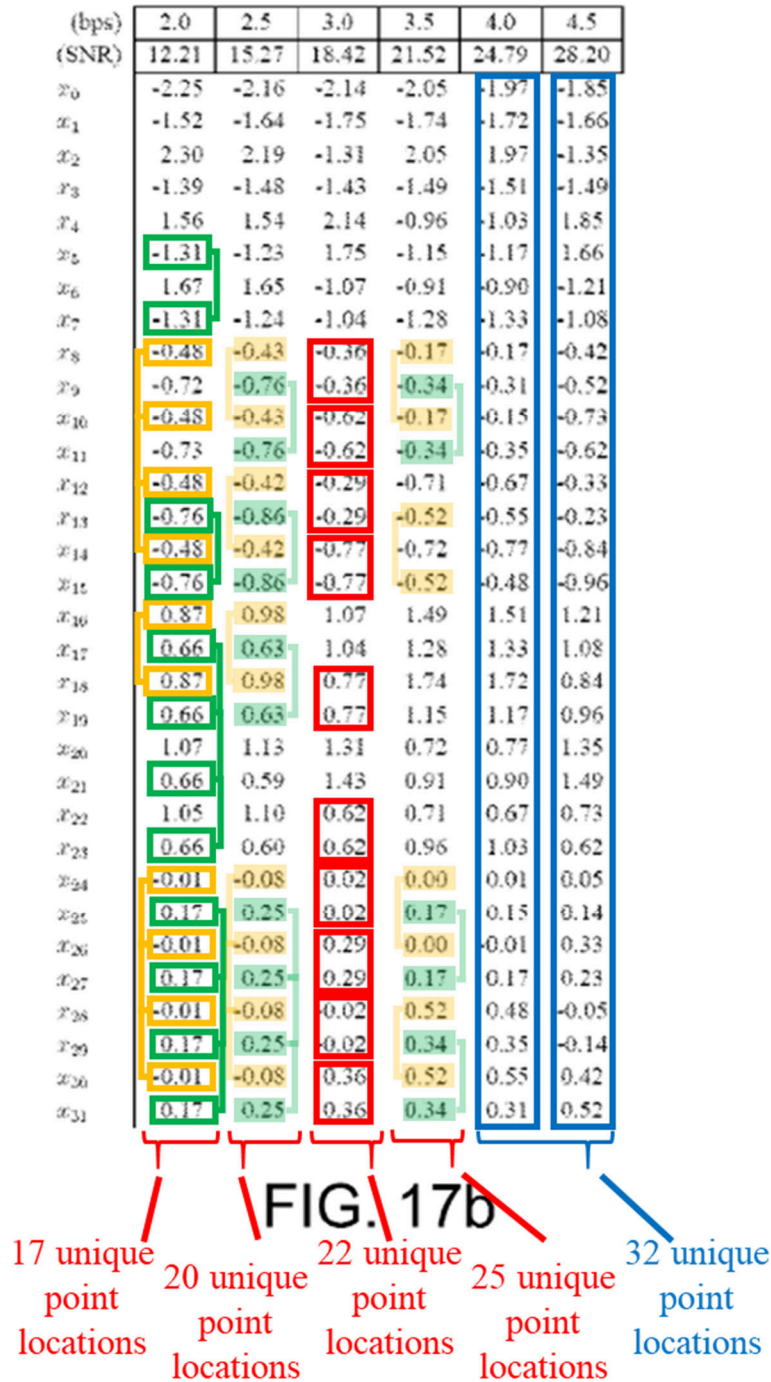
(bps)	1.5	2.0	2.5	3.0	3.5
(SNR)	9.00	12.25	15.42	18.72	22.13
x_0	-1.72	-1.98	-1.89	-1.84	-1.75
x_1	-1.72	-1.29	-1.36	-1.42	-1.42
x_2	-0.81	1.94	1.89	1.84	1.75
x_3	-0.81	-1.17	-1.14	-1.11	-1.15
x_4	1.72	-0.38	-0.35	-0.40	-0.47
x_5	1.72	-0.65	-0.70	-0.65	-0.68
x_6	-0.62	-0.38	-0.34	-0.29	-0.28
x_7	-0.62	-0.68	-0.76	-0.83	-0.90
x_8	0.62	1.09	1.13	1.11	1.15
x_9	0.62	0.76	0.76	0.84	0.90
x_{10}	0.02	1.26	1.35	1.42	1.42
x_{11}	0.02	0.76	0.70	0.65	0.68
x_{12}	0.81	0.06	0.00	0.05	0.09
x_{13}	0.81	0.29	0.34	0.29	0.28
x_{14}	-0.02	0.06	0.00	-0.05	-0.09
x_{15}	-0.02	0.29	0.35	0.40	0.47

FIG. 15b

8 unique point locations 12 unique point locations 15 unique point locations 16 unique point locations

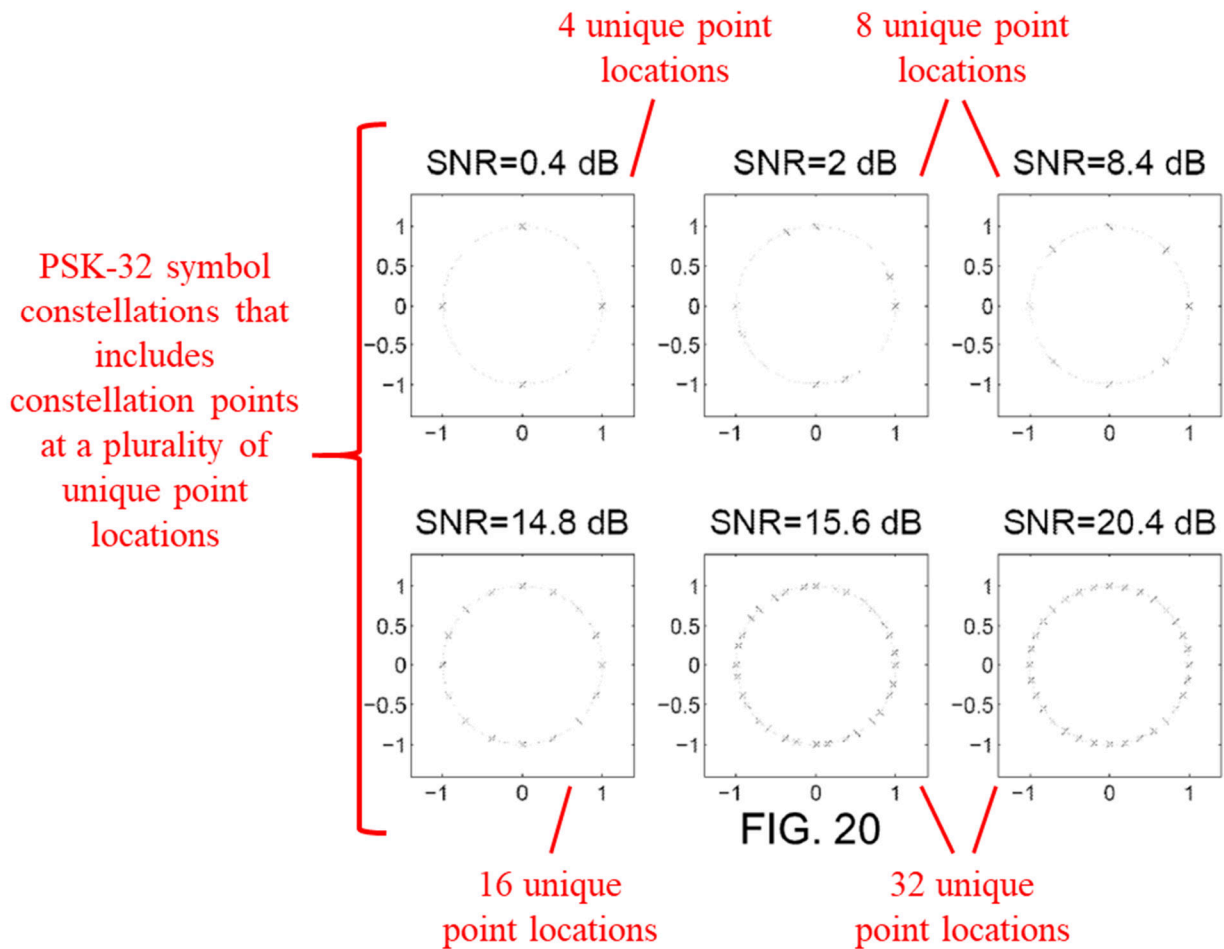
LGE1027, 15b.

PAM-32 constellations optimized for parallel decoding capacity at different



LGE1027, 17b.

Similarly, in FIG. 20, '777 illustrates, "a series of PSK-32 constellations optimized for PD capacity at different SNRs." LGE1027, 4:26-28. In FIG. 20, different configurations of PSK-32 symbol constellation illustrates optimized locations of constellation points based on SNR values. LGE-1027, FIG. 20; LGE1003, ¶[134]. For example, at SNR=0.4dB, PSK-32 has constellation points at 4 unique point locations, at SNR=2dB and 8.4dB, PSK-32 has constellation points at 8 unique point; at SNR=14.8dB, PSK-32 has constellation points at 16 point locations, and at SNR=15.6dB and 20.4dB, PSK-32 has constellation points at 32 unique points locations. LGE1027, FIG. 20; LGE1003, ¶[134].



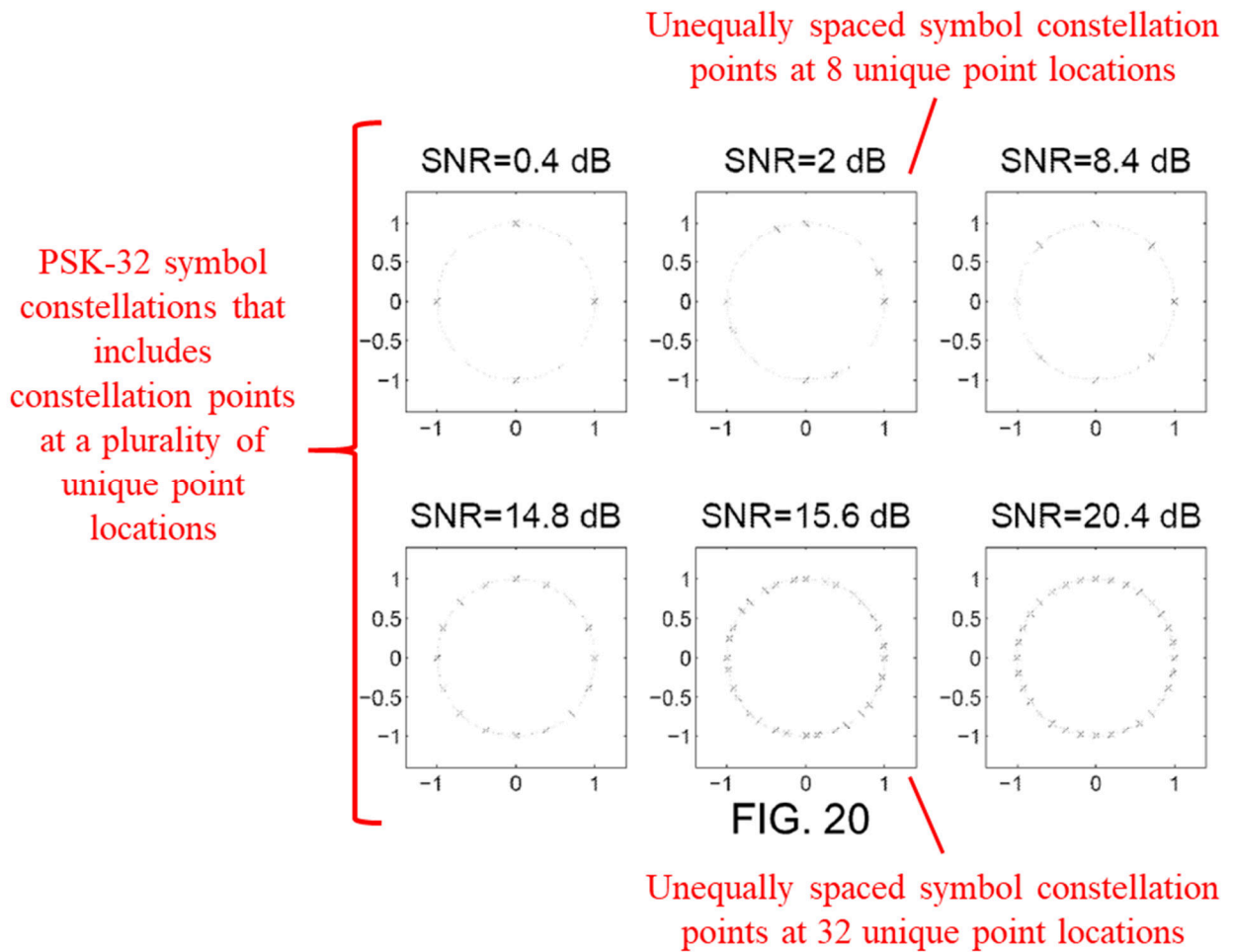
LGE1027, FIG. 20.

Thus, the features of [1c-1] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[135].

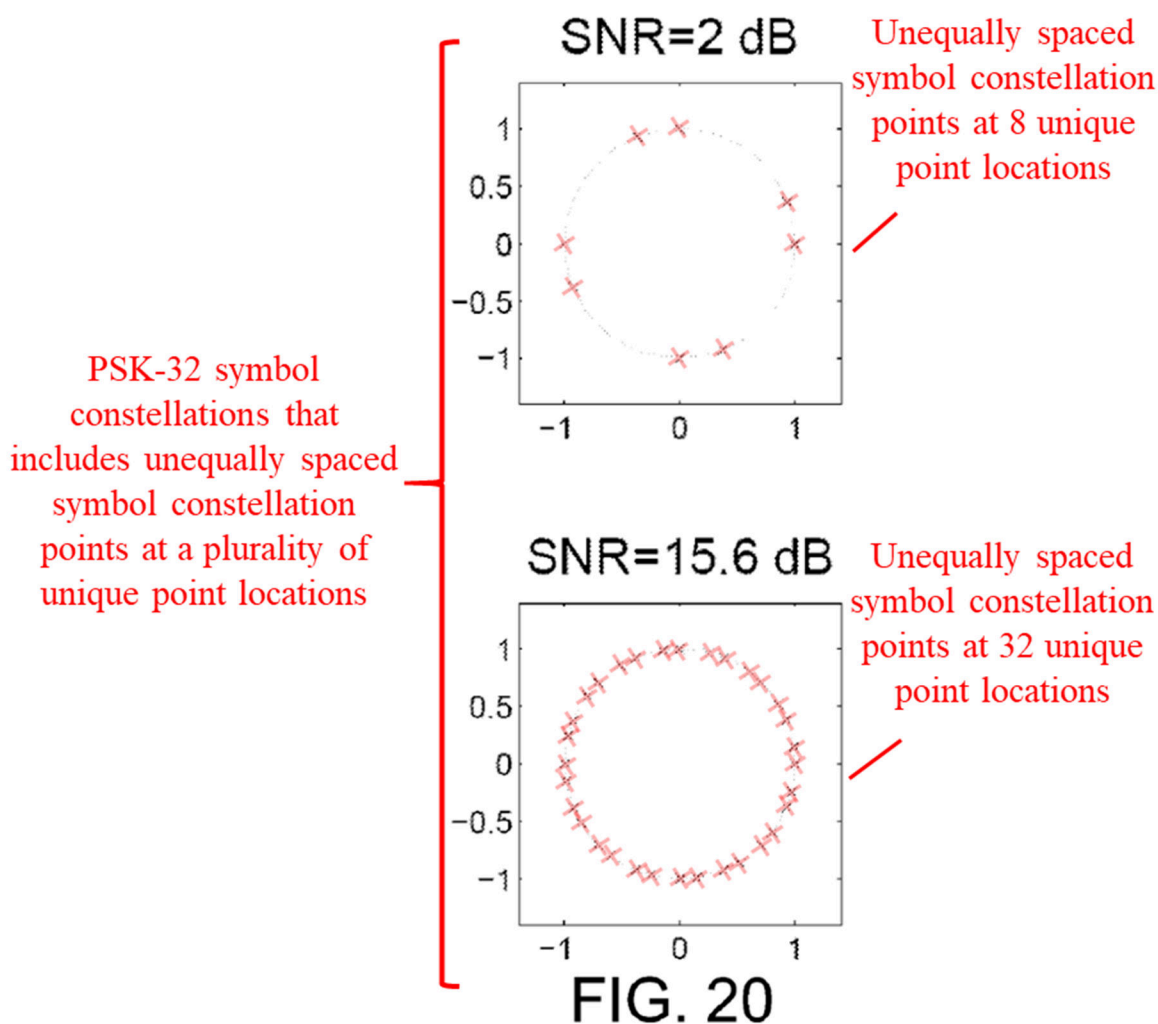
[1c-2]

Supra §V.A.4.[1c-1]; LGE1003, ¶[136]. The '777 discloses ***the plurality of unique point locations are unequally spaced***. The '777 discloses that “[t]he present invention generally relates to bandwidth and/or power efficient digital transmission systems and more specifically to ***the use of unequally spaced constellations*** having

increased capacity.” LGE1027, 1:25-29. The ’777 further establishes that the “communication systems in accordance with embodiments of the invention are described that use *signal constellations, which have unequally spaced* (i.e. ‘geometrically’ shaped) *points*.” LGE1027, 4:47-59; LGE1003, ¶[136]. As discussed above in [1c-1], ’777 discloses *a symbol constellation that includes constellation points at a plurality of unique point locations*. Supra §V.A.4.[1c-1]; LGE1003, ¶[136]. In FIG. 20, the ’777 illustrates different configurations of PSK-32 symbol constellation with optimized locations of constellation points based on SNR values. LGE1027, FIG. 20; LGE1003, ¶[136]. For example, at SNR=2dB, PSK-32 has unequally spaced symbol constellation points at 8 unique point and at SNR=15.6dB, PSK-32 has unequally spaced symbol constellation points at 32 unique points locations. LGE1027, FIG. 20; LGE1003, ¶[136].

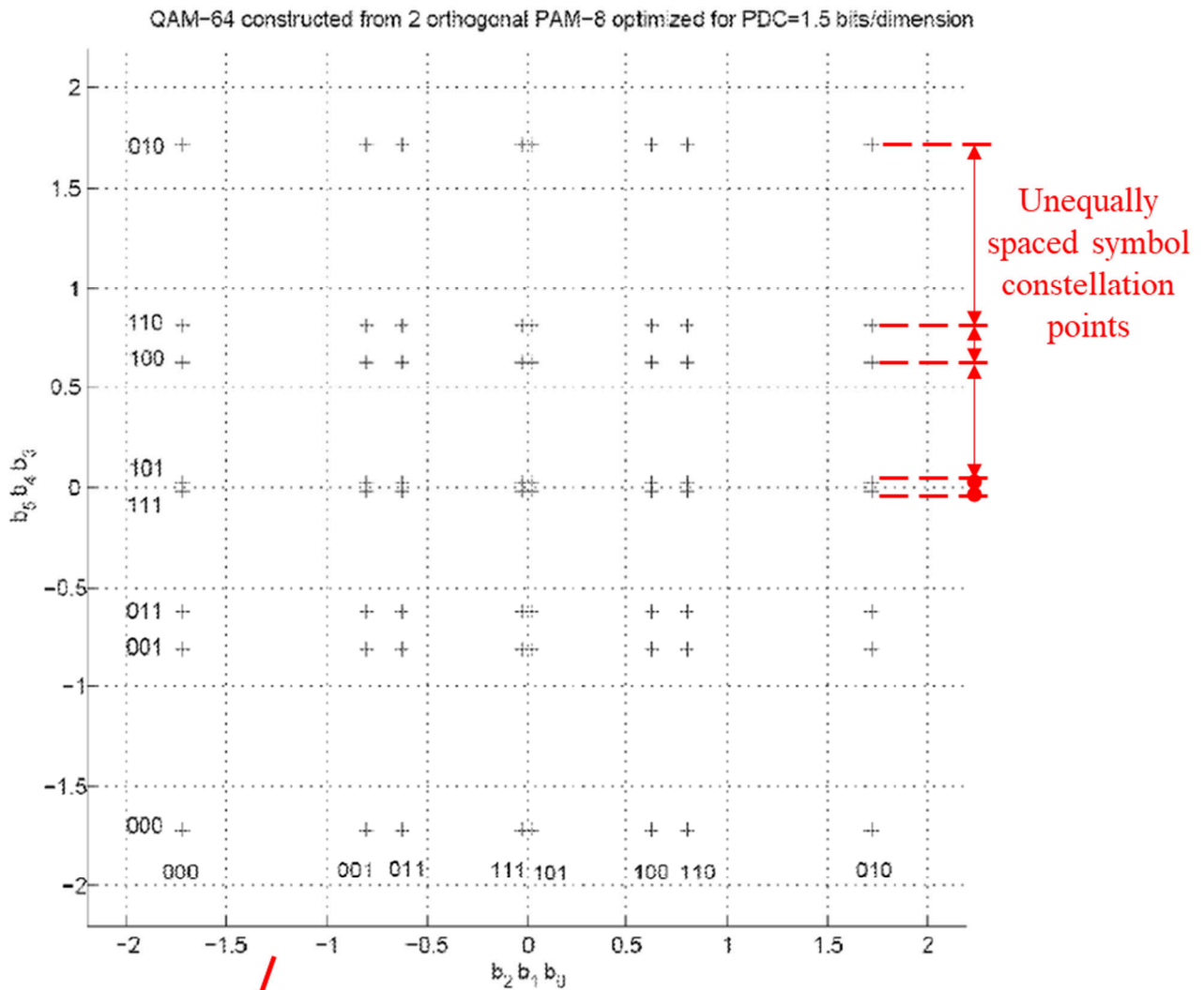


LGE1027, FIG. 20.



LGE1027, FIG. 20 (annotated and magnified view showing PSK-32 unequally spaced symbol constellations at unique point locations, at SNR=2dB and 15.6dB).

Further, in FIG. 21, the '777 also illustrates a QAM-64 unequally spaced symbol constellation points at 64 unique point locations. LGE1027, FIG. 21; LGE1003, ¶[137].

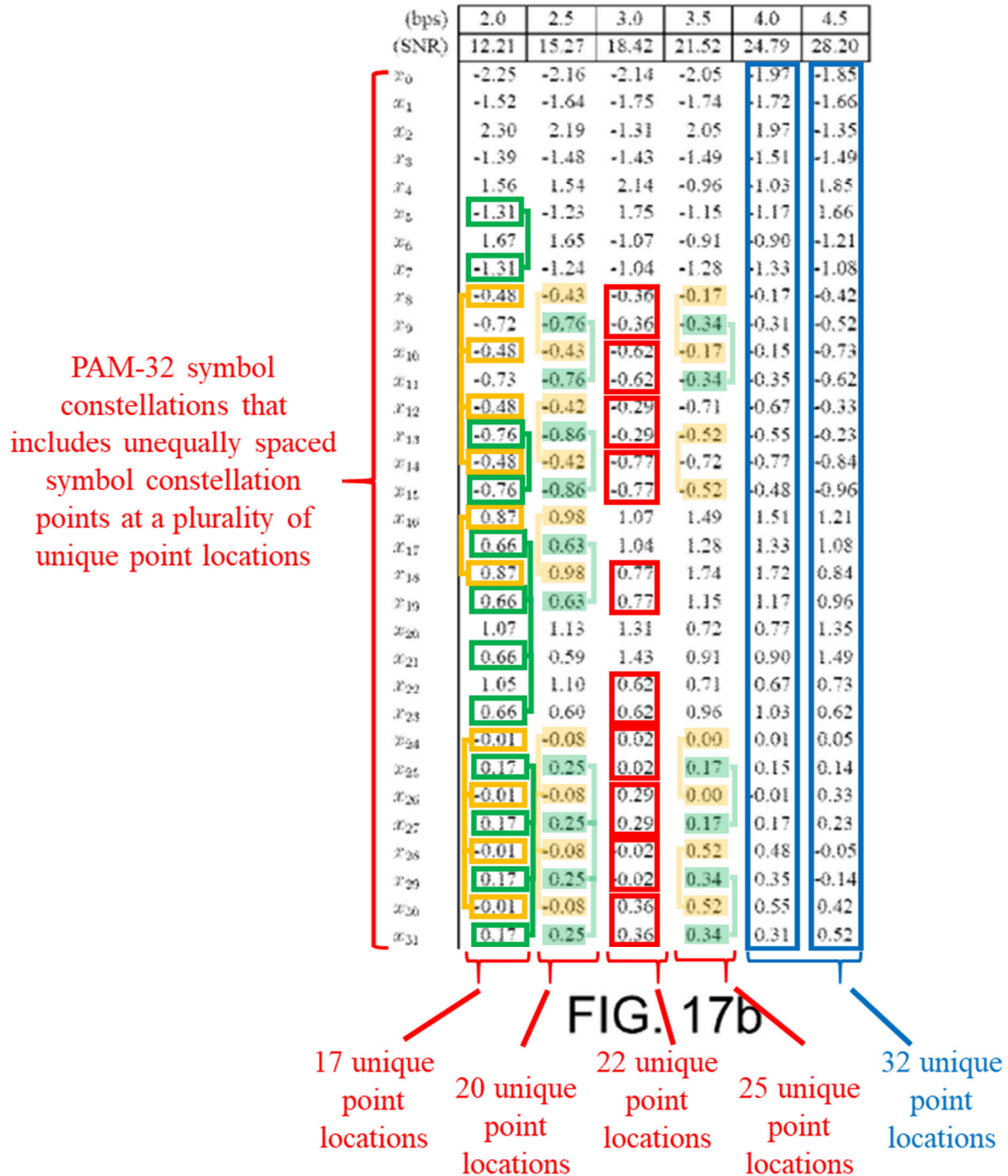


QAM-64 symbol constellation that includes
unequally spaced symbol constellation points
at 64 unique point locations

FIG. 21

LGE1027, FIG. 21.

PAM-32 constellations optimized for parallel decoding capacity at different

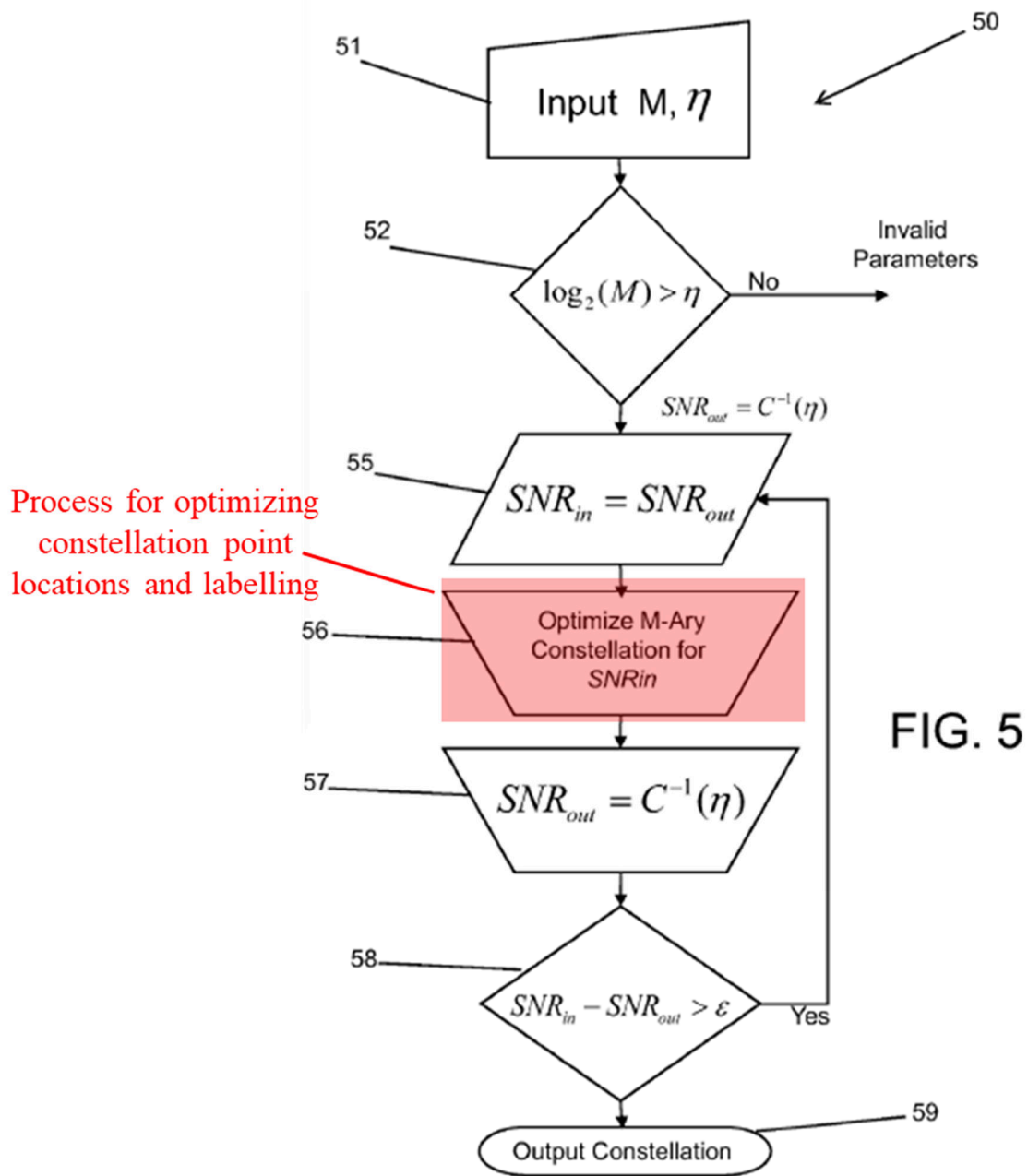


LGE1027, FIG. 17b.

Thus, the features of [1c-2] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[138].

[1c-3]

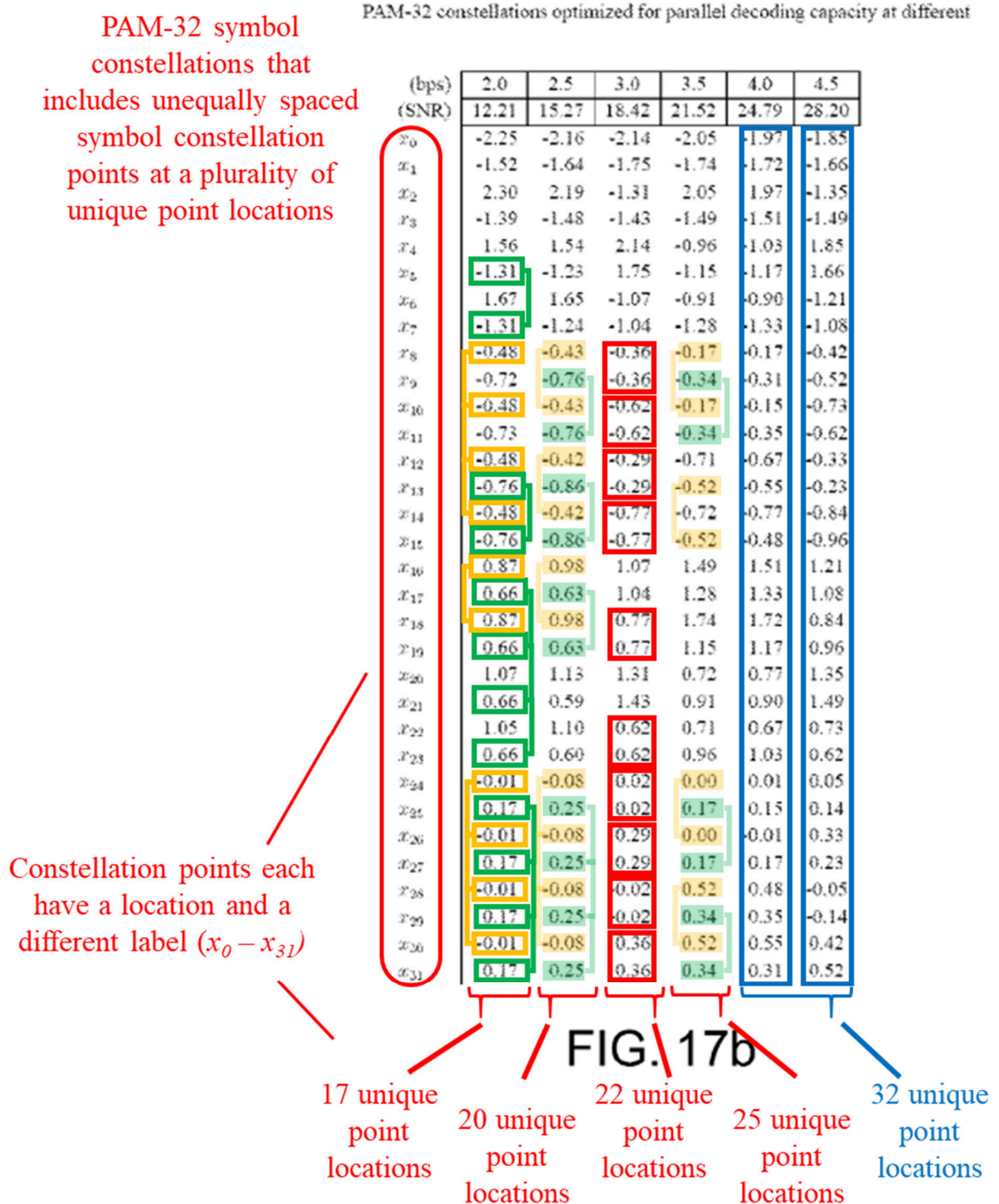
The '777 discloses *the constellation points each have a location and a different label*. For example, as discussed above, the symbol constellation points each have a location. *Supra* §§V.A.4.[1c-1], V.A.4.[1c-2]; LGE1003, ¶[139]. Further, in FIG. 5, the '777 illustrates a flowchart about “[a] process for selecting the points [location], and potentially the labeling, of a geometrically shaped constellation for use in a communication system” and includes “[an] optimization process [that] gives the location of each constellation point identified by its symbol labeling.” LGE1027, 7:15-19; *Id.*, 8:41-42; *see also* 6:45-51, 8:30-46, 8:57-9:2, 10:25-35, FIG. 5; LGE1003, ¶[139].



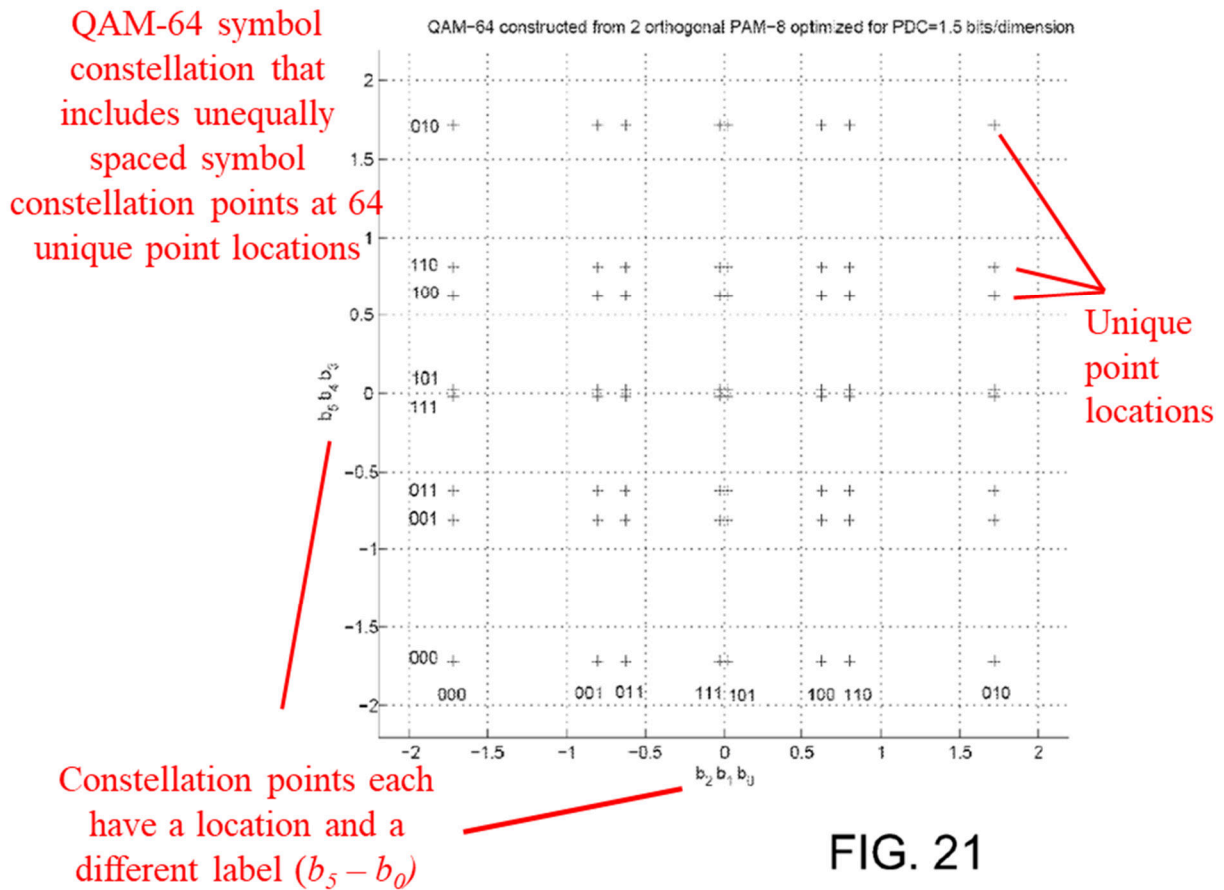
LGE1027, FIG. 5.

In FIGs. 10a-17b, the '777 discloses “locus plots and design tables show PAM-4,8,16,32 *constellation point locations and labelings* from low to high SNR

corresponding to a range of low to high spectral efficiency.” LGE1027, 10:32-35;
see also id., FIGs. 10a-17b, FIG. 21. LGE1003, ¶[140].



LGE1027, FIG. 17b.



LGE1027, FIG. 21.

Thus, the features of [1c-3] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[141].

[1c-4]

The '777 discloses *the locations of at least two of the constellation points are the same*. For example, in 17b, the '777 illustrates PAM-32 constellation optimized for parallel decoding capacity at different values of SNR. LGE1027, FIG. 17b; LGE1003, ¶[142]. When SNR has values 2.0, 2.5, 3.0, and 3.5, the PAM-32

constellations having locations of at least two of the constellation points same.

LGE1027, FIG. 17b; LGE1003, ¶[142].

PAM-32 constellations optimized for parallel decoding capacity at different

(bps)	2.0	2.5	3.0	3.5	4.0	4.5
(SNR)	12.21	15.27	18.42	21.52	24.79	28.20
x_0	-2.25	-2.16	-2.14	-2.05	-1.97	-1.85
x_1	-1.52	-1.64	-1.75	-1.74	-1.72	-1.66
x_2	2.30	2.19	-1.31	2.05	1.97	-1.35
x_3	-1.39	-1.48	-1.43	-1.49	-1.51	-1.49
x_4	1.56	1.54	2.14	-0.96	-1.03	1.85
x_5	-1.31	-1.23	1.75	-1.15	-1.17	1.66
x_6	1.67	1.65	-1.07	-0.91	-0.90	-1.21
x_7	-1.31	-1.24	-1.04	-1.28	-1.33	-1.08
x_8	-0.48	-0.43	-0.36	-0.17	-0.17	-0.42
x_9	-0.72	-0.76	-0.36	-0.34	-0.31	-0.52
x_{10}	-0.48	-0.43	-0.62	-0.17	-0.15	-0.73
x_{11}	-0.73	-0.76	-0.62	-0.34	-0.35	-0.62
x_{12}	-0.48	-0.42	-0.29	-0.71	-0.67	-0.33
x_{13}	-0.76	-0.86	-0.29	-0.52	-0.55	-0.23
x_{14}	-0.48	-0.42	-0.77	-0.72	-0.77	-0.84
x_{15}	-0.76	-0.86	-0.77	-0.52	-0.48	-0.96
x_{16}	0.87	0.98	1.07	1.49	1.51	1.21
x_{17}	0.66	0.63	1.04	1.28	1.33	1.08
x_{18}	0.87	0.98	0.77	1.74	1.72	0.84
x_{19}	0.66	0.63	0.77	1.15	1.17	0.96
x_{20}	1.07	1.13	1.31	0.72	0.77	1.35
x_{21}	0.66	0.59	1.43	0.91	0.90	1.49
x_{22}	1.05	1.10	0.62	0.71	0.67	0.73
x_{23}	0.66	0.60	0.62	0.96	1.03	0.62
x_{24}	-0.01	-0.08	0.02	0.00	0.01	0.05
x_{25}	0.17	0.25	0.02	0.17	0.15	0.14
x_{26}	-0.01	-0.08	0.29	0.00	-0.01	0.33
x_{27}	0.17	0.25	0.29	0.17	0.17	0.23
x_{28}	-0.01	-0.08	-0.02	0.52	0.48	-0.05
x_{29}	0.17	0.25	-0.02	0.34	0.35	-0.14
x_{30}	-0.01	-0.08	0.36	0.52	0.55	0.42
x_{31}	0.17	0.25	0.36	0.34	0.31	0.52

Locations of at least two of the constellation points are the same

FIG. 17b

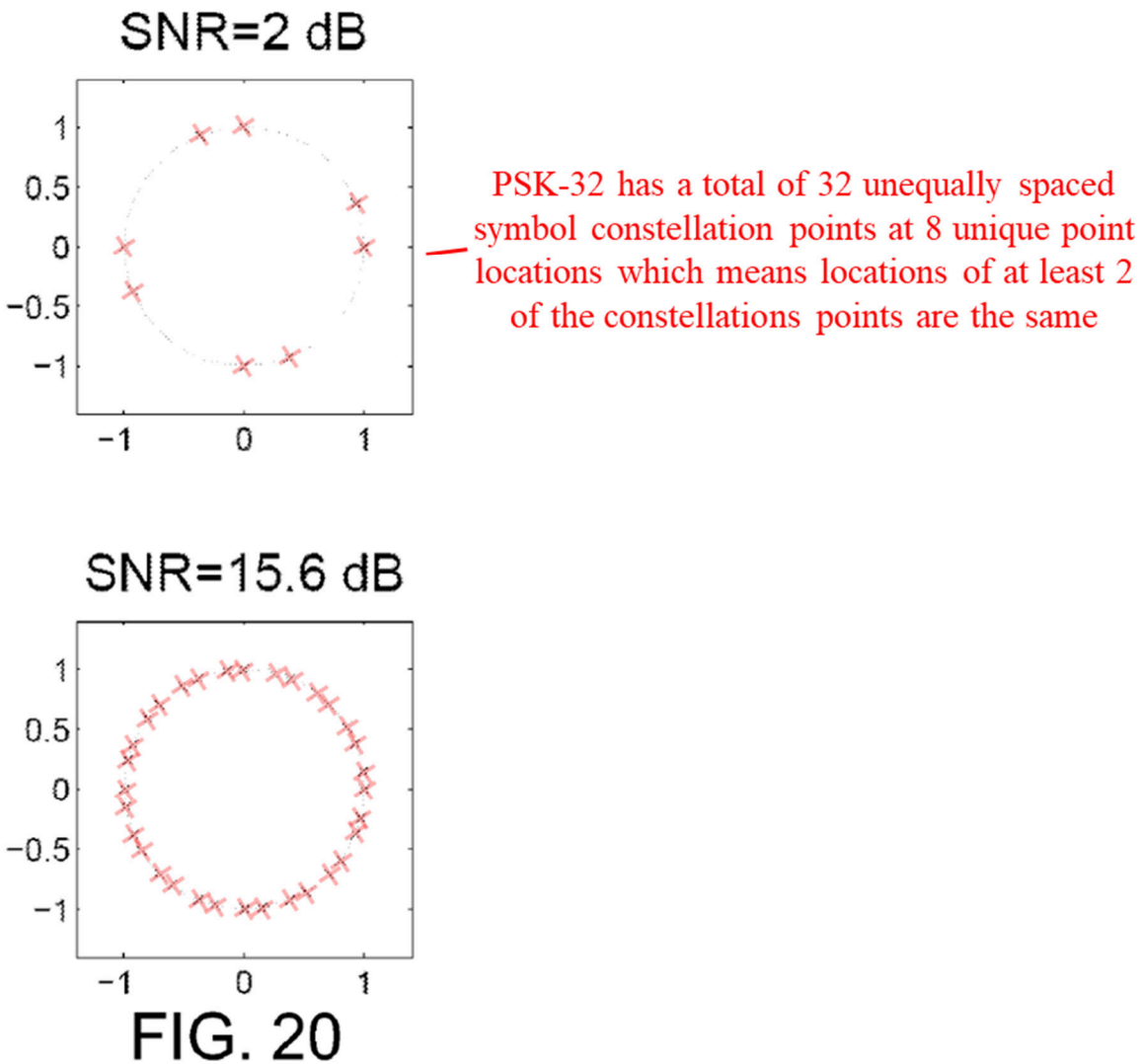
17 unique point locations

20 unique point locations

22 unique point locations

25 unique point locations

LGE1027, FIG. 17b.



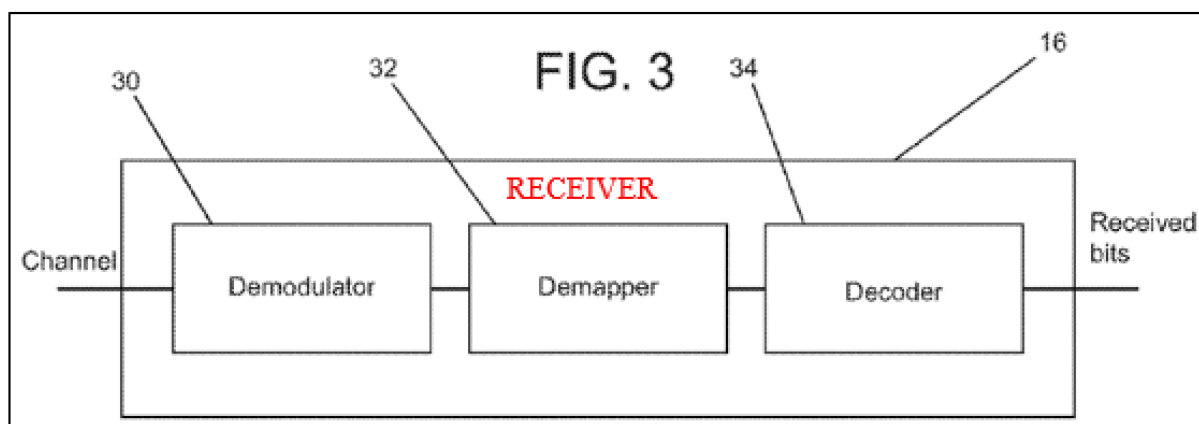
LGE1027, FIG. 20 (annotated and magnified view showing PSK-32 unequally spaced symbol constellations at 8 unique point locations, at SNR=2dB)

Thus, the features of [1c-4] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[143].

[1d]

The '777 discloses *a decoder coupled to the demapper*. LGE1027, 5:40-43;

Fig. 3. The '777's coupling of the decoder 34 to the demapper 32 is shown, for example, in FIG. 3 of the '777 (reproduced below) LGE1003 ¶[144].:



LGE1027, FIGS. 3.

The '777 discloses *a decoder 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*. LGE1027, 5:41-43; 13:31-33; 13:50-51; *see also supra* §V.A.4.[1b]. The decoder of the '777 “provides the likelihoods to a decoder 34 that decodes the encoded bitstream to provide a sequence of received bits to a sink.” LGE1027, 5:41-43. The encoded bitstream that the decoder decodes is encoded using an “encoder (such as an LDPC encoder) at the transmitter.” LGE1027, 6:45-49; 5:25-27. Given that LDPC encoding is used to encode the bitstream, a POSITA would understand that the decoder is configured to decode LDPC encoding.” LGE1003, ¶[145]; *see also* LGE1014, 198, 255 (“On reception of the signals

transmitted from the satellite, the processing steps that were carried out at the encoder have to be reversed”). Accordingly, using the decoder of the ’777 to decode a sequence of received bits that were previously encoded using LDPC based upon a low density parity check (LDPC) code would have been obvious to a POSITA. *Id.* Thus, claim limitation above would have been obvious to a POSITA in view of the ’777. LGE1003, ¶[145].

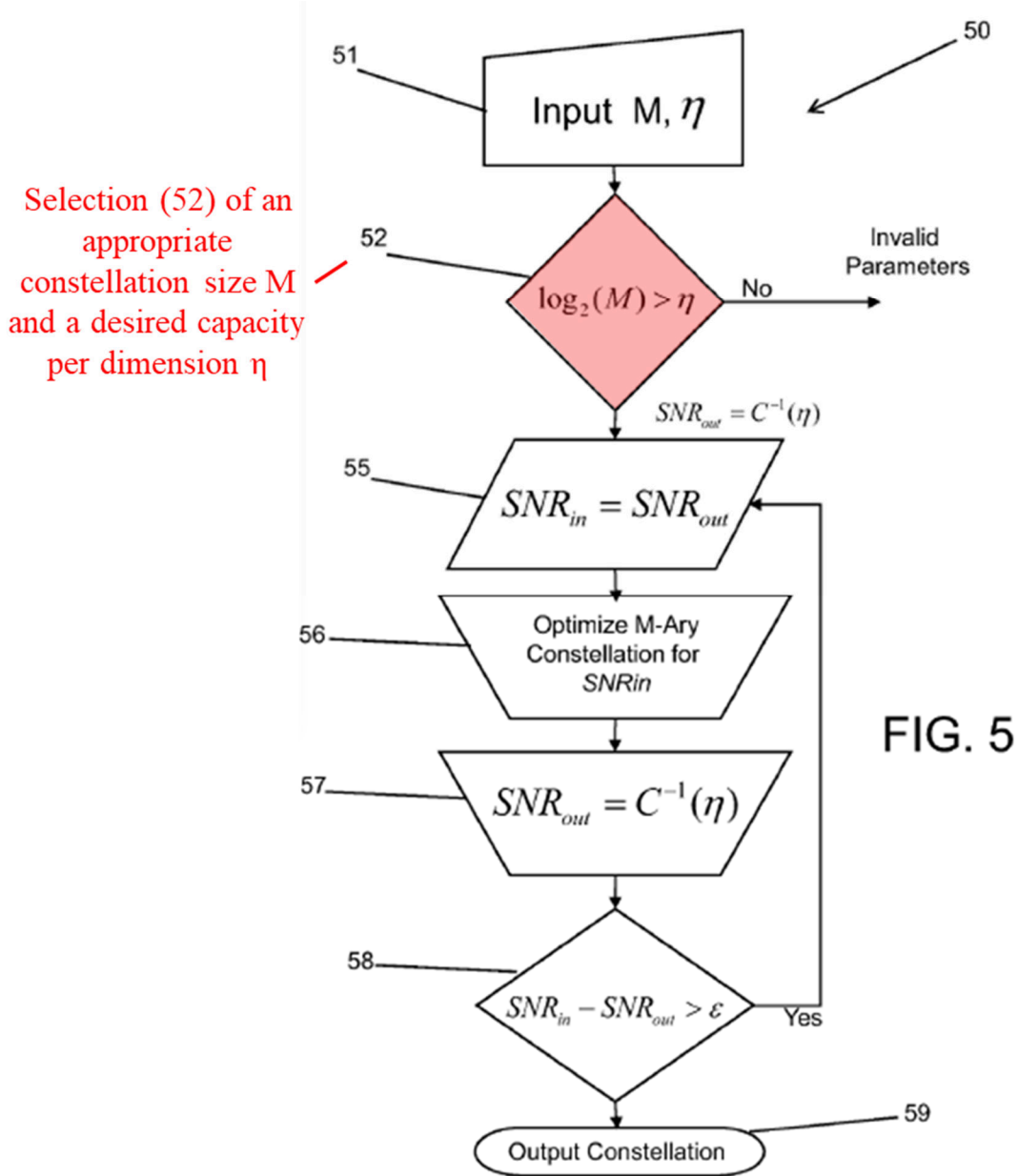
Claim 2

[2a]⁹

In the combination, the ’777 discloses ***the symbol constellation is selected from a plurality of unequally spaced symbol constellations***. The ’777 discloses a section dedicated on “[s]electing a [c]onstellation [h]aving an [o]ptimal [c]apacity” and illustrates the process involved in FIG. 5, “a flow chart showing a process for obtaining a constellation optimized for capacity for use in a communication system having a fixed code rate and modulation scheme.” LGE1027, 7:11-8:29; *id.*, 3:39-42, FIG. 5; *see also id.*, 5:4-7; LGE1003, ¶[146]. In FIG. 5 illustrates that “process

⁹ Because claim 3 depends from claim 1 and 2, this Petition also includes a mapping of the prior art references against claims 1 and 2 (and similarly other independent claims). In Ground 1, this petition is relying on the ’777 as disclosing all the features of claim 2.

50 commences with the selection (52) of an appropriate constellation size M and a desired capacity per dimension η "; in addition, "the process involves a check (52) to ensure that the constellation size can support the desired capacity." LGE1027, 7:19-21; *id.*, 7:21-23. The selection takes of the symbol constellation takes place from among multiple "[g]eometrically shaped constellations." LGE1027, 7:10-11. The '777 further establishes that the "communication systems in accordance with embodiments of the invention are described that use *signal constellations, which have unequally spaced* (i.e. 'geometrically' shaped) *points*." LGE1027, 4:47-59; LGE1003, ¶[146]. Thus, '777 discloses *the symbol constellation is selected from a plurality of unequally spaced symbol constellations*. LGE1003, ¶[146].



LGE1027, FIG. 5.

Thus, the features of [1d] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[147].

[2b]

In the combination, the '777 discloses *the plurality of unequally spaced*

symbol constellations includes a plurality of unequally spaced symbol constellations of a first type that comprise multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations. The '777 discloses geometric (i.e., non-uniform) one dimensional PAM-8 constellations of FIG. 13b. LGE1027, 10:56-62, FIG. 13b. LGE1003, ¶[148]. However, the '777 explains that one dimensional geometric PAM constellations can be orthogonalized into multidimensional QAM constellations. LGE1027, 3:11-19; 4:29-31; 12:12-16; 12:26-33; 12:38-49; LGE1003, ¶[148]. A POSITA would have understood in view of the teachings of the '777 that orthogonalizing the geometric (i.e., non-uniform) one dimensional PAM-8 constellations of FIG. 13b into respective multidimensional QAM constellations would yield multiple different geometric (i.e., non-uniform) multidimensional QAM-64 constellations (FIG. 21 being one example). LGE1027 12:26-33, FIG. 21. LGE1003, ¶[148]. A POSITA would have understood that the '777 that the plurality of multidimensional symbol constellations would be capable of including the geometric (i.e., non-uniform) multidimensional QAM-64 constellations. LGE1027, 3:11-19; 4:29-31; 5:56-6:4; 12:12-16; 12:38-49; LGE1003, ¶[148]. Thus, these features of [3a] would have been obvious to a POSITA. LGE1003, ¶[148].

For the reasons stated above, a POSITA would have found it obvious to continue the orthogonalization process described above to take a PAM-8 and create an QAM-64, to then repeat the process for orthogonalizing a PAM-16 into a QAM-256 and a PAM-32 into a QAM-1024. LGE1027 12:26-33, FIG. 21. LGE1003, ¶[149].

As discussed above in [1c-3] and [1c-4], the '777 also discloses *unequally spaced symbol constellations of the first type include at least two constellation points having locations that are the same and different labels*. *Supra* §§V.A.4.[1c-3], V.A.4.[1c-4]; LGE1003, ¶[150]. A POSITA would have been motivated to implement QAM-64, QAM-256, and QAM-1024 *unequally spaced symbol constellations of the first type* including *at least two constellation points having locations that are the same and different labels*. In another instance, a POSITA would have also considered other modulations schemes such as PSK, PAM, and/or the like. LGE1003, ¶[150].

Thus, the features of [2b] above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[151].

[2c]

The '777 discloses *wherein the receiver is capable of selecting an LDPC code rate and unequally spaced symbol constellation pair from a plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs*

for at least the reasons set forth above with respect to limitation *[1c-1]* above.

Supra §V.A.4.*[1c-1]*; LGE1003, ¶*[152]*.

The '777 discloses a plurality of geometric (i.e., unequally spaced or non-uniform), one-dimensional constellations that each have the number of constellation points (i.e., 4) in FIG. 11b (annotated and reproduced below)

LGE1003 ¶*[153]*::

PAM-4 constellations optimized for parallel decoding capacity at different

(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39
Code rate	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$

FIG. 11b

LGE1027, FIG. 11b

As described in *[1c-1]*-*[1c-4]* above, the '777 explains that each of the four constellations in the constellation design table of FIG. 11b can be optimized into a plurality of corresponding geometric unequally spaced symbol constellations. *See above* *[1c-1]*-*[1c-4]*; LGE1003, ¶*[154]*.

Also implicit in the constellation design tables such as FIG. 11b is a corresponding specific code rate that effectively creates a constellation-code rate pair combination for each column. LGE1003, ¶*[155]*. For example, the LDPC

code rate (shown in green text in annotated FIG. 11b above) is determined the constellation optimization equation set forth in the '319 application provisional, which is incorporated by reference into the '777. In particular, the LDPC code rate for each constellation in FIG. 11b is determined based on “[t]he number of user bits per dimension, η , is related to code rate (e.g., LDPC code rate), R , and the total number of real signaling dimensions, N_{dim} ,” using the following equation:

$$\eta = \frac{R(\log_2(M))}{N_{\text{dim}}},$$

wherein M is, as best understood by Petitioner, the number of constellation points. LGE1015, 2; LGE1003, ¶[156]. Here, η is the capacity in bps provided in FIG. 11b, N_{dim} is the number of dimensions (e.g., 1 for PAM-4 (shown in FIG. 11b) or 2 for QAM constellation), and M is number of points (e.g., 4 for PAM-4 (shown in FIG. 11b) or 16 for the optimized unequally spaced QAM constellation). LGE1027, FIG. 11b; LGE1015, 2; LGE1003, ¶[156]. Thus, a POSITA would have understood that each column of FIG. 11b comprises unequally spaced symbol constellation and LDPC code rate pairs. LGE1003, ¶[156].

Thus, a POSITA would have understood that '777 discloses [2c]. LGE1003 ¶[156].:

[2d]

In the combination, the '777 discloses *each of the plurality of unequally spaced symbol constellations is only included in one of the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs* for at least the reasons set forth above with respect to limitation [2a] and the analysis of other features of [2c] above. Supra §§V.A.4.[2a] and [2c]; LGE1003, ¶[157]. As explained above in [1c-1]-[1c-4] and [2a], the constellation design tables such as FIG. 11b is a corresponding specific code rate that effectively creates a constellation-code rate pair combination for each column. LGE1003. Thus, [2d] would have been obvious to a POSITA in view of the '777. LGE1003, ¶[157].

Claim 3

[3a]

In the combination, the '777 discloses *wherein the plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs includes: multiple LDPC code rate and unequally spaced symbol constellation pairs* for at least the reasons above in [2a], [2b], [2c], and [2d]. LGE1003 ¶[158].:

Regarding the particular ranges claimed, the '777-ATSC327 combination uses the look-up tables of A327 which disclose that when optimizing the non-uniform constellations and LDPC code rate pairs, “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination,” and “a look-up table with the defined constellation mapping for each ModCod combination can be

used.” LGE1028, 32. The annotated look-up table (below) shows the claimed ranges. LGE1003, [159]. Additionally, a POSITA would have found it obvious to select a 64QAM constellations having a code rate that falls within the claimed range. LGE1003, ¶[159]. For example, referring to Table 4.3 (reproduced below), a POSITA would have found it obvious to select multiple 64QAM having a respective code rates falling within the code rates as 2/15, 3/15, and 4/15 at the required SNR values of -0.26, 2.27, and 4.15, respectively. LGE1028, Table 4.3; LGE1003, ¶[159].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[3b]

The annotated look-up table (below) shows the claimed ranges. LGE1003, [160]. Additionally, a POSITA would have found it obvious to select a 256QAM constellations having a code rate that falls within the claimed range. For example, referring to Table 4.3 (reproduced below), a POSITA would have implemented multiple 256QAM having a respective code rates falling within the code rate ranges of 2/15-9/15 with their respective required SNR values. LGE1028, Table 4.3; LGE1003, ¶[160].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[3c]

The annotated look-up table (below) shows the claimed ranges. LGE1003, [161]. Additionally, a POSITA would have found it obvious to select a 1024QAM constellations having a code rate that falls within the claimed range. For example, referring to Table 4.3 (reproduced below), a POSITA would have implemented multiple 1024QAM having a respective code rates falling within the code rate ranges of 2/15-10/15 with their respective required SNR values. LGE1028, Table 4.3; LGE1003, ¶[161].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

Claim 4

[4a]

In the combination, the '777 discloses *wherein the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel is:* for at least the reasons set forth above in [1pre], [1a], and [1b]. LGE1003, [162].

[4b]

In the combination, the ATSC327 discloses *equal to or less than 5.27 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate that is below 1/3 and a sixty-four-point unequally spaced symbol constellation of the first type.*

Recall that “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination,” in Table 4.3 and that LDPC code rates are used. LGE1028, 32. LGE1003, [163]. For example, referring to Table 4.3 (reproduced below), a POSITA would have been motivated to implement ModCod combinations in the '777's communication system. LGE1027, 5:12-43; LGE1028, Table 4.3; LGE1003, ¶[164]. As discussed in above in [2b], a POSITA would have selected a first type of unequally spaced symbol constellation having 64 constellations points paired with a predetermined LDPC code rate to form ModCod combinations. LGE1027, 5:34-6:1; LGE1003, ¶[164]. For example, referring to Table 4.3 (reproduced below), a POSITA would have implemented multiple 64QAM having a respective code rates falling within the code rates as 2/15, 3/15, and 4/15 at the

required SNR values of -0.26, 2.27, and 4.15, respectively. LGE1028, Table 4.3; LGE1003, ¶[165]. Similarly, referring to Table 4.4 (reproduced below), a POSITA would have implemented multiple 64QAM having a respective code rates falling within the code rates as 2/15 and 3/15 at the required SNR values of 0.86 and 3.61, respectively. LGE1028, Table 4.4; LGE1003, ¶[163-165].

The annotated look-up table (below) shows the claimed ranges and values.

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[4c]

In the combination, the ATSC327 discloses *equal to or less than 15.42 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 5/8 and a two-hundred-fifty-six-point*

unequally spaced symbol constellation of the first type. As discussed in above in [2b], a POSITA would have selected a first type of unequally spaced symbol constellation having 256 constellations points paired with a predetermined LDPC code rate to form ModCod combinations. LGE1027, 5:34-6:1; LGE1003, ¶[166]. For example, referring to Table 4.3 (reproduced below), a POSITA would have implemented multiple 256QAM having a respective code rates falling within the code rates $2/15$, $3/15$, $4/15$, $5/15$, $6/15$, $7/15$, and $8/15$ at the required SNR values of 1.6, 4.3, 6.57, 8.53, 10.61, 12.1, and 13.91, respectively. Similarly, referring to Table 4.4 (reproduced below), a POSITA would have implemented multiple 256QAM having a respective code rates falling within the code rates as ranges $2/15$ - $7/15$ with their respective required SNR values. LGE1028, Table 4.4; LGE1003, ¶[166].

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [167].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[4d]

In the combination, the ATSC327 discloses *equal to or less than 21.52 dB while using an LDPC code rate and unequally spaced symbol constellation pair that includes an LDPC code rate below 7/10 and a one-thousand-twenty-four-point unequally spaced symbol constellations of the first type*. As discussed in above in [2b], a POSITA would have selected a first type of unequally spaced symbol constellation having 1024 constellations points paired with a predetermined LDPC code rate to form ModCod combinations. LGE1027, 5:34-6:1; LGE1003, ¶[168]. For example, referring to Table 4.3 (reproduced below), a

POSITA would have implemented multiple 1024QAM constellations that each have a respective code rates falling within the code rate that falls within the code rate range of 2/15-10/15 at their respective required SNR values. Similarly, referring to Table 4.4 (reproduced below), a POSITA would have implemented multiple 1024QAM constellation that each have a respective code rates falling within the code rate that falls within the code rate ranges of 2/15-8/15 with their respective required SNR values. LGE1028, Table 4.4; LGE1003, ¶[168].

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [169].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

Claim 5

[5a]

In the combination, the '777 discloses *the plurality of unequally spaced symbol constellations include a plurality of unequally spaced symbol constellations of a second type that comprises multiple different sixteen-point symbol constellations, multiple different sixty-four-point symbol constellations, multiple different two-hundred-fifty-six-point symbol constellations, and multiple different one-thousand-twenty-four-point symbol constellations:* for at least the reasons set forth above in [2a], [2b], and [2c]. LGE1003, [170].

[5b]

Within the ModCod combination look-up tables, “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination.” LGE1028, 32; LGE1003, [171].

[5c]

Supra [1c-1]. The '777-ATSC327 combination provides the ability of the demapper to demodulate multidimensional signals. LGE1027, 12:44-47; LGE1003, [172].

[5d]

The annotated look-up table (below) shows the claimed ranges and values.

LGE1028, 18; LGE1003, [173]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 a *plurality of predetermined LDPC code rate and unequally spaced symbol constellation pairs include*: For example, recall that the ModCod pairs all have non-uniform constellations *see* [5b] and that the '777 Combination can utilize LDPC codes *see* [1d]. LGE1027, 5:41-43; 13:31-33; 13:50-51; LGE1028, 32. Table 4.3 also discloses *multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8 and a sixteen-point unequally spaced symbol constellation*. For example, a 8/15 LDPC code rate can be selected with a 16QAM constellation for the table. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[173].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[5e]

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [174]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 *multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 3/6 and less than or equal to 5/6 and a sixty-four-point unequally spaced symbol constellation*. For example, a 10/15 LDPC code rate can be selected with a 64QAM constellation for the table. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced

symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[174].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Co 3/6												Co 5/6	
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53		
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83		
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03		
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22		
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62		
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83		

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Co 3/6												Co 5/6	
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97		
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85		
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82		
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62		
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59		
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54		

LGE1028, Table 4.3-4.4, 18

[5f]

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, ¶[175]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 *multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 6/8 and less than or equal to 7/8 and a two-hundred-and-fifty-six-point unequally spaced symbol constellation.* For example, a 12/15 LDPC

code rate can be selected with a 256QAM constellation for the table. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[175].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											6/8	7/8
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53	
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83	
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03	
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22	
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62	
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83	

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											6/8	7/8
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97	
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85	
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82	
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62	
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59	
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54	

LGE1028, Table 4.3-4.4, 18

[5g]

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [176]. In the “777-ATSC327 combination, A327 discloses through Table 4.3 *multiple LDPC code rate and unequally spaced*

symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 8/10 and less than or equal to 9/10 and a one- thousand-twenty-four-point unequally spaced symbol constellation. For example, a 12/15 LDPC code rate can be selected with a 1024QAM constellation for the table. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[176].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											8/10	9/10
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53	
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83	
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03	
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22	
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62	
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83	

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											8/10	9/10
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97	
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85	
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82	
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62	
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59	
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54	

LGE1028, Table 4.3-4.4, 18

[5h]

The '777-ATSC327 combination teaches *the receiver is capable of decoding the signals received over the communication channel when the SNR of the communication channel, see [1a], [1b], and [1d].* LGE1003 ¶[177].:

Further the A327 teaches to “[n]ote that these mandatory ModCod combinations may be useful when broadcasters have a desired physical layer throughput and need to choose the best-performing ModCod combination among all the possible ModCod combinations that have the same throughput. For maximum broadcaster flexibility, and possible future extensibility of ATSC 3.0, *it is strongly recommended that all the ModCod combinations* (i.e., 72 choices for long codes and 48 choices for short codes) *be implemented* in ATSC 3.0 *transmitters as well as* in ATSC 3.0 *receivers.*” LGE1028, 19. LGE1003 ¶[178].:

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [179]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 an SNR of *between 3.11 dB and 9.25 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8 and a sixteen-point unequally spaced symbol constellation.* For example, a 8/15 LDPC code rate can be selected with a 16QAM constellation for the table having a SNR value of 6.30dB. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of

unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same.

Supra §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[179].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54

LGE1028, Table 4.3-4.4, 18

[5i]

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [180]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 an SNR of *between 9.00 dB and 15.93 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or*

greater than 3/6 and less than or equal to 5/6 and a sixty-four-point unequally spaced symbol constellation. For example, a 10/15 LDPC code rate can be selected with a 64QAM constellation for the table having a SNR value of 12.88dB. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[180].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Co 3/6												5/6
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53	
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83	
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03	
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22	
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62	
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83	

Table 4.4 Required SNRs (dB) for all ModCod Combinations, Long LDPC Codes (64800 bits) and i.i.d. Rayleigh Channel

Constellation	Co 3/6												5/6
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15	
QPSK	-5.72	-3.62	-1.97	-0.55	0.86	1.95	3.16	4.35	5.62	7.05	8.76	10.97	
16QAM	-1.84	0.81	2.69	4.32	5.98	7.21	8.63	9.94	11.40	12.78	14.60	16.85	
64QAM	0.86	3.61	5.88	7.74	9.72	11.10	12.75	14.25	15.81	17.44	19.39	21.82	
256QAM	2.89	5.97	8.46	10.59	12.92	14.58	16.54	18.23	20.06	21.94	24.01	26.62	
1024QAM	4.65	8.04	10.85	13.25	15.91	17.84	20.13	22.34	24.47	26.61	28.82	31.59	
4096QAM	6.23	9.83	12.95	15.75	18.79	21.03	23.67	26.37	28.64	31.18	33.82	36.54	

LGE1028, Table 4.3-4.4, 18

[5j]

The annotated look-up table (below) shows the claimed ranges and values.

LGE1028, 18; LGE1003, [181]. In the '777-ATSC327 combination, A327

discloses through Table 4.3 an SNR of *between 18.72 dB and 22.13 dB while using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 6/8 and less than or equal to 7/8 and a two-hundred-and-fifty-six-point unequally spaced symbol constellation*. For example, a 12/15 LDPC code rate can be selected with a 256QAM constellation for the table having a SNR value of 20.44dB. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[181].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate												6/8	7/8
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15		
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53		
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83		
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03		
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22		
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62		
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83		

LGE1028, Table 4.3, 18

[5k]

The annotated look-up table (below) shows the claimed ranges and values. LGE1028, 18; LGE1003, [182]. In the '777-ATSC327 combination, A327 discloses through Table 4.3 an SNR of *between 24.79 dB and 28.20 dB while*

using at least one of the multiple LDPC code rate and unequally spaced symbol constellation pairs that each include an LDPC code rate that is equal to or greater than 8/10 and less than or equal to 9/10 and a one-thousand-twenty-four-point unequally spaced symbol constellation. For example, a 12/15 LDPC code rate can be selected with a 1024QAM constellation for the table having a SNR value of 5.52dB. As discussed above in §V.A.3, the 777-ATSC327 may include a second type of unequally spaced symbol constellation that includes no two constellation points within an unequally spaced symbol constellation share locations that are the same. *Supra* §V.A.3; LGE1027, FIG. 20; LGE1003, ¶[182].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate												8/10	9/10
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15		
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53		
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83		
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03		
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22		
1024QAM	3.23	6.17	8.77	11.07	13.46	15.30	17.46	19.45	21.35	23.43	25.52	27.62		
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83		

LGE1028, Table 4.3, 18

Claim 6

[6a]

The '777 discloses all the features of [6a] for the reasons set forth above.

See [1a] and [2a]. LGE1003, [183].

[6b]

In the '777-ATSC327 combination, '777 teaches that *each of the plurality*

of unequally spaced symbol constellations is characterized by the assignment of labels (*Supra* [2d]) and ATSC327 discloses the other limitations of [6b].

LGE1028, 18, Table 4.3, 4.4. In the '777-ATSC327 combination, ATSC327 is used to enable the communication system to have “a look-up table with the defined constellation mapping for each ModCod combination can be used.” LGE1028, 32. In this table (e.g., Tables 4.3), “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination.” LGE1028, 32. LGE1003, [184].

A POSITA would have understood how to implement Table 4.3 (reproduced below) was look-up table that includes a *plurality of unequally spaced symbol constellations* that are optimized for capacity *at a symbol constellation operating SNR*. LGE1028, 18, Table 4.3, 4.4; LGE100, [185]. Further, a POSITA would have found it obvious that when comparing ModCod combinations from the implemented Table 4.3, that *each* of the constellation code rate pairs has a required SNR in order to achieve a desired capacity and that to compare two constellations from this table *at the same SNR* would result in one of the two constellations (the constellation optimized to perform at a symbol constellation operating SNR) *providing a greater capacity than the other symbol constellation*. LGE1028, 18, Table 4.3, 4.4; LGE1003, [185].

Table 4.3 Required SNRs (dB) for all ModCod Combinations, Long LDPC codes (64800 bits) and AWGN Channel

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	-6.23	-4.32	-2.89	-1.70	-0.54	0.30	1.16	1.97	2.77	3.60	4.49	5.53
16QAM	-2.73	-0.25	1.46	2.82	4.21	5.21	6.30	7.32	8.36	9.50	10.57	11.83
64QAM	-0.26	2.27	4.15	5.96	7.66	8.92	10.31	11.55	12.88	14.28	15.57	17.03
256QAM	1.60	4.30	6.57	8.53	10.61	12.10	13.91	15.55	17.13	18.76	20.44	22.22
1024QAM	3.23	6.17	8.77	11.07	13.48	15.30	17.46	19.45	21.35	23.43	25.52	27.62
4096QAM	4.58	7.85	10.73	13.45	16.04	18.22	20.69	23.05	25.55	28.11	30.34	32.83

LGE1028, Table 4.3-4.4, 18

For example, Table 4.3 (annotated above) shows *a first plurality of unequally spaced symbol (QAM-16) constellations* (annotated in the red box) with code rates 4/15-5/15 *and another plurality of unequally spaced symbol (QAM-16) constellations* (annotated in the blue box) with code rates 7/15-9/15. LGE1003, [186]. *When comparing the capacity of each* of the symbol constellations in the first plurality (red box) relative to the symbol constellations of the second plurality (blue box) *at the same SNR* of 2.82dB, *each of the plurality of constellations in the first plurality unequally spaced symbol constellation QAMs* (red box) *will have a greater capacity at 2.82dB than the other constellations in the second plurality* (blue box) operating at the same 2.82dB. *Id.* This is because when a constellation code rate pair from the blue box, for example 16QAM and 9/15, requires a minimum SNR of, for example 7.32dB, and that 16QAM and 9/15 code rate is operated below its required minimum SNR of 7.32db, this can result in dropped packets leading to lower throughput. *Id.*

In addition, ATSC327 teaches “mandatory ModCod combinations for long

codes (shown in table 4.7),” which explicitly discloses the two pluralities (annotated in Table 4.7 below). LGE1028, 19 A POSITA would have found it obvious that the constellations optimized for performance *at a symbol constellation operating SNR*, when compared at the *same* SNR, which is either the same or closer to the minimum required SNR of a plurality of optimized constellations, that the constellations more closely optimized to the SNR at which the constellations are being compared (same SNR), will have more capacity than those constellations that are optimized for SNRs farther separated from the compared (same SNR). LGE1003, [187]. A POSITA would have known that operating a constellation below its minimum required SNR would have deleterious effects on the throughput of the constellation. LGE1003, [187]

A POSITA would have found it obvious that when two pluralities of constellations that have each been optimized for capacity *at a symbol constellation operating SNR*, are then compared at the same SNR, and if the (same) SNR at which they are being compared is within the range of one of the pluralities, that the plurality operating (during the comparison) closer to its own required SNR will have a higher capacity than the plurality operating further from its required SNR. LGE1003, [187]-[188].

Table 4.7 Mandatory ModCod Combinations for Long Codes (64800 bits)

Constellation	Code Rate											
	2/15	3/15	4/15	5/15	6/15	7/15	8/15	9/15	10/15	11/15	12/15	13/15
QPSK	✓	✓	✓	✓	✓	✓	✓	✓		✓		
16QAM			✓	✓		✓	✓	✓		✓		
64QAM		✓	✓	✓	✓	✓	✓	✓	✓	✓		
256QAM			✓	✓		✓	✓	✓	✓	✓	✓	✓
1024QAM				✓		✓	✓	✓	✓	✓	✓	✓
4096QAM						✓		✓		✓	✓	✓

LGE1028, 19

Therefore, the limitations of [5] would have been obvious to a POSITA in view of the '777-ATSC327 combination. *See also* LGE1030, 199; LGE1023, 59-62; LGE1003, [189]-[192].

As a corroborating reference, Loghin discloses in ATSC 3.0, a constellation provides greater parallel decoding capacity (maximized BICM capacity) when operated at its associated SNR than any of the other plurality of symbol constellation when operated at the same SNR. LGE1030, 199; LGE1023, 59-62; LGE1003,¶ [192]. Thus, it would have been obvious for a POSITA, at a specific SNR, each of the plurality of different non-uniform unequally spaced symbol constellations is capable of providing a greater parallel decoding capacity than any of the plurality of ATSC 3.0 specified constellations. LGE1030, 199; LGE1023, 59-62; LGE1003,¶ [192].

Claim 7

[7]

The '777-ATSC327 combination teaches *wherein the symbol constellation operating SNR is a channel SNR where the receiver is capable of using the respective unequally spaced symbol constellation to receive data at a frame error rate (FER) of 10^{-2} or lower.*

ATSC327 discloses through figure 6.12, receiver performance against the theoretical channel capacity limit or Shannon Limit. LGE1028, 82. "Given the four different LDPC decoding algorithms (i.e., SPA, MSA, OMSA, and NMSA), the simulation performance of ATSC 3.0 LDPC codes in an AWGN channel was analyzed." LGE1028, 79. A POSITA would have known that an Additive White Gaussian Noise (AWGN) channel contributes to a baseline estimated channel SNR. Figure 6.12 (annotated below) shows that when using a channel SNR, the receiver is capable of receiving data at a frame error rate (FER) of 10^{-2} or lower. LGE1003, [194].

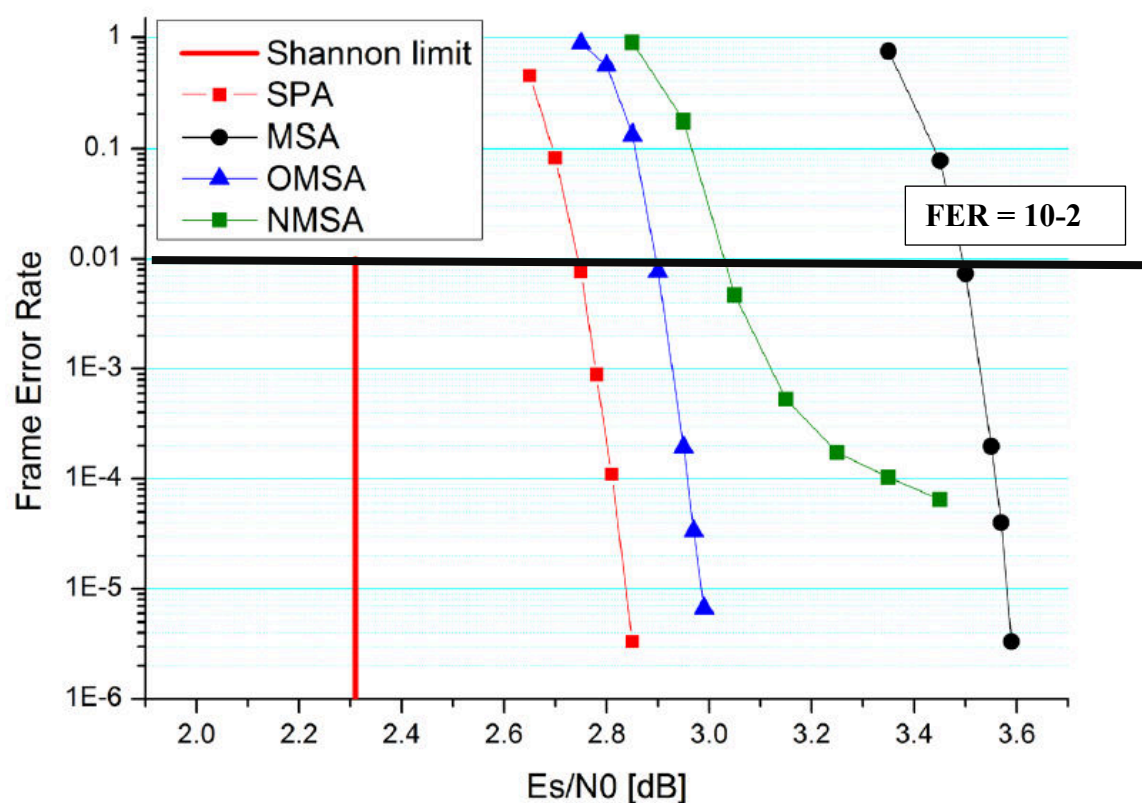


Figure 6.12 LDPC code performance based on various decoding algorithms (Code rate = 10/15, Code length = 64800, AWGN channel).

LGE1028, 82

Claim 11

[11pre]

To the extent the preamble is limiting, 777 in view of ATSC renders [11pre] obvious. *Supra* [1pre]; LGE1003, ¶[195].

[11a]

Supra [1a]; LGE1003, ¶[196].

[11b]

Supra [1b]; LGE1003, ¶[197].

[11c-1]

Supra [1c-1]; LGE1003, ¶[198].

[11c-2]

Supra [1c-2]; LGE1003, ¶[199].

[11c-3]

Supra [1c-3]; LGE1003, ¶[200].

[11c-4]

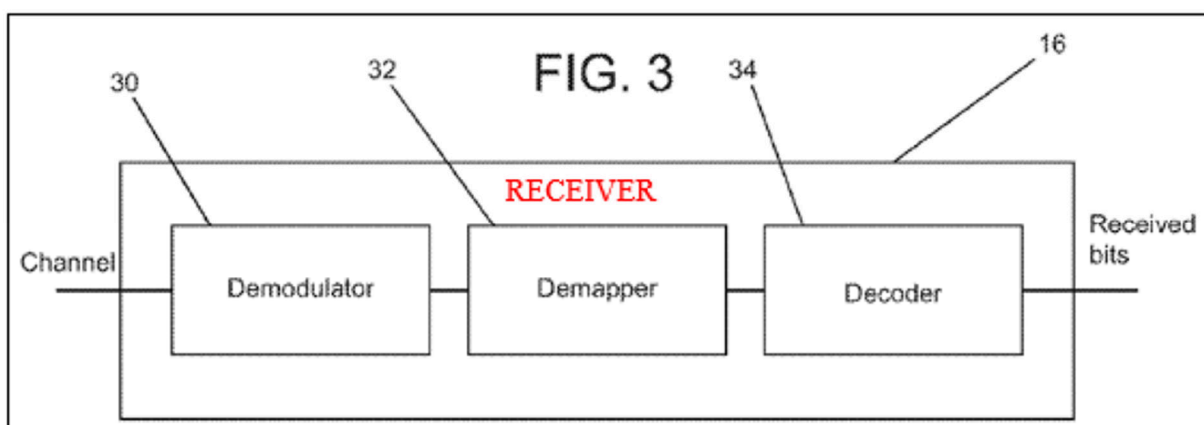
Supra [1c-4]; LGE1003, ¶[201].

[11d]

Supra [1d]; LGE1003, ¶[202].

[11e]

Supra [1a], [1b], and [1d]; LGE1003, ¶[203]. For example, the “receiver 16 includes a demodulator 30 that demodulates a signal received via the channel to obtain symbol or bit likelihoods.” LGE1027, 5:35-43; 13:37-38. The receiver 16 of the communication system 10 is shown in FIG. 3 of the ’777 (reproduced below) illustrates a demapper 32 interposed between a demodulator 30 and a decoder 34. LGE1027, FIG. 3.



LGE1027, FIGS. 3.

Thus, claim limitation above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[204].

Claims 12 and 23

[12a], [23a]

Supra [2a]; LGE1003, ¶[205].

[12b], [23b]

Supra [2b]; LGE1003, ¶[206].

[12c], [23c]

Supra [2c]; LGE1003, ¶[207].

[12d], [23d]

Supra [2d]; LGE1003, ¶[208].

Claims 13 and 24

[13a], [24a]

Supra [3a]; LGE1003, ¶[209].

[13b], [24b]

Supra [3b]; LGE1003, ¶[210].

[13c], [24c]

Supra [3c]; LGE1003, ¶[211].

Claims 14 and 25

[14a], [25a]

Supra [4a]; LGE1003, ¶[212].

[14b], [25b]

Supra [4b]; LGE1003, ¶[213].

[14c], [25c]

Supra [4c]; LGE1003, ¶[214].

Claims 15 and 26

[15a], [26a]

Supra [5a]; LGE1003, ¶[215].

[15b], [26b]

Supra [5b]; LGE1003, ¶[216].

[15c]

Supra [5c]; LGE1003, ¶[217].

[26c]

Supra [21b]; LGE1003, ¶[218]. As discussed above in [21b], in the

combination, the '777 discloses that *the receiver also transforms received signals into received bits using an unequally spaced symbol constellation of the second type*. Regarding *the second type*, the '777 discloses multiple examples in 11b, 13b, 15b, and 17b, of PAM-4, PAM-8, PAM-16, and PAM-32, respectively wherein no two constellation points have locations that are the same. *Supra* [2b] and [26b]. LGE1003, ¶[218].

Thus, claim limitation above would have been obvious to a POSITA in view of the '777. LGE1003, ¶[219].

[15d], [26d]

Supra [5d]; LGE1003, ¶[220].

[15e], [26e]

Supra [5e]; LGE1003, ¶[221].

[15f], [26f]

Supra [5f]; LGE1003, ¶[222].

[15g], [26g]

Supra [5g]; LGE1003, ¶[223].

[15h], [26h]

Supra [5h]; LGE1003, ¶[224].

[15i], [26i]

Supra [5i]; LGE1003, ¶[225].

[15j], [26j]

Supra [5j]; LGE1003, ¶[226].

[15k], [26k]

Supra [5k]; LGE1003, ¶[227].

Claims 16 and 27

[16a], [27a]

Supra [6a]; LGE1003, ¶[228].

[16b], [27b]

Supra [6b]; LGE1003, ¶[229].

Claims 17 and 28

[17], [28]

Supra [7]; LGE1003, ¶[230].

Claim 21

[21pre]

To the extent the preamble is limiting, '777 and ATSC renders [21pre] obvious. *Supra* [1pre]; LGE1003, ¶[231].

[21a]

Supra [1a]; LGE1003, ¶[232].

[21b]

Supra [21pre], [21a], and [1c-3]; LGE1003, ¶[233]. In this combination, the '777 discloses ***the receiver uses a symbol constellation to transform the received signals into received bits, and the symbol constellation includes constellation***

points at a plurality of unique point locations. For example, “the receiver includes a demodulator configured to demodulate the received signal via the communication channel, a demapper configured to estimate likelihoods from the demodulated signal, a decoder that is configured to estimate decoded bits from the likelihoods generated by the demapper.” LGE1027, Abstract, 5:35-43; 13:37-38. As discussed above in [1c-1], in the combination, the ’777 discloses *symbol constellation includes constellation points at a plurality of unique point locations.* LGE1003, ¶[233].

Thus, claim limitation above would have been obvious to a POSITA in view of the ’777. LGE1003, ¶[234].

[21c-1]

Supra [1c-2]; LGE1003, ¶[235].

[21c-2]

Supra [1c-3]; LGE1003, ¶[236].

[21c-3]

Supra [1c-4]; LGE1003, ¶[237].

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

Patent Owner (“Constellation”) filed an infringement action against LGE involving seven patents. *See* LGE1022 (Complaint). The action, assigned Case No.

2:21-cv-00448 (“the Related Litigation”), is concurrently pending in the Eastern District of Texas before the Honorable Judge Rodney Gilstrap. LGE1026.

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

Here, Petitioner has eliminated any risk of duplicated effort by voluntarily stipulating to counsel for Patent Owner that, if the Board institutes an IPR, Petitioner will not pursue, in the District Court proceedings with respect to claims 3-7, 13-17, and 24-28 of the ’509 Patent, the grounds asserted in this IPR petition or on any other ground that was raised or could have been reasonably raised by Petitioner in an IPR. LGE1021; *Sotera Wireless, Inc. v. Masimo Corp.*, Case IPR2020-0109, Paper 12 (PTAB Dec. 1, 2020). Because Petitioner is submitting a *Sotera*-style stipulation in these proceedings that has the same scope as the stipulation described in the PTAB’s updated *Fintiv* guidance, the *Fintiv* factors do

not favor discretionary denial.

VII. CONCLUSION

Petitioner requests institution and cancellation of the Challenged Claims.

VIII. FEES

LGE authorizes charge of Deposit Account No. 06-1050 for any fees.

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

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

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

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

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

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

Petitioner provides the following designation of counsel.

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D. Service Information

Please address correspondence/service to the above-listed address. LGE consents to email service at IPR19688-0197IP2@fr.com (referencing No. 19688-0197IP2 and cc'ing PTABInbound@fr.com).

Respectfully submitted,

Dated: December 9, 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 13,905 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: December 9, 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 9, 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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