

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
MULTIDIMENSIONAL CONSTELLATIONS AND CODE RATE
PAIRS

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

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EXHIBITS

LGE1001	U.S. Patent No. 10,693,700
LGE1002	Prosecution History for U.S. Patent No. 10,693,700
LGE1003	Expert Declaration of Dr. Bertrand Hochwald
LGE1004	RESERVED
LGE1005	RESERVED
LGE1006	RESERVED
LGE1007	RESERVED
LGE1008	Ulrich Reimers et al., <i>DVB The Family of International Standards for Digital Video Broadcasting</i> , Second Edition, 2005 (“Ulrich”)
LGE1009	RESERVED
LGE1010	U.S. Provisional application No. 60/933,319 (“’319 Provisional”)
LGE1011	Declaration of June Munford (ATSC322)
LGE1012	Second Stipulation by Petitioner, LGE, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1013	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. Patent No. 7,978,777
LGE1016	RESERVED
LGE1017	RESERVED
LGE1018	Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (USPTO June 21, 2022) (“Interim Procedure”)
LGE1019	Docket Control Order, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1020	Complaint, <i>Constellation Designs, LLC v. LG Electronics, Inc. et al</i> , Case No. 2:21-cv-00448 (E.D. Tex.)
LGE1021	RESERVED
LGE1022	ATSC Recommended Practice: Guidelines for the Physical Layer Protocol, Document no. A/327:2018
LGE1023	ATSC 3.0 Standard: Physical Layer Protocol, Document no. A/322:2018
LGE1024	Loghin, et al., <i>Non-Uniform Constellations for ATSC 3.0</i> , IEEE Transactions on Broadcasting, Vol 62, No. 1, March 2016. (“Loghin”)
LGE1025	G. Ungerboeck, Channel Coding with Multilevel/Phase Signals, IEEE Trans. Inform. Theory, Vol. IT-28, No. 1, Jan. 1982, pp. 55-67 (“Ungerboeck”)
LGE1026	Declaration of June Munford (ATSC327)
LGE1027	Declaration of June Munford (DG)
LGE1028	Declaration of June Munford (Loghin)

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]	a demapper, coupled to the demodulator, capable of determining likelihoods using the demodulated signal and a multidimensional symbol constellation selected from a plurality of multidimensional symbol constellations; and
[1d]	a decoder, coupled to the demapper, capable of using the likelihoods determined by the demapper to provide a sequence of received bits based upon a low density parity check (LDPC) code;

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

Claim 2	
[2a]	The communication system of claim 1, wherein: the demodulator is capable of using a demodulation scheme that is based on quadrature amplitude modulation (QAM) and the degrees of freedom available to the multidimensional symbol constellations are in phase and quadrature components;
[2b]	each of the plurality of different non-uniform multidimensional symbol constellations is a sixteen point quadrature amplitude modulated (QAM) symbol constellation; and
[2c]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the plurality of different non-uniform multidimensional symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$.

Claim 3	
[3a]	The communication system of claim 2, wherein: the plurality of multidimensional symbol constellations further comprises an additional plurality of different non-uniform multidimensional symbol constellations that are quadrature amplitude modulated (QAM) symbol constellations and 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;
[3b]	the constellation points of the additional plurality of different non-uniform multidimensional symbol constellations are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellation;
[3c]	each of the additional plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs;

[3d]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $2/6$ and less than or equal to $5/6$;
[3e]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $7/8$;
[3f]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $4/10$ and less than or equal to $9/10$.
Claim 5	
[5a]	The communication system of claim 1, wherein each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR.

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 demapper that determines likelihoods using the demodulated signal and a multidimensional symbol constellation selected from a plurality of multidimensional symbol constellations; and
[11c]	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;
[11d]	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;

[11e]	wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points, where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;
[11f]	wherein the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.

Claim 12	
[12a]	The communication system of claim 11, wherein the demodulator uses a demodulation scheme that is based on quadrature amplitude modulation (QAM) and the degrees of freedom available to the multidimensional symbol constellations are in phase and quadrature components;
[12b]	each of the plurality of different non-uniform multidimensional symbol constellations is a sixteen point quadrature amplitude modulated (QAM) symbol constellation; and
[12c]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the plurality of different non-uniform multidimensional symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$.

Claim 13	
[13a]	The communication system of claim 12, wherein: the plurality of multidimensional symbol constellations further comprises an additional plurality of different non-uniform multidimensional symbol constellations that are quadrature amplitude modulated (QAM) symbol constellations and 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;
[13b]	the constellation points of the additional plurality of different non-uniform multidimensional symbol constellations are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;
[13c]	each of the additional plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs;

[13d]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $2/6$ and less than or equal to $5/6$;
[13e]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $7/8$;
[13f]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $4/10$ and less than or equal to $9/10$.
Claim 15	
[15a]	The communication system of claim 11, wherein each of the plurality of different non-uniform multidimensional symbol constellations has a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR.

Claim 21	
[21pre]	A communication system, comprising:
[21a]	a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver uses a multidimensional symbol constellation to transform the received signals into received bits and the multidimensional symbol constellation is selected from a plurality of multidimensional symbol constellations;
[21b]	wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points, where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;

[21c]	wherein the receiver selects an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.
Claim 22	
[22a]	The communication system of claim 21, wherein: the receiver uses a demodulation scheme that is based on quadrature amplitude modulation (QAM) and the degrees of freedom available to the multidimensional symbol constellations are in phase and quadrature components;
[22b]	each of the plurality of different non-uniform multidimensional symbol constellations is a sixteen point quadrature amplitude modulated (QAM) symbol constellation; and

[22c]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the plurality of different non-uniform multidimensional symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$.
Claim 23	
[23a]	The communication system of claim 22, wherein: the plurality of multidimensional symbol constellations further comprises an additional plurality of different non-uniform multidimensional symbol constellations that are quadrature amplitude modulated (QAM) symbol constellations and 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;
[23b]	the constellation points of the additional plurality of different non-uniform multidimensional symbol constellations are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations;

[23c]	each of the additional plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs;
[23d]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $2/6$ and less than or equal to $5/6$;
[23e]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol constellations have an LDPC code rate that is equal to or greater than $3/8$ and less than or equal to $7/8$;
[23f]	the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol constellations have an LDPC code rate that is equal to or greater than $4/10$ and less than or equal to $9/10$.

Claim 25	
[25a]	The communication system of claim 21, wherein each of the plurality of different non-uniform multidimensional symbol constellations has a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR.

LG Electronics, Inc. (“**Petitioner**” or “**LGE**”) petitions for *inter partes* review (“**IPR**”) of claims 2-3, 5, 12-13, 15, 22-23, and 25 (“**the Challenged Claims**”) of U.S. Patent 10,693,700 (“**the ’700 Patent**”). As explained below, the Challenged Claims are unpatentable.

I. REQUIREMENTS FOR IPR

A. Standing

Petitioner certifies that the ’700 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review. Petitioner was served with a complaint of infringement of the ’700 Patent on December 9, 2021. LGE1013.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the grounds¹ identified in the table below. Additional explanation and support for each ground is set forth in the declaration of Dr. Hochwald (LGE1003). LGE1003, ¶¶[1]-[228].

Ground	Claims	Prior Art Basis
1A	2-3, 12-13, 22-23	§103 – ’777 patent in view of ATSC322

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

Ground	Claims	Prior Art Basis
1B	5, 15, 25	§103 – '777 patent in view of ATSC327

The '700 Patent was filed on Dec. 23, 2019 and claims the benefit of U.S. Provisional application No. 60/933,319 (“**319 Provisional**” or LGE1010), which was filed on June 5, 2007. As explained in Section II(A)-(B) below, the Challenged Claims are not entitled to the June 5, 2007 priority date, and should be assigned a priority date of December 23, 2019, the filing date of the '700 patent. Each of the references relied upon in this Petitioner are prior art under 35 §§ 102(a)(1) in view of the December 23, 2019 priority date. The declarations of June Munford (LGE1011) and ATSC (LGE1024) provide additional information regarding the public availability of the non-patent literature references.

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

A. Legal Standard for Priority

In order to rely on the filing date of an earlier application, 35 U.S.C. § 120 requires that the earlier application include a disclosure that complies with the written description requirement of 35 U.S.C. § 112. *Lockwood v. Am. Airlines*,

Inc., 107 F.3d 1564, 1571-72 (Fed. Cir. 1997).² To comply with the written description requirement, the specification “must describe the inventions sufficiently to convey to a person of skill in the art that the patentee had possession of the claimed invention at the time of the application, i.e., that the patentee invented what is claimed.” *Lizardtech, Inc. v. Earth Res. Mapping Inc.*, 424 F.3d 1336, 1345 (Fed. Cir. 2005).

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).

Here, the Challenged Claims were not “original claims” of any priority application, and the claimed subject matter was not included in the ’319

² *See SAP Am., Inc. v. Pi-Net Int’l, Inc.*, IPR No. 2014-00414, Paper No. 11, 11-14 (PTAB Aug. 18, 2014) (relying on § 112 case law is proper in an *inter partes* review to establish effective filing date)

provisional application or the '777 patent (collectively referred to herein as the "Barsoum Patents"). LGE1010; LGE1015. Instead, the text of the challenged claims were filed on December 23, 2019 when US. App. No. 16/726,037, which eventually issued as the '700 patent, was filed. LGE1002, 1,088-1,097. This December 23, 2019 filing is more than 12 years after the earliest priority date of the Barsoum Patents.

1. The Barsoum Patents Do Not Contain Written Description Support For the Claimed Code Rate Ranges of Claims 2-3, 12-13, and 22-23

The Barsoum Patents lack written description support for the limitations of claims 2-3, 12-13, and 22-23 directed towards respective QAM constellations having an LDPC code rate within a specific range of LDPC code rates. Claims 2, 12, and 22 are directed towards a QAM constellation having "*an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8.*" LGE1003, ¶[50]; LGE1001, 14:6-55, 16:6-55, 18:1-50. Claims 3, 13, and 23, depend from claims 2, 12, and 22, respectively, and further comprises specific limitations of an additional plurality of different non-uniform multidimensional symbol constellations comprising claim multiple different sixty-four-point **QAM** constellations, multiple different **QAM-256** constellations, and multiple different **QAM-1024** constellations, wherein each of the additional plurality of different non-uniform multidimensional symbol constellations is only included in *one* of the

plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs, wherein:

- the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol QAM constellations have an *LDPC code rate that is equal to or greater than 2/6 and less than or equal to 5/6*;
- the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol QAM constellations have an *LDPC code rate that is equal to or greater than 3/8 and less than or equal to 7/8*; and
- the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol QAM constellations have an *LDPC code rate that is equal to or greater than 4/10 and less than or equal to 9/10*.

Id. The Barsoum Patents do not contain written description support for these claim features sufficient to show that the Patent Owner had possession of the claimed subject matter as of the priority dates of the Barsoum Patents. LGE1003, ¶[51]

**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. LGE1010, 1-6.

To contrary, the '319 provisional application explains that there is “link margin to be gained by tailoring the design of a constellation *for a specific code rate.*”

LGE1010, 2 (emphasis added). LGE1003, ¶[52]

To achieve the link margin gain, the '319 provisional application seeks to parameterize constellation design based on a *target code rate*. *Id.* Indeed, the '319 provisional application explains that “optimal design of a constellation depends on the *target code rate* to be used with it.” LGE1010, 2. To this end, the '319 provisional application 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:

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

wherein M is, as best understood by Petitioner, to be the number of constellation points. LGE1010, 2. Thus, though '319 provisional application suggests optimizing the design of a constellation based on a *target code rate*, there is nothing in the '319 provisional application that suggests, or otherwise identifies, the code rate ranges of the challenged claims. Indeed, the examples illustrated in Fig. 6 of the '319 provisional application focus on code rate = $\frac{1}{2}$. LGE1003, ¶[53]

Determination of a *code rate range* requires determination of a *minimum code rate* as a lower bound to the code rate range (e.g., 3/8 in claim 2), determination of a *maximum code rate* as an upper bound to the code rate range (e.g., 6/8 in claim 2), and determination of 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 2, as the language recites equal to or greater than). None of these aspects of the code rate ranges of the challenged claims are found in the '319 provisional application. LGE1003, ¶[54]

The '777 patent does not remedy the deficiencies of the '319 provisional application regarding support for the claimed *code rate ranges*. The '777 patent describes “[p]rocesses for selecting capacity optimized constellations to achieve increased coding gains based upon a *specific coding rate*...” LGE1015, 5:4-7. In line with this design objective, the '777 patent provides design tables of constellations such as those 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* that can be calculated using the equation from the '319 provisional application identified above. LGE1015, 3:61-4:21, 10:25-11:13, FIGS. 10a-17b; LGE1003, ¶[55].

For example, FIGs. 11a and 11b of the '777 patent 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, ¶[56] (explaining that each column in the table is a different constellation). The *specific code rate* for each single dimensional PAM-4 constellation of the design tables in FIGs. 11a and 11b and determined using the equation of the '319 provisional application 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. LGE1015, 10:35-55, FIGs. 10a-11b; LGE1003, ¶[56]. Thus, the constellation design tables of FIGs. 11a and 11b describe a plurality of single dimensional PAM-4 constellations (not QAM constellations) that are each 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*. LGE1015, 10:35-55, FIGs. 10a-11b; LGE1003, ¶[56].

By way of another example, FIGs. 13a and 13b of the '777 patent 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, ¶[57]. The *specific code rate* for each PAM-8 constellation of the

design tables in FIGs. 13a and 13b and determined using the equation of the '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. LGE1015, 10:56-11:7, FIGs. 12a-13b; LGE1003, ¶[57]. Thus, the constellation design tables of FIGs. 13a and 13b describe a plurality of single dimensional PAM-8 constellations (not QAM 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*. LGE1015, 10:56-11:7, FIGs. 12a-13b; LGE1003, ¶[57]. 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. LGE1015, 11:1-7. Nonetheless, the resulting analysis is the same. Via application of the equation from the '319 provisional application, a list of discrete code rates can be determined. LGE1003, ¶[57].

In claiming benefit of priority of the Barsoum Patents, Patent Owner appears to contend that one can determine, in hindsight, certain code rate ranges for

multidimensional **QAM** constellations from examples of specific code rates for single dimensional **PAM** constellations provided in the Barsoum Patents.

LGE1010, 2-4, FIGs. 1-3; LGE1015, 10:34-11:13, FIG. 11b, 13b, 15b, 17b; LGE1001, 14:6-55. To be clear, the Barsoum Patents do not provide a single statement explaining that the code rate for one dimensional PAM constellations would be the same as a code rate for a multidimensional QAM. As explained in *Purdue*, the Barsoum Patents themselves must provide sufficient “blaze marks” directing a Person of Ordinary Skill In The Art (POSITA) to teachings within the Barsoum Patents that support the claimed LDPC code rate ranges of the challenged patents. *See Purdue*, 230 F.3d at 1326-1327. Here, no blaze marks exist. *Id.* Therefore, claims 2-3, 12-13, and 22-23 are not entitled to the priority date of the Barsoum Patents. LGE1003, ¶[58].

Moreover, the *specific code rate* described with respect to each respective constellation in the constellation design tables of FIG. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b is directed towards a single dimensional **PAM** constellation, whereas the *code rate ranges* of the challenged claims are for multidimensional **QAM** constellations, thus making the code rate ranges of the challenged claims even *further* removed from anything found in the written description of the ’777 patent described above. LGE1015, 3:61-4:21, 10:25-11:13, FIGS. 10a-17b; LGE1001, 14:6-55, 16:6-55, 18:1-49; LGE1003, ¶[59]. Nothing in the Barsoum Patents

provides any “blaze marks” that would direct a Person Of Ordinary Skill in the Art (POSITA) to find the *minimum code rate* of a code rate range for a multidimensional *QAM* constellation, the *maximum code rate* of the claimed code rate range for a multidimensional *QAM* constellation, or whether minimum code rate, maximum code rate, or both, are included in or excluded from a code range of a multidimensional *QAM* constellation. LGE1003, ¶[59]; see *Purdue*, 1326-1327. Thus, the Barsoum Patents fail to provide support for the *code rate ranges* of the challenged claims. LGE1003, ¶[59].

Finally, to the extent that it can be argued that Figures 10c, 12c, 14c, and 16c show constellation points optimized for parallel decoding capacity over a continuum of (or range of) capacities or code rates, nothing in these figures even prescribes the code rate ranges described in the claims. LGE1003, ¶[60]. For example, the lowest code rate in Figure 14c appears to be somewhat larger than code rate = 3/8. LGE1003, ¶[60].

Therefore, the claims 2-3, 12-13, and 22-23 are not entitled to priority date of the Barsoum Patents. LGE1003, ¶[61]-[68].

3. The Written Description of the Barsoum Patents Do Not Demonstrate that the Patent Owner Was “In Possession” of the Communication System Claimed by claims 2-3, 12-13, and 22-23

As explained in Section II(B)(1) above, the Barsoum Patents do not include

sufficient written description that supports the *code rate ranges* of the Challenged Claims. 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, ¶[69].

Claims 2-3, 12-13, and 22-23, which incorporate the features of the independent claims by virtue of their dependency, impart a *code rate range* limitation on the different non-uniform multidimensional constellation that is included in one of the “plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs” from which an LDPC code rate and multidimensional symbol constellation pair is selected by the receiver of the claimed communication system. LGE1001, 13:43-14:30; LGE1003, ¶[70].

However, the *code rate ranges* are not supported by the written description of the Barsoum Patents for the reasons set forth in Section II(B)(1). Accordingly, a POSITA would not be able to discern that the Patent Owner had possession of a communication system that selects “an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs” that is limited to multidimensional symbol constellation pairs having code rates specified by the *code rate ranges* of the challenged claims. LGE1003, ¶[70].

For at least the reasons set forth in Section II(B)(1) and Section II(B)(2), the written description of the Barsoum Patents is not sufficient to show possession of the subject matter of claims 2-3, 12-13, and 22-23. Therefore, claims 2-3, 12-13, and 22-23 are not entitled to priority date of the Barsoum Patents. LGE1003, ¶[71].

4. The Written Description of the Barsoum Patents Do Not Demonstrate that the Patent Owner Was “In Possession” of a Communication System recited by claims 5, 15, and 25

Claim 5 recites:

“each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR.” LGE1001, 14:65-15:3.

These features do not find support in the written description of the Barsoum Patents. LGE1003, ¶[72].

This limitation defines a very specific relative relationship between two groupings of non-uniform spaced constellations that is not supported by the ’777 Patent specification. LGE-1003, ¶[73]. In particular, claim 5 recites an observation of a relative relationship between a first group of *non-uniform multidimensional*

*symbol constellations*³ to a second group of other symbol constellations⁴ when the two groups are *operated at the same SNR*. LGE1003, ¶[73]. Nothing in the '777 patent provides sufficient written description support for the comparison of these two groups of *constellations*. LGE1003, ¶ [73]. To the contrary, the '777 patent, at best, only describes determining a relative relationship between *a* geometrically shaped (i.e., unequally spaced) constellation and a constellation optimized for $d_{\min}$. LGE1015, 6:14-20, 2:56-63; LGE1003, ¶[73]. This disclosure of the '777 *does not* support the very specific groups or the relationship claimed between the groups. LGE1003, ¶[73]. No other portions of the '777 Patent provide written description support that a POSITA would understand as indicating that Patent Owner has possession of the subject matter of claim 5 as of the priority date of the '777 Patent. The '319 provisional application similarly lacks written description support for the features of claim 5. LGE1003, [73]. Thus, subject matter of claim 5 is not entitled to the priority date of the '777 patent. LGE1003, ¶[73].

3 i.e., - “*each of the plurality* of different non-uniform multidimensional symbol constellations having the same number of constellation points”

4 i.e., - “the other symbol constellations in the plurality of multidimensional symbol constellations”

Claims 15 and 25 include features that correspond to claim 5. Thus, the subject matter of claims 15 and 25 are not entitled to the priority date of the '777 patent for at least the same reasons as claim 5. LGE1003, ¶[74].

5. The Written Description of the Barsoum Patents Does Not Demonstrate that the Patent Owner Was “In Possession” of a 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 5, 15, and 25

Claim 5 recites:

“each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR.” LGE1001, 14:65-15:3. LGE1003, ¶[75].

These features do not find support in the written description of the Barsoum Patents. The '777 patent 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. LGE1015, 6:13-22. LGE1003, ¶[76].

A POSITA would understand this passage of the '777 patent as specifying

that *at least some* geometrically shaped (i.e., non-uniform) constellations used by the communications system of the '777 patent *do not* have a greater capacity than other constellations used by the communication system of the '777 patent. LGE1015, 6:13-22; LGE1003, ¶[77]. In addition, a POSITA would have understood the '777 patent as explaining that operations can be performed on a non-uniform constellation so that the non-uniform constellation *can be optimized* for joint capacity optimization or parallel decoding optimization in order to have greater capacity. LGE1015 6:13-22; LGE1003, ¶[77]. Thus, though some non-uniform constellations do not have a greater capacity than other constellations maximized for $d_{\min}$, the written description of the '777 patent *explains how to optimize a non-uniform* constellation *so that it can be capable* of having a greater capacity such as a greater parallel decoding capacity. LGE1015, 6:13-22; LGE1003, ¶[77].

Turning to claim 5, the Barsoum Patents fail to disclose that *each of the plurality* of different non-uniform multidimensional symbol constellations *have been optimized* to be *capable* of having greater parallel decoding capacity. LGE1003, ¶[78]. Indeed, neither the language of claim 5 nor the language of parent claim 1 indicate that *each of the plurality* of different non-uniform multidimensional symbol constellations have been optimized for parallel decoding capacity. LGE1003, ¶[78]. Moreover, nothing in the specification of the '777 patent or '700 patent provides any indication that *each of the plurality of* different non-uniform

multidimensional symbol constellations of claim 5 have been optimized for parallel decoding capacity. LGE1003, ¶[78]. To the contrary, a review of the specification of the '777 patent and the '700 patent reveals that “***[n]ot all geometrically shaped constellations have a greater capacity than that of a constellation maximized for d_{min} .***” LGE1001, 6:33-35; LGE1015, 6:13-15; LGE1003, ¶[78] (emphasis added).

Claim 5 is not supported by the written description of the '777 patent because “[n]ot all” ***of the plurality of*** different non-uniform multidimensional symbol constellations are ***capable of providing a greater parallel decoding capacity at a specific SNR*** than the ***other symbol constellations in the plurality of multidimensional symbol constellations*** recited by claim 5. Thus, claim 5 is not entitled to the priority date of the '777 patent. LGE1003, ¶[79].

Finally, to the extent Patent Owner argues that even a constellation that is not optimized for parallel decoding capacity, as described by col. 6, 15-23 of the '777 patent, ***is capable*** of providing a greater parallel decoding capacity at a specific SNR than other symbol constellations in the plurality multidimensional symbol constellations at the same SNR, such an assertion further proves that the claim feature of “the plurality of different non-uniform multidimensional symbol constellations” includes non-uniform constellations that are not optimized for parallel decoding capacity, of which, “***[n]ot all***” have a greater capacity than that of other symbol constellations in the plurality of multidimensional symbol

constellations. LGE1003, ¶[80]. 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. LGE1015, 6:13-22; LGE1003, ¶[80].

For such an argument to prevail, Patent Owner would need to show that the *each of the plurality of* different non-uniform multidimensional symbol constellations of claim 5 have been optimized for parallel decoding capacity . However, nothing in the claims or specification of the '777 patent indicates that *each of the plurality* of different non-uniform multidimensional symbol constellations of claim 5 have been optimized for parallel decoding capacity. Thus, claim 5 is not supported by the specification of the '777 patent in sufficient detail to convey to a POSITA that Patent Owner had possession of the subject matter of claim 5 as of the priority date of the '777 patent. LGE1003, ¶[81]. Nothing else in the '777 patent or the '319 provisional application does anything to change the calculus of this analysis. LGE1003, ¶[81].

For at least these reasons, the Barsoum Patents fail to provide support for the features of claim 5 that recite “*each of the plurality* of different non-uniform multidimensional symbol constellations *is capable of providing a greater parallel decoding capacity at a specific SNR* than the other symbol constellations in the

plurality of multidimensional symbol constellations at the same SNR.” LGE1001, 14:65-15:3. LGE1003, ¶[82].

Claims 15 and 25 include claim features that correspond to the features of claim 5. Claims 15 and 25 lack support in the Barsoum Patents for the same reasons set forth above with respect to claim 5. LGE1003, ¶[83].

Therefore, the claims 5, 15, and 25 are not entitled to priority date of the Barsoum Patents. LGE1003, ¶[84].

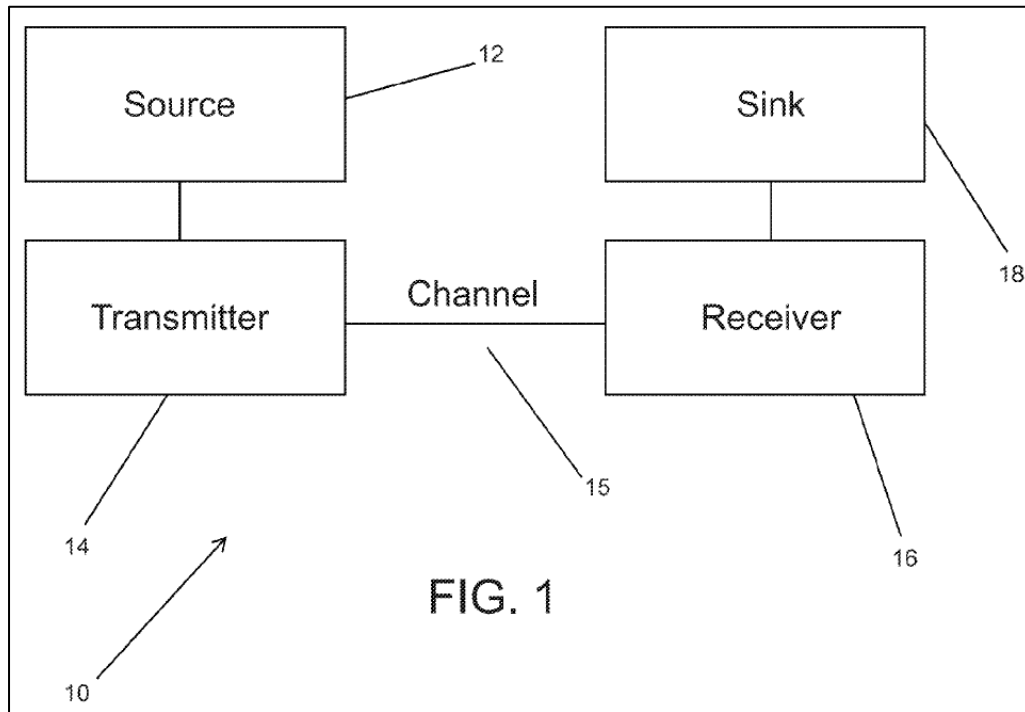
III. OVERVIEW OF THE '700 PATENT

A. Brief Description of the '700 Patent

The '700 Patent is directed to communication systems that use geometrically-shaped constellations. LGE1001, Abstract. In communication systems, the term “‘constellation’ is used to describe the possible symbols that can be transmitted by a typical digital communication system.” *Id.*, 1:42-44. When a transmitter transmits data symbols, a “receiver attempts to detect the symbols that were transmitted by mapping a received signal to the constellation.” *Id.*, 1:42-46. The '700 Patent explains that the “minimum distance (d_{min}) between constellation points is indicative of the capacity of a constellation at high signal-to-noise ratios (SNRs),” so “constellations used in many communication systems are designed to maximize d_{min} .” *Id.*, 1:46-50; LGE1003, ¶¶[85]-[92].

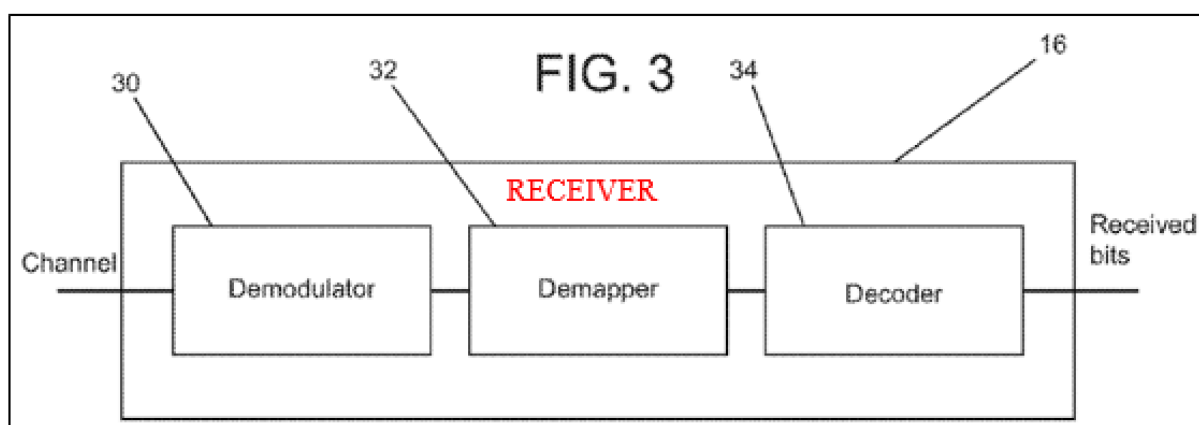
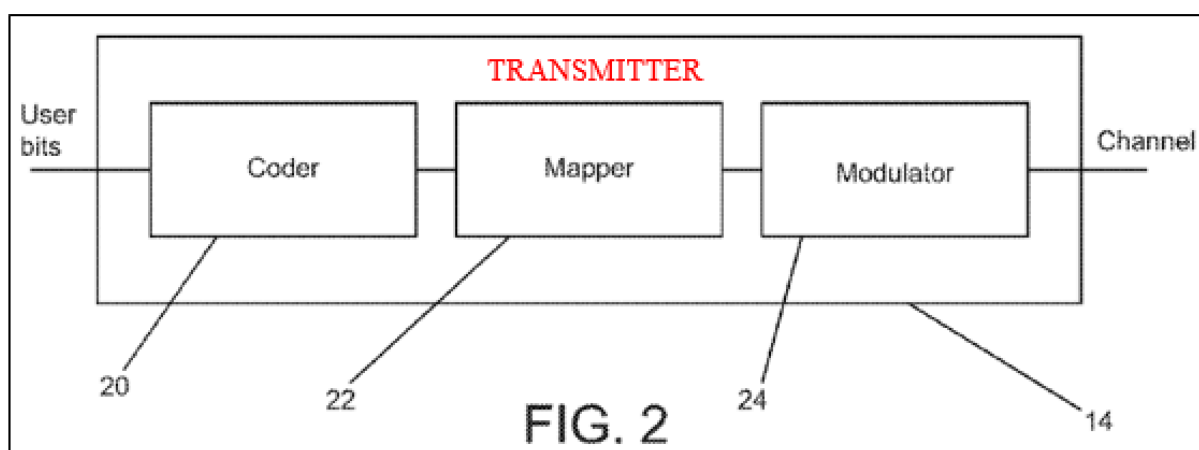
The '700 Patent discloses “constructing a modulation such that the constrained capacity between a transmitter and a receiver approaches the Gaussian channel limit first described by Shannon.” LGE1001, 2:21-25. The '700 Patent discloses a method for locating points (in a one or multiple dimensional space) in order to maximize capacity between the input and output of a bit or symbol mapper and demapper respectively.” *Id.*, 2:29-34; LGE1003, ¶[86].

Figure 1 (reproduced below) shows a communication system 10 according to the '700 Patent, which includes “a source 12 that provides user bits to a transmitter 14,” which in turn “transmits symbols over a channel to a receiver 16 using a predetermined modulation scheme.” LGE1001, 5:32-35. Using knowledge of the modulation scheme, the receiver 16 decodes the signal and provides the decoded bits to a sink device 18 connected to the receiver 16. *Id.*, 5:33-35; LGE1003, ¶[86].



LGE1001, FIG. 1.

FIG. 2 (reproduced below) of the '700 Patent depicts the transmitter 14 and its components, which include a coder 20, a mapper 22, and a modulator 24. LGE1001, 3:45-46, 5:40-51. FIG. 3 (reproduced below) of the '700 Patent depicts the receiver 16 and its components, which include a demodulator 30, a demapper 32, and a decoder 34. LGE1001, 3:47-48, 5:53-59; LGE1003, ¶[87].



LGE1001, FIGS. 2-3.⁵

The coder 20 of the transmitter 14 “receives user bits from a source and encodes the bits in accordance with a predetermined coding scheme,” such as a capacity approaching code (*e.g.*, turbo code, LDPC code) or other coding schemes that provide a coding gain. LGE1001, 5:40-44. A mapper 22 connected to the coder

⁵ Annotations to this and other figures in this petition are indicated by colored text and/or marks.

“maps the bits output by the coder to a symbol within a geometrically distributed signal constellation stored within the mapper” and “provides the symbols to a modulator 24, which modulates the symbols for transmission via the channel.” *Id.*, 5:46-51. The mapper of the transmitter encodes bits to symbols in a symbol constellation that “is a capacity optimized geometrically spaced symbol constellation that provides a given capacity at a reduced signal-to-noise ratio compared to a signal constellation that maximizes d_{min} .” *Id.*, 2:52-55, 2:56-62, 4:66-5:3. Signal-to-noise ratio (SNR) is “defined as the ratio of the average constellation energy per dimension to the average noise energy per dimension.” *Id.*, 7:52-54. The ’700 Patent explains that “capacity optimized constellation at low SNRs are geometrically shaped constellations that can achieve significantly higher performance gains (measured as reduction in minimum required SNR) than constellations that maximize d_{min} .” *Id.*, 8:25-29; LGE1003, ¶[88].

“Capacity measures that can be used in the selection of the location of constellation points include ... parallel decode (PD) capacity and joint capacity.” LGE1001, 5:6-8. The “PD capacity of a channel can be viewed in terms of the mutual information between the output bits of the encoder (such as an LDPC encoder) at the transmitter and the likelihoods computed by the demapper at the receiver,” and it is “influenced by both the placement of points within the constellation and by the labelling assignment.” *Id.*, 6:64-7:3. Joint capacity

describes “the achievable capacity between the input of the mapper on the transmit side of the link and the output of the channel (including for example AWGN and Fading channels).” *Id.*, 7:18-21; LGE1003, ¶[89].

Receiver 16 of FIG. 3 “includes a demodulator 30 that demodulates a signal received via the channel to obtain symbol or bit likelihoods” and a demapper 32 that “uses knowledge of the geometrically shaped symbol constellation used by the transmitter to determine these likelihoods.” LGE1001, 5:54-58. The demapper also “provides the likelihoods to a decoder 34 that decodes the encoded bit stream to provide a sequence of received bits to a sink.” *Id.*, 5:58-60; LGE1003, ¶[90].

The '700 Patent discloses that “[t]ransmitters and receivers ... utilize geometrically shaped symbol constellations” and that a geometrically shaped symbol constellation can be “used that optimizes the capacity of the constellation.” LGE1001, 5:62-66. Various factors dictate the selection of a constellation, including whether the code rate is fixed and specific performance requirements (e.g., specified bit rate, a maximum transmit power). *Id.*, 5:66-6:1, 6:7-8. The '700 Patent states that in “many embodiments, a geometrically shaped constellation is used to replace a conventional constellation (i.e. a constellation maximized for d_{min}) in the mapper of transmitters and the demapper of receivers within a communication system.” *Id.*, 6:8-13. Moreover, a conventional communication system can easily substitute a conventional constellation with a “geometrically shaped constellation that provides

a capacity, which is greater than the capacity of a constellation maximized for d_{min} ,” by way of firmware or software upgrades of the transmitter/receiver. *Id.*, 6:25-32; LGE1003, ¶[91].

The '700 Patent explains that PAM constellations can be paired with specific code rates to optimize capacity. LGE1001, 10:10-29. For example, FIG. 8a shows the lower SNR required for optimized constellations relative to classic PAM constellations. *Id.* The '700 Patent discloses certain conditions (e.g., bit rate, SNR) at which the PAM constellations can be optimized. For instance, FIGS. 11a-b provides a range of bit rates and SNRs at which PAM-4 constellations can be optimized for joint capacity or parallel decoding capacity. LGE1001, 11:9-16; LGE1003, ¶[92].

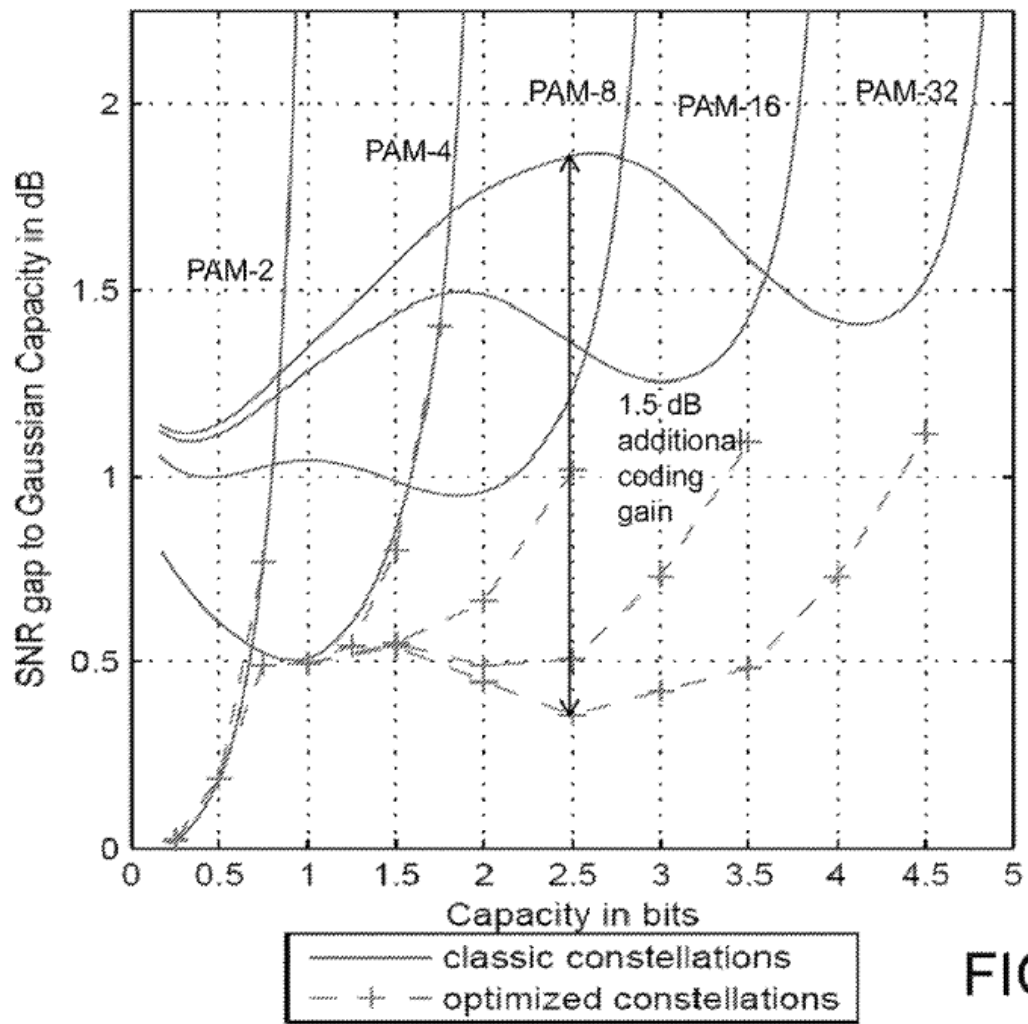


FIG. 8a

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

LGE1003, FIG. 11b.

B. Level of Ordinary Skill in the Art

For purposes of this IPR, Petitioner submits that a person of ordinary skill in the art at the time of the alleged invention (a “POSITA”) would have had at least a Master’s degree in an academic area emphasizing electrical engineering or a similar discipline, and at least two years of experience in the field working with, teaching, or researching communication systems including the use of constellations in transmitting signals between devices. LGE1003, ¶[93]. Superior education could compensate for a deficiency in work experience, and *vice-versa*. *Id.*

IV. CLAIM CONSTRUCTION

Petitioner submits no claim constructions are necessary. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Petitioner reserves the right to respond to any constructions offered/adopted by Patent Owner or the Board. LGE1003, ¶[42].

V. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

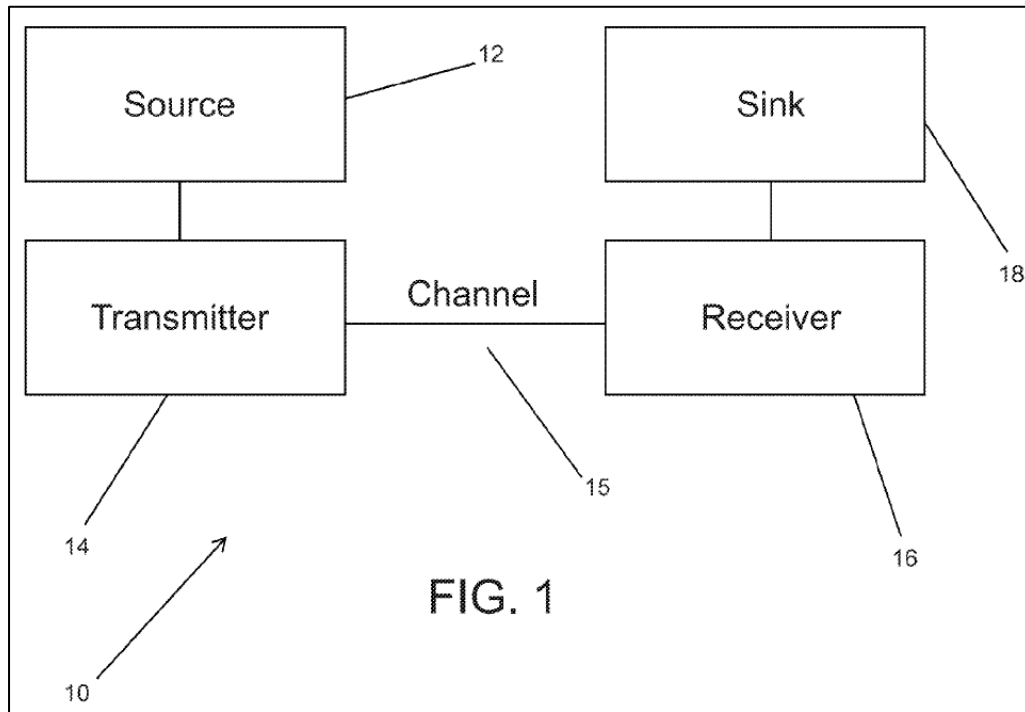
A. Ground 1A: ’777 patent in view of ATSC322

1. Overview of the '777 patent⁶

The '777 Patent discloses “constructing a modulation such that the constrained capacity between a transmitter and a receiver approaches the Gaussian channel limit first described by Shannon.” LGE1015, 2:7-10. The '777 Patent discloses “a method for locating points (in a one or multiple dimensional space) in order to maximize capacity between the input and output of a bit or symbol mapper and demapper respectively.” *Id.*, 2:17-20; LGE1003, ¶[94].

Figure 1 (reproduced below) shows a communication system 10 according to the '777 Patent, which includes “a source 12 that provides user bits to a transmitter 14,” which in turn “transmits symbols over a channel to a receiver 16 using a predetermined modulation scheme.” LGE1015, 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, ¶[95].

⁶ 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.



LGE1015, FIG. 1.

The features and functionality of the '777 patent are the same as the '700 patent described above in Section III(A), as the '700 patent and the '777 patent share the same written description and drawings. LGE1003, ¶[96]-[101]

2. Overview of the ATSC322

ATSC322 is a technical standard that “describes RF/Transmission of a physical layer waveform.” LGE1023, 1. “The ATSC physical layer protocol is intended to offer the flexibility to choose among many different operating modes depending on desired robustness/efficiency tradeoffs.” LGE1023, 6. The physical layer protocols are the means by which data is transmitted over a channel. LGE1003, [102]. The ATSC 3.0 Standard is “built on the foundation of OFDM modulation with

a suite of LDPC FEC codes, of which there are 2 code lengths and 12 code rates defined. *Id.*; LGE1003, ¶[102].

ATSC322 describes “bit interleaved coding and modulation (BICM). LGE1023, 17. BICM is a form of parallel encoding of information for transmission or parallel decoding of encoded information that has been received. LGE1003, ¶[103]. A block diagram of a BICM block is reproduced below. *Id.*; LGE1003, ¶[103].

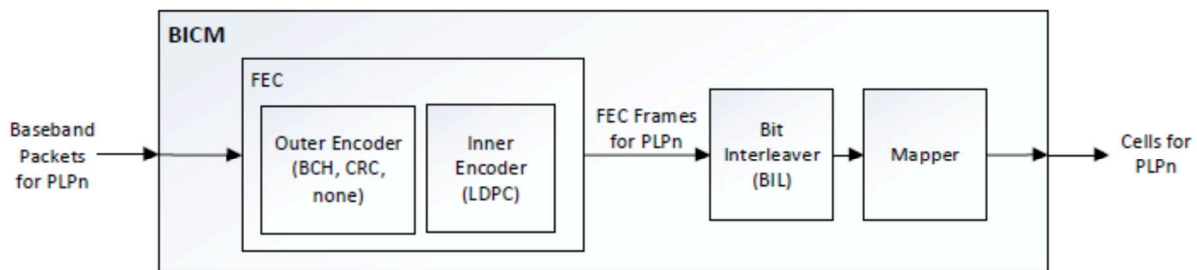


Figure 6.1 Block diagram of BICM.

LGE1023, Figure 6.1

ATSC322 explains that, “[t]o provide various robustness levels suitable for wide SNR range, the protection level of L1-Detail signaling is categorized into 7 modes based on LDPC codes, modulation order and shortening/puncturing parameter, i.e., a ratio of bits to be punctured to the number of bits to be shortened.” Additionally, “[t]he L1-Basic and L1-Detail signaling are protected by a concatenation of BCH Outer Code and LDPC Inner Code.” LGE1023, 39; LGE1003, ¶[104].

ATSC322 further describes design of a mapper that “*map[s] ... FEC encoded and bit interleaved bits to complex valued quadrature amplitude modulation (QAM) constellation points* on the IQ Plane.” LGE1023, 29 (emphasis added). “The input to the constellation mapping block is a stream of bit-interleaved FEC Frames and the output is cells, grouped as a FEC Block when necessary.” *Id.*; LGE1003, ¶[105].

According the design described by ATSC322, “[t]he Mapper consists of a DeMultiplexer block which followed by a bit-to-IQ mapping block.” *Id.* “A block diagram of the Mapper is shown in Figure 6.10,” which is reproduced below LGE1003, ¶[106]:

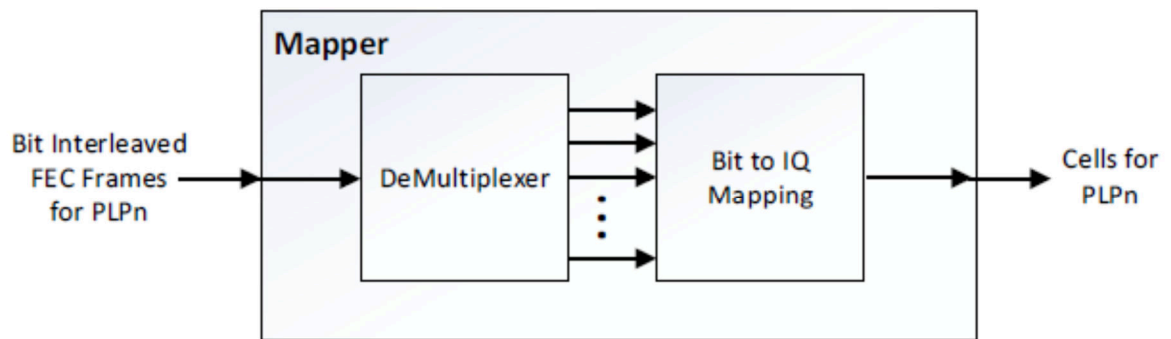


Figure 6.10 Mapper structure.

LGE1023, 30

LGE1023, 29-30. “The details for each type of modulation are described in Section 6.3.4.1 for QPSK, Section 6.3.4.2 for 16QAM to 256QAM and Section 6.3.4.3 for 1024 and 4096 QAM.” *Id.*; LGE1003, ¶[106-107].

The design of ATSC322 can transmit “uniform QPSK modulation and *five non-uniform constellations (NUC) sizes; 16QAM, 64QAM, 1024QAM, and 4096QAM respectively.*” LGE1023, 29-30. “The non-uniform constellations 16QAM, 64QAM and 256QAM are 2-dimensional (2D) quadrant-symmetric QAM constellations and are constructed by symmetry from a single quadrant.” *Id.* To reduce the complexity during QAM de-mapping at the receiver, *the 1024QAM and 4096QAM constellations are derived from non-uniform 1-dimensional (1D) PAM (pulse amplitude modulation) constellations* for both in-phase (I) and quadrature (Q) components.” *Id.* (emphasis added); LGE1003, ¶¶ [108-110].

ATSC322 specifies a plurality of **QAM** constellation and code rate pairs in Table 6.12 and 6.13 (reproduced below) LGE1003, ¶¶ [110-111].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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 6.13 Mandatory Modulation and Coding Combinations $N_{inner} = 16200$ Bits

Code Rate/ Constellation	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				✓		✓	✓	✓	✓	✓	✓	✓

LGE1023, 31

3. The '777-ATSC322 Combination

The '777-ATSC322 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. LGE1015, 4:60-5:11, 5:35-43, FIG. 3; LGE1023, 29-31; LGE1003, ¶[112].

In the combination, the '777 Patent 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.” LGE1015, 5:45-49. The mapper of the transmitter encodes bits to symbols in a PAM symbol constellation that “is a capacity optimized geometrically spaced symbol constellation that provides a given capacity at a reduced signal-to-noise ratio compared to a signal constellation that maximizes d_{min} .” *Id.*, 2:37-41, 2:45-48, 4:47-5:11. The '777 Patent explains that PAM constellations can be paired with specific code rates to optimize capacity. LGE1015, 9:52-10:3. Then, using knowledge of the modulation scheme, the communication system of the '777 patent uses a receiver 16 to decode the signal and provides the decoded bits to a sink device 18 connected to the receiver 16. *Id.*, 5:18-21; LGE1003, ¶[113].

Also in the combination, the '777 patent describes “[p]rocesses for selecting capacity optimized constellations to achieve increased coding gains based upon a

specific coding rate.” LGE1015, 5:4-7. In addition, the ’777 patent provides a number of one dimensional constellation design tables. LGE1015, 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b. In the combination, the ’777 patent 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. LGE1015, 5:4-7; 10:25-11:13. For the PAM-4 and PAM-8 constellations, the ’777 patent explicitly provides a discrete list of respective code rates, with each specific code rate in the list of code rates corresponding to a constellation in a constellation design table. LGE1015, 10:47-55, FIGs. 11a, 11b, 10:58-62, FIGs. 13a, 13b. The ’777 Patent also explains to a POSITA that that ***QAM*** constellations can be derived from ***PAM*** constellations. LGE1015, 3:9-19, 12:11-16; LGE1003, ¶[114].

Also in the combination, the system of the ’777 patent is modified with the teachings of ATSC322 to pair multidimensional ***QAM*** constellations with specific code rate ranges. LGE1023, 29-34. In the communication system of the combination, the teachings of ATSC322 are used to enable the communication system to transmit “uniform QPSK modulation and ***five non-uniform constellations (NUC) sizes; 16QAM, 64QAM, 1024QAM, and 4096QAM respectively.***” *Id.* “The non-uniform constellations 16QAM, 64QAM and

256QAM are 2-dimensional (2D) quadrant-symmetric QAM constellations and are constructed by symmetry from a single quadrant.” *Id.* To reduce the complexity during QAM de-mapping at the receiver, *the 1024QAM and 4096QAM constellations are derived from non-uniform 1-dimensional (1D) PAM (pulse amplitude modulation) constellations* for both in-phase (I) and quadrature (Q) components.” *Id.* (emphasis added); LGE1003, ¶[115].

In the combination, the communication system of the ’777 patent is configured to optimize multidimensional **QAM** constellations to have a specific code rate, thus creating **QAM** constellation and code rate pairs, using the **QAM** constellation and code rate pairs in Table 6.12 and 6.13 from ATSC322 (reproduced below) LGE1003, ¶[116].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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 6.13 Mandatory Modulation and Coding Combinations $N_{inner} = 16200$ Bits

Code Rate/ Constellation	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				✓		✓	✓	✓	✓	✓	✓	✓

Though the teachings of ATSC322 are described from the perspective of a transmitting device, the '777-ATSC322 combination is not so limited. To the contrary, the '777-ATSC combination also includes use of the multidimensional *QAM* constellations and code rate pairs by a receiving device in the communication system. Specifically, a POSITA armed with the teachings of ATSC322 would have found it obvious to implement a receiving device that demaps and decodes data that is encoded and transmitted by the transmitter of the ATSC322. LGE1003, ¶[117]; LGE1008, 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”). LGE1003, ¶[117].

4. Reasons to Combine the '777 patent and ATSC322

A POSITA would find it obvious to modify the '777 patent with the teachings of the ATSC322 Standard. LGE1003, ¶[118]. First, the ATSC322 is a technical standards document that “describes RF/Transmission of a physical layer waveform.” LGE1023, 1. The physical layer deals with the transmission of bits or data over a communication channel. LGE1003, ¶[118]. Thus, a POSITA working with a communication system such as the communication system of the '777 patent would have looked to standards documents to identify solutions to problems in the field. LGE1003, ¶[118].

Second, a POSITA would have looked to the ATSC322 standard because the

ATSC322 standard “offer[s] the flexibility to choose among many different operating modes depending on desired robustness/efficiency tradeoffs.” LGE1023, 6; LGE1003, ¶[119]. For example, ATSC322 provides a finite list of multiple different non-uniform multidimensional QAM constellation-code rate pairs as listed in, for example, Tables 6.12, 6.13. 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. This is especially true since the ATSC322 standard discloses, “[f]or efficiency, new forward error correcting options with the adoption of non-uniform constellations has brought the operation of the BICM closer to the theoretical Shannon Limit; offering over 1dB of gain compared to the use of uniform constellations using the same operating parameters.” LGE1023, 10. Hence, a POSITA would understand that ATSC322 addresses coding and modulation optimizations that are similar to those disclosed in the ’777 patent. LGE1003, ¶[119].

Corroborating this is Loghin who states: “When optimizing NUCs of a given constellation size m for a transmission system using a BICM chain, we need to maximize the BICM capacity CB NUCs for ATSC3.0 have been optimized both with respect to performance over flat AWGN channel and over independent and

identically distributed Rayleigh fading with perfect side information at receiver side. To further optimize the combination of coding and modulation, the bit interleaver was carefully optimized as well for each combination of constellation size and code rate.” LGE1024, 199. LGE1003, ¶[120].

Third, a POSITA would have been motivated to design a system that uses the particular operating modes of the ATSC322 Standard 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, ¶[121].

5. Manner in which ’777-ATSC322 renders the Challenged Claims obvious

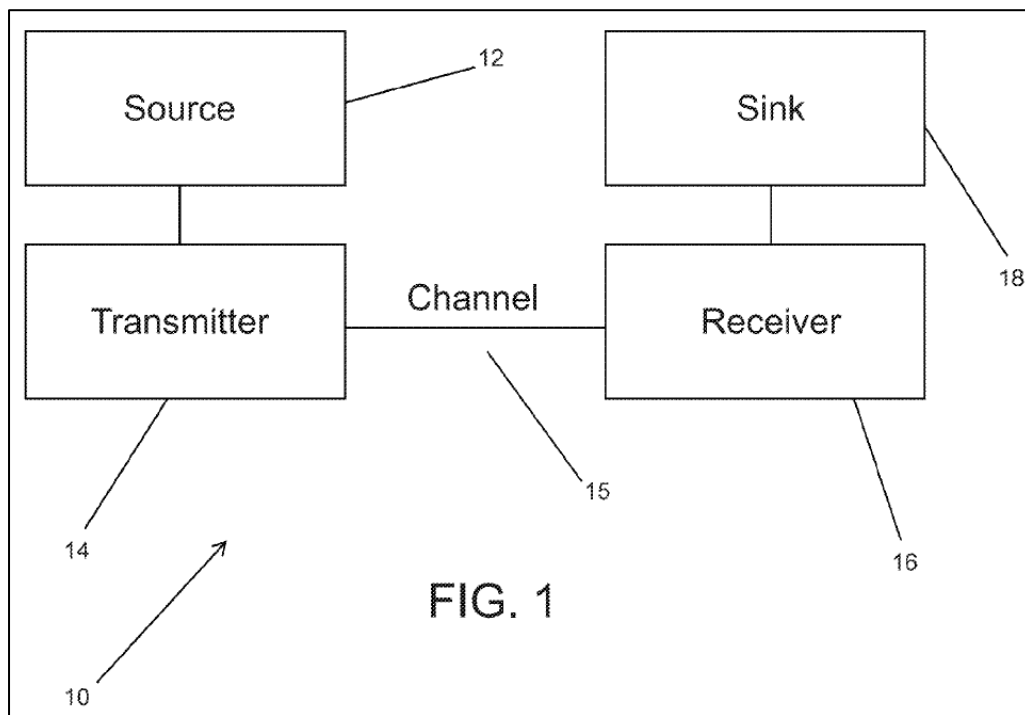
Claim 1⁷

Limitation [1pre]

The ’777 patent discloses a communication system. LGE1015, 5:16-21,

⁷ Because claim 2 depends from claim 1, this Petition also includes a mapping of the prior art references against claim 1 (and similarly other independent claims). In Grounds 1A and 1B, this petition is relying on the ’777 patent as disclosing all the features of claim 1.

abstract, FIGs. 1-3. For example, the '777 patent discloses “a digital communications system including a transmitter transmitting signal via a communications channel...” LGE1015, abstract. The digital communication system 10 of the '777 patent is depicted by FIG. 1 (reproduced below) LGE1003, ¶¶ [122-123].:



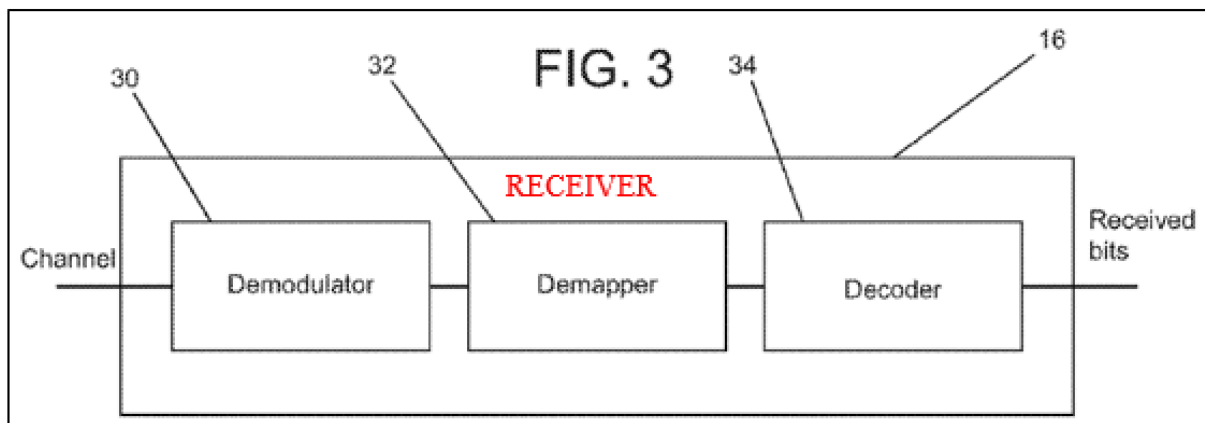
LGE1015, FIG. 1.

The communication system 10 (depicted above) 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.” LGE1015, 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, ¶¶[124-126].

Limitation [1a]

The '777 patent discloses *a receiver 16 that is capable of receiving signals via a communication channel*. LGE1015, 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 of the communication system 10 is shown in FIG. 3 of the '777 patent (reproduced below) LGE1003, ¶[127]:



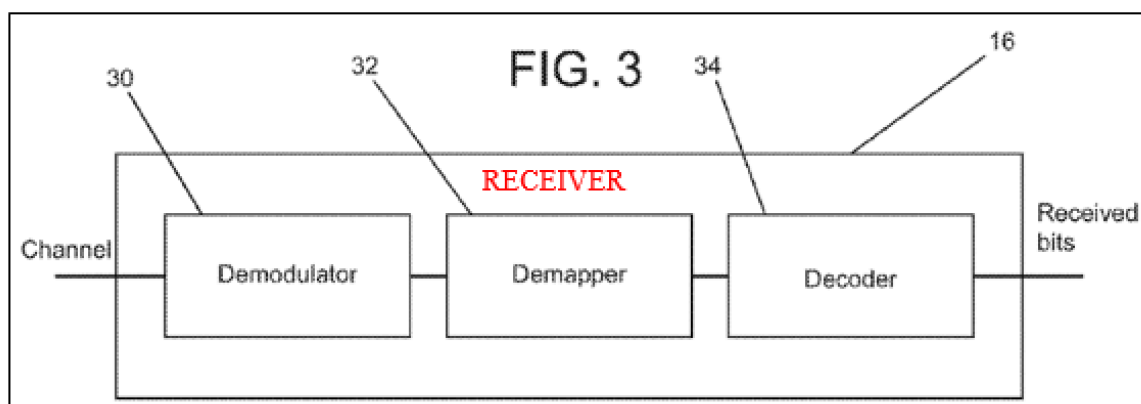
LGE1015, FIG. 3.

It is known in the art that a communication channel has a channel signal-to-noise ratio (SNR). LGE1003, ¶[128]. The '777 patent 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).” LGE1015, 4:54-56; 7:26-33; 7:47-49; 13:34-38. Accordingly, the claim limitations of [1a] would have been obvious to a POSITA. LGE1003, ¶[128].

Limitation [1b]

The '777 patent discloses *a demodulator capable of demodulating a received signal into a demodulated signal*. LGE1015, 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. LGE1015, 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 patent depicts a demodulator 30 (reproduced below) LGE1003, ¶[129]:

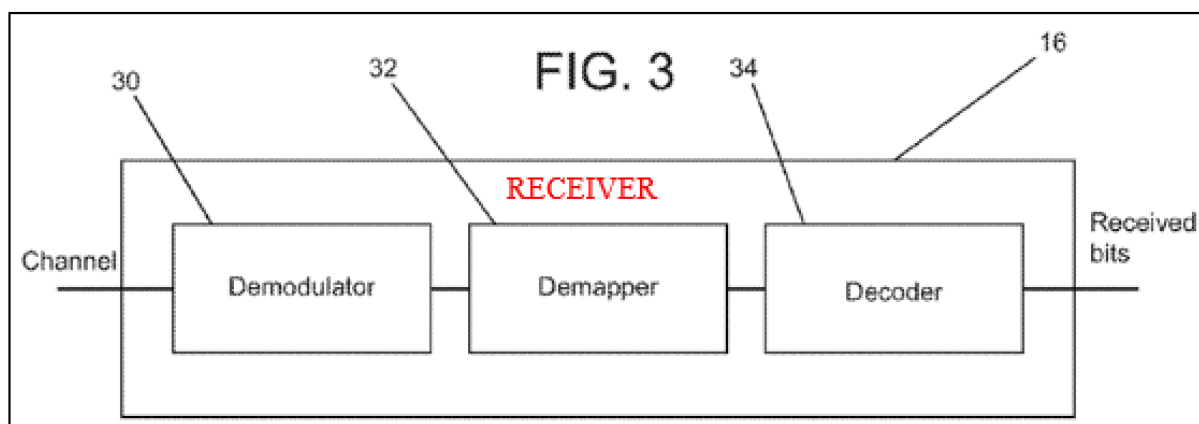


LGE1015, FIG. 3.

Limitation [1c]

The '777 patent discloses *a demapper coupled to the demodulator*.

LGE1015, 3:32-33, 5:35-43; FIG. 3; LGE1003, ¶[130]. The '777 patent's coupling of the demapper 32 to the demodulator is shown, for example, in FIG. 3 of the '777 patent (reproduced below) LGE1003, ¶[130].:



LGE1015, FIG. 3.

The '777 patent discloses *a demapper that is capable of determining likelihoods using the demodulated signal and a multidimensional symbol constellation*. LGE1015, 2:52-55; 5:35-43, 6:24-51 FIG. 3; LGE1003, ¶[131]. For example, the '777 patent discloses that “the demapper uses knowledge of the geometrically shaped symbol constellation used by the transmitter to determine likelihoods.” LGE1015, 5:35-43. The '777 patent discloses that the geometrically shaped symbol constellation can be a “QAM constellation.” LGE1015, 3:11-19; 4:29-31; 12:12-16; FIG. 21. QAM constellations are multidimensional symbol constellations. LGE1015, 12:38-49; LGE1003, ¶[131].

The '777 patent discloses that *the multidimensional symbol constellation*

[was] selected from a plurality of multidimensional symbol constellations.

LGE1015, 2:56-58, 5:54-6:4, 7:8-10, 8:7-15, 8:47-54, 12:12-16; LGE1003, ¶[132].

For example, the '777 patent discloses that "...a geometrically shaped constellation is used to replace a conventional constellation..." and that "...a geometrically shaped constellation *is selected* in conjunction with a code rate to meet specific performance requirements..." LGE1015, 5:54-6:4. The '777 patent also discloses that the selected geometrically shaped (i.e., unequally spaced or non-uniform) constellations may be selected from a plurality of geometric constellations.

LGE1015, 2:56-58, 5:54-6:4, 7:8-10, 8:7-15, 8:47-54, 12:12-16; 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b; LGE1003, ¶[132].

For example, the '777 patent 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, ¶[133].:

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

LGE1015, FIG. 11b

Each column in the constellation design table of FIG. 11b corresponds to a specific geometric (i.e., unequally spaced or non-uniform) constellation.

LGE1015, 10:47-55; LGE1003, ¶[134]. A POSITA would understand that one of these geometric (i.e., unequally spaced or non-uniform) constellations would have been selected by the receiver 16 during geometric constellation selection operations described by the '777 patent. LGE1015, 5:56-6:4; LGE1003, ¶[134]. Likewise, a POSITA would have understood that a geometric constellation could have also been selected from one of the geometric constellations provided in, for example, FIGs. 13b, 15b, 17b. *Id.*

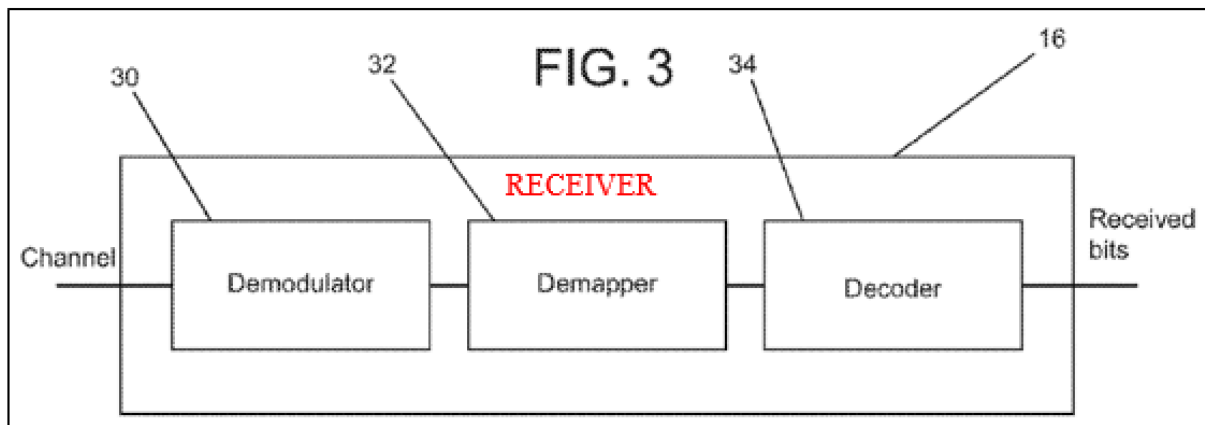
Nonetheless, the constellations of FIG. 11b, 13b, 15b, 17b are one dimensional PAM constellations. LGE1003, ¶[135]. However, the '777 patent explains that one dimensional geometric PAM constellations can be optimized into multidimensional QAM constellations. LGE1015, 3:11-19; 4:29-31; 12:12-16; 12:38-49; LGE1003, ¶[135]. Thus, selecting a multidimensional symbol constellation from a plurality of multidimensional symbol constellations as recited by [1c] would have been obvious to a POSITA. LGE1003, ¶[135].

Limitation [1d]

The '777 patent discloses a decoder coupled to the demapper. LGE1015, 5:40-43; Fig. 3. The '777 patent's coupling of the decoder 34 to the demapper 32

is shown, for example, in FIG. 3 of the '777 patent (reproduced below) LGE1003,

¶[136].:



LGE1015, FIG. 3.

The '777 patent 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*. LGE1015, 5:41-43; 13:31-33; 13:50-51.

The decoder of the '777 patent “provides the likelihoods to a decoder 34 that decodes the encoded bitstream to provide a sequence of received bits to a sink.”

LGE1015, 5:41-43. The encoded bitstream that the decoder decodes is encoded using an “encoder (such as an LDPC encoder) at the transmitter.” LGE1015, 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, ¶[137]; *see also* LGE1008, 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 patent 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.*

Limitation [1e]

The ’777 patent discloses *wherein the plurality of multidimensional symbol constellations comprises a plurality of different non-uniform multidimensional symbol constellations having the same number of constellation points* for at least the reasons in limitation [1c] above. LGE1015, 2:56-58, 5:54-6:4, 7:8-10, 8:7-15, 8:47-54, 12:12-16; 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b; LGE1003, ¶[138]. A POSITA would have understood that the geometric (i.e., non-uniform) one dimensional constellations of FIG. 11b having the same number of constellation points (i.e., 4) would have been capable of being optimized into four respective geometric (i.e., non-uniform) multidimensional constellations and then one selected therefrom for use by the receiver 16. *Id.*; LGE1003, ¶[138].

The ’777 patent discloses *where the constellation points are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellations* for at least the reasons in limitation [1c] above. LGE1015, 2:56-58, 5:54-6:4, 7:8-10, 8:7-15, 8:47-54, 12:12-16; 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b; LGE1003, ¶[139]. In addition, a POSITA would have

understood that when optimizing the geometric (i.e., non-uniform) one dimensional PAM constellation points into geometric (i.e., non-uniform) multidimensional QAM constellation points that the non-uniformity of the resulting constellation points would carry over into each degree of freedom added. LGE1015, 12: 38-44; LGE1003, ¶[139]. Therefore, a POSITA would have found the limitations of [1e] obvious in view of the teachings of the '777 patent. *Id.*

Limitation [1f]

The '777 patent discloses ***wherein the receiver is capable of selecting an LDPC code rate and multidimensional symbol constellation pair from a plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs*** for at least the reasons in limitation 1[c] above. LGE1003, ¶[140].

For example, the '777 patent 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, ¶[141].:

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

LGE1015, FIG. 11b

As described in [1c] and [1e] above, the '777 patent explains that each of the four constellations in the constellation design table of FIG. 11b can be optimized into a plurality of corresponding geometric (i.e., non-uniform) multidimensional QAM constellations having the same number of constellation points and non-uniformity in each degree of freedom. *See* [1c]; [1e]; LGE1003, ¶[142].

Also implicit in the constellation design tables, such as those in FIG. 11b, is a corresponding specific code rate that effectively creates a constellation-code rate pair combination for each column. LGE1003. For example, the LDPC code rate (shown in green text in annotated FIG. 11b above) is determined by the constellation optimization equation set forth in the '319 application provisional, which is incorporated by reference into the '777 patent. 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. LGE1010, 2; LGE1003, ¶[143]. Here, η is the capacity in bps provided in FIG. 11b, N_{dim} is the number of dimensions (e.g., 1 for FIG. 11b or 2 for multidimensional QAM constellation), and M is number of points (e.g., 4 for FIG. 11b or 16 for the optimized multidimensional QAM constellation). LGE1015, FIG. 11b; LGE1010, 2; LGE1003, ¶[143]. Thus, a POSITA would have understood that each column of FIG. 11b comprises geometric (i.e., non-uniform) one dimensional constellation and LDPC code rate pairs. LGE1003, ¶[143]. As explained in [1c] and [1e] above, a POSITA would have understood that these one dimensional constellation and LDPC code rate pairs would have been capable of being optimized into multidimensional constellation and code rate pairs. LGE1003, ¶[143]. Therefore, the bolded features of [1f] above would have been obvious to a POSITA in view of the '777 patent. LGE1003, ¶[143].

The '777 patent discloses *where each of the plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol*

constellation pairs for at least the reasons in limitation 1[c] above and the analysis of features of [1f] above. LGE1003, ¶[144]. As explained above at [1c], [1e], and [1f], each column in an optimized version of FIG. 11b that results from converting the geometric (i.e., non-uniform) one-dimensional PAM constellation-code rate pairs into respective geometric (i.e., non-uniform) multidimensional QAM constellation-code rate pairs is a single geometric (i.e., non-uniform) multidimensional QAM constellation-code rate pair. *See* [1c], [1e], and [1f]; LGE1003, ¶[144]. And, in that plurality of geometric (i.e., non-uniform) multidimensional QAM constellation-code rate pairs, each geometric (i.e., non-uniform) multidimensional QAM constellation-code rate pair occurs only once. LGE1015, FIG. 11b, 13b, 15b, 17b; LGE1003, ¶[144]. Therefore, the features of [1f] above would have been obvious to a POSITA in view of the '777 patent. LGE1003, ¶[144].

Claim 2

Limitation [2a]

In the combination, the '777 patent ***discloses wherein the demodulator is capable of using a demodulation scheme that is based on quadrature amplitude modulation (QAM) and the degrees of freedom available to the multidimensional symbol constellations are in phase and quadrature components*** for at least the reasons in [1c], [1e], and [1f]. For example, in view of the teachings of the '777

patent, a POSITA would have understood that the geometric (i.e., non-uniform) one dimensional PAM constellations would have been capable of being optimized into a geometric (i.e., non-uniform) multidimensional quadrature amplitude modulation (QAM) constellation “inphase and quadrature components” and having “degrees of freedom presented by an extra spatial dimension.” LGE1015, 12:12-16, 12:37-44; LGE1003, ¶[145]; *see also* [1c], [1e], and [1f]. Indeed, the ’777 patent explains that “it is possible to take direct advantage in the optimization step of the additional degree of freedom presented by an extra spatial dimension.” LGE1015, 12:39-42. A POSITA would have understood that the geometric (i.e., non-uniform) one dimensional PAM constellations orthogonalized into QAM constellations, the demodulator of the receiver 16 would be capable of using the optimized geometric (i.e., non-uniform) multidimensional QAM constellations. LGE1015, 12:12-14; 12:39-42; LGE1003, ¶[145]. Therefore, the features of [2a] above would have been obvious to a POSITA in view of the ’777 patent-ATSC322 combination. LGE1003, ¶[145].

Limitation [2b]

In the combination, the ’777 patent discloses *each of the plurality of different non-uniform multidimensional symbol constellations is a sixteen point quadrature amplitude modulated (QAM) symbol constellation* for at least the reasons set forth above with respect to [1c], [1e], and [1f]. A POSITA would have

understood that when the geometric (i.e., non-uniform) one dimensional PAM-4 constellations of FIG. 11b were orthogonalized into a geometric (i.e., non-uniform) multidimensional QAM constellation, the resulting geometric (i.e., non-uniform) multidimensional QAM constellation would be a geometric (i.e., non-uniform) multidimensional 16 point QAM constellation (i.e., a geometric (i.e., non-uniform) multidimensional QAM-16 constellation). LGE1015 12:26-33; LGE1003, ¶[146]. Therefore, the features of [2a] above would have been obvious to a POSITA in view of the '777 patent-ATSC322 combination. LGE1003, ¶[146].

Limitation [2c]

The '777 patent does not disclose that *the LDPC code rate and multidimensional symbol constellation pairs that include one of the plurality of different non-uniform multidimensional symbol constellations have an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8*. LGE1003, ¶[147]. However, in the combination, ATSC322 discloses not only the pairs of constellations and code rates, but *that the LDPC code rate and multidimensional symbol constellation pairs that include one of the plurality of different non-uniform multidimensional symbol constellations have an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8*. LGE1023, 29-34, Tables 6.12, 6.13; Annex C, 164, 172. For example, ATSC322 discloses in a non-uniform multidimensional QAM – code rate pair combination

comprising (i) a non-uniform multidimensional QAM-16 constellation and (ii) an LDPC code rate of 7/15 in Tables 6.12 and 6.13 (annotated and reproduced below) LGE1003, ¶[147].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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 6.13 Mandatory Modulation and Coding Combinations $N_{inner} = 16200$ Bits

Code Rate/ Constellation	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				✓	✓	✓	✓	✓	✓	✓	✓	✓

LGE1023, 31.

The LDPC code rate of 7/15 falls within the claimed range of an *LDPC code rate that is equal to or greater than 3/8 and less than or equal to 6/8*. LGE1023 30-31; LGE1003, ¶[148]. Therefore, the features of [2c] above would have been obvious to a POSITA in view of the '777 patent-ATSC322 combination. LGE1003, ¶[148].

Claim 3

Limitation [3a]

The '777-ATSC322 combination renders obvious all of the limitations of claim 2 above. Also in the combination, the '777 patent discloses *wherein: the*

plurality of multidimensional symbol constellations further comprises an additional plurality of different non-uniform multidimensional symbol constellations that are quadrature amplitude modulated (QAM) symbol constellations and comprises multiple different sixty-four-point symbol

constellations for at least the reasons set forth in the [1c], [1e], [1f], and [2b]. For

example, the '777 patent discloses geometric (i.e., non-uniform) one dimensional

PAM-8 constellations of FIG. 13b. LGE1015, 10:56-62, FIG. 13b; LGE1003,

¶[149]. However, the '777 patent explains that one dimensional geometric PAM

constellations can be orthogonalized into multidimensional QAM constellations.

LGE1015, 3:11-19; 4:29-31; 12:12-16; 12:26-33; 12:38-49; LGE1003, ¶[149]. A

POSITA would have understood in view of the teachings of the '777 patent 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). LGE1015 12:26-33, FIG. 21.

LGE1003, ¶[149]. A POSITA would have understood from the teachings of the

'777 patent that the plurality of multidimensional symbol constellations would be

capable of including the geometric (i.e., non-uniform) multidimensional QAM-64

constellations. LGE1015, 3:11-19; 4:29-31; 5:56-6:4; 12:12-16; 12:38-49;

LGE1003, ¶[149]. Thus, these features of [3a] would have been obvious to a

POSITA. LGE1003, ¶[149].

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 a QAM-64, to then repeat the process for orthogonalizing a PAM-16 into a QAM-256 and a PAM-32 into a QAM-1024. LGE1015 12:26-33, FIG. 21. LGE1003, ¶[150].

In the combination, the '777 patent discloses *wherein the additional plurality of different non-uniform multidimensional symbol constellations further comprises multiple different two-hundred-fifty-six-point symbol constellations* for at least the reasons set forth in the [1c], [1e], [1f], and [2b]. For example, the '777 patent discloses geometric (i.e., non-uniform) one dimensional PAM-16 constellations of FIG. 15b. LGE1015, 11:8-10, FIG. 15b. LGE1003, ¶[151]. However, the '777 patent explains that one dimensional geometric PAM constellations can be optimized into multidimensional QAM constellations. LGE1015, 3:11-19; 4:29-31; 12:12-16; 12:38-49; LGE1003, ¶[151]. A POSITA would have understood in view of the teachings of the '777 patent that optimizing the geometric (i.e., non-uniform) one dimensional PAM-16 constellations of FIG. 15b into respective multidimensional QAM constellations would yield multiple different geometric (i.e., non-uniform) multidimensional QAM-256 constellations. LGE1003, ¶[151]. A POSITA would have understood from the teachings of the

'777 patent that the plurality of multidimensional symbol constellations would be capable of including the geometric (i.e., non-uniform) multidimensional QAM-256 constellations. LGE1015, 3:11-19; 4:29-31; 5:56-6:4; 12:12-16; 12:38-49; LGE1003, ¶[151]. Thus, these features of [3a] would have been obvious to a POSITA. LGE1003, ¶[151].

In the combination, the '777 patent discloses *wherein the additional plurality of different non-uniform multidimensional symbol constellations further comprises multiple different one-thousand-twenty-four-point symbol constellations* for at least the reasons set forth in the [1c], [1e], [1f], and [2b]. For example, the '777 patent discloses geometric (i.e., non-uniform) one dimensional PAM-32 constellations of FIG. 17b. LGE1015, 11:11-13, FIG. 17b. LGE1003, ¶[152]. However, the '777 patent explains that one dimensional geometric PAM constellations can be optimized into multidimensional QAM constellations. LGE1015, 3:11-19; 4:29-31; 12:12-16; 12:38-49; LGE1003, ¶[152]. A POSITA would have understood in view of the teachings of the '777 patent that optimizing the geometric (i.e., non-uniform) one dimensional PAM-32 constellations of FIG. 17b into respective multidimensional QAM constellations would yield multiple different geometric (i.e., non-uniform) multidimensional QAM-1024 constellations. LGE1003, ¶[152]. A POSITA would have understood from the teachings of the '777 patent that the plurality of multidimensional symbol

constellations would be capable of including the geometric (i.e., non-uniform) multidimensional QAM-1024 constellations. LGE1015, 3:11-19; 4:29-31; 5:56-6:4; 12:12-16; 12:38-49; LGE1003, ¶[152]. Thus, these features of [3a] would have been obvious to a POSITA. LGE1003, ¶[152].

Limitation [3b]

The '777-ATSC combination renders obvious that *the constellation points of the additional plurality of different non-uniform multidimensional symbol constellations are non-uniformly spaced in each degree of freedom available to the multidimensional symbol constellation* for at least the same reasons set forth in 1[e]. LGE1015, 2:56-58, 5:54-6:4, 7:8-10, 8:7-15, 8:47-54, 12:12-16; 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b; LGE1003, ¶[153]. For example, a POSITA would have understood in view of the teachings of the '777 patent that when orthogonalizing the geometric (i.e., non-uniform) one dimensional PAM constellation points into geometric (i.e., non-uniform) multidimensional QAM constellation points as described in limitation [3a] that the non-uniformity of the resulting constellation points would “replicate a complete set of PAM-8 points in the in-phase dimension.” LGE1015, 12: 38-44; LGE1003, ¶[153]. Thus, the orthoganilization gives the resulting constellation “in-phase and quadrature components,” or degrees of freedom. LGE1015 12:33-34. The '777 patent states that when “designing constellations in 1-D (PAM for instance) and

then extending to 2-D (QAM), it is possible to take direct advantage in the optimization step of the additional degree of freedom presented by an extra spatial dimension.” LGE1015, 12: 39-43. Therefore, a POSITA would have found the limitations of [1e] obvious in view of the teachings of the ’777-ATSC322 combination. *Id.* LGE1003, ¶[153].

Limitation [3c]

The ’777-ATSC combination discloses that *each of the additional plurality of different non-uniform multidimensional symbol constellations is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs* for at least the reasons set forth in the [1c], [1e], [1f], [2b], and [3a]. For example, each constellation design table shown in FIGs. 11b, 13b, 15b, and 17b, respectively, have a plurality of columns with each respective column corresponding to a geometric (i.e., non-uniform) one dimensional PAM constellation and code rate pair for at least the reasons set forth in [1f]. A POSITA would have understood that once the respective geometric (i.e., non-uniform) one dimensional PAM constellations of FIGs. 11b, 13b, 15b, and 17b were orthogonalized into their respective geometric (i.e., non-uniform) multidimensional QAM form as set forth above in [3a], each of the non-uniform QAM constellations would still correspond to a single LDPC code rate and multidimensional symbol constellation pair. LGE1003, ¶[154]. Therefore, a

POSITA would have found the limitations of [3c] obvious in view of the '777-ATSC322 combination. LGE1003, ¶[154].

Limitation [3d]

The '777 patent does not disclose that *the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol constellations have an LDPC code rate that is equal to or greater than 2/6 and less than or equal to 5/6*. LGE1003, ¶[155].

However, in the combination, ATSC322 discloses *an LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different sixty-four-point symbol constellations have an LDPC code rate that is equal to or greater than 2/6 and less than or equal to 5/6*. LGE1023, 29-34, Tables 6.12, 6.13; Annex C, 165, 173. For example, ATSC322 discloses in a non-uniform multidimensional QAM – code rate pair combination comprising (i) a non-uniform multidimensional QAM-64 constellation and (ii) an LDPC code rate of 7/15 in Tables 6.12 and 6.13 (annotated and reproduced below) LGE1003, ¶[156].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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 6.13 Mandatory Modulation and Coding Combinations $N_{inner} = 16200$ Bits

Code Rate/ Constellation	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				✓	✓	✓	✓	✓	✓	✓	✓	✓

The LDPC code rate of 7/15 falls within the claimed range of an *LDPC code rate that is equal to or greater than 2/6 and less than or equal to 5/6*. LGE1003, ¶[157]. Therefore, the features of [3d] above would have been obvious to a POSITA in view of the '777 patent-ATSC322 combination. LGE1003, ¶[157].

Limitation [3e]

The '777 patent does not disclose that *the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol constellations have an LDPC code rate that is equal to or greater than 3/8 and less than or equal to 7/8*. LGE1003, ¶[158].

However, in the combination, ATSC322 discloses *the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different two-hundred-fifty-six-point symbol constellations have an LDPC code*

rate that is equal to or greater than 3/8 and less than or equal to 7/8. LGE1023, 29-34, Tables 6.12, 6.13; Annex C, 166-168, 173. For example, ATSC322 discloses in a non-uniform multidimensional QAM – code rate pair combination comprising (i) a non-uniform multidimensional QAM-256 constellation and (ii) an LDPC code rate of 7/15 in Tables 6.12 and 6.13 (annotated and reproduced below) LGE1003, ¶[159].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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 6.13 Mandatory Modulation and Coding Combinations $N_{inner} = 16200$ Bits

Code Rate/ Constellation	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				✓		✓	✓	✓	✓	✓	✓	✓

The LDPC code rate of 7/15 falls within the claimed range of an *LDPC code rate that is equal to or greater than 3/8 and less than or equal to 7/8.* LGE1003, ¶[160]. Therefore, the features of [3d] above would have been obvious to a POSITA in view of the '777 patent-ATSC combination. LGE1003, ¶[160].

Limitation [3f]

The '777 patent does not disclose that *the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol constellations have an LDPC code rate that is equal to or greater than 4/10 and less than or equal to 9/10.* LGE1003, ¶[161].

However, in the combination, ATSC322 discloses that *the LDPC code rate and multidimensional symbol constellation pairs that include one of the multiple different one-thousand-twenty-four-point symbol constellations have an LDPC code rate that is equal to or greater than 4/10 and less than or equal to 9/10.* LGE1023, 29-34, Tables 6.12, 6.13; Annex C, 169, 174. For example, ATSC Standard 3.0 discloses in a non-uniform multidimensional QAM – code rate pair combination comprising (i) a non-uniform multidimensional QAM-1024 constellation and (ii) an LDPC code rate of 7/15 in Tables 6.12 (annotated and reproduced below) LGE1003, ¶[162].:

Table 6.12 Mandatory Modulation and Coding Combinations $N_{inner} = 64800$ Bits

Code Rate/ Constellation	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						✓	✓	✓		✓	✓	✓

The LDPC code rate of 7/15 falls within the claimed range of an *LDPC code*

rate that is equal to or greater than 4/10 and less than or equal to 9/10.

LGE1003, ¶[163]. Therefore, the features of [3f] above would have been obvious to a POSITA in view of the '777 patent-ATSC322 combination. LGE1003, ¶[163].

Claims 11

Limitation [11pre]

See supra [1pre]; LGE1003, ¶[164].

Limitation [11a]

See supra [1a]; LGE1003, ¶[165].

Limitation [11b]

See supra [1b]; LGE1003, ¶[166].

Limitation [11c]

See supra [1c]; LGE1003, ¶[167].

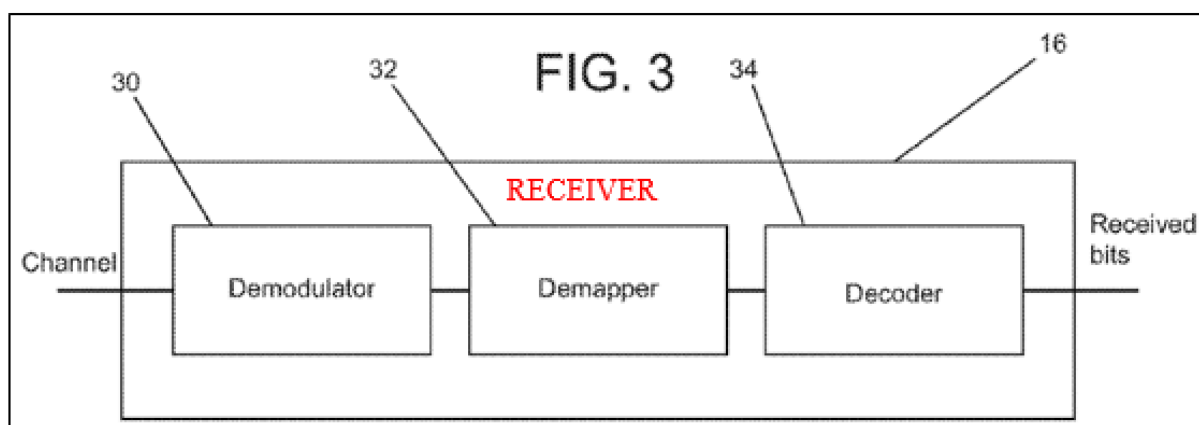
Limitation [11d]

See supra [1d]; LGE1003, ¶[168].

Limitation [11e]

See supra [1b]-[1d]; LGE1003, ¶[169].

The receiver 16 of the communication system 10 is shown in FIG. 3 of the '777 patent (reproduced below), where *the demapper is interposed between the demodulator and the decoder*. LGE1003, ¶[170].



LGE1015, FIG. 3.

Receiver 16 of FIG. 3 “includes a demodulator 30 that demodulates a signal received via the channel to obtain symbol or bit likelihoods” and a demapper 32 that “uses knowledge of the geometrically shaped symbol constellation used by the transmitter to determine these likelihoods.” LGE1015, 5:35-40. 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.*, 5:41-43; LGE1003, ¶[171].

Limitation [11f]

See supra [1f]; LGE1003, ¶[172].

Limitation [11g]

See supra [1g]; LGE1003, ¶[173].

Claim 21

Limitation [21pre]

See supra [1pre]; LGE1003, ¶[183].

Limitation [21a]

See supra [1a], [1b], and [1c]; LGE1003, ¶[184].

For the reasons noted above in [1a] and [1c], the combination renders obvious ***a receiver that receives signals via a communication channel having a channel signal-to-noise ratio (SNR) and the multidimensional symbol constellation is selected from a plurality of multidimensional symbol constellations***, respectively, as recited in claim 21. LGE1015, 5:35-43; 13:37-38; 4:54-56; 7:26-33; 7:47-49; 13:34-38; LGE1003, ¶[185].

It is known in the art that a communication channel has a channel signal-to-noise ratio (SNR). LGE1003, ¶[194]. The '777 patent 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).***” LGE1015, 4:54-56; 7:26-33; 7:47-49; 13:34-38. Accordingly, it would have been obvious to a POSITA that the communication channels of the '777 patent have an SNR. LGE1003, ¶[186].

For the reasons noted above in [1c] and [1d], the combination renders obvious ***a receiver that uses a multidimensional symbol constellation to transform the received signals into received bits and the multidimensional symbol constellation is selected from a plurality of multidimensional symbol constellations***. For example, the '777 patent discloses that “receiver 16 includes a demodulator 30 that demodulates a signal received via the channel to obtain

symbol or bit likelihoods,” and that “...a geometrically shaped constellation *is selected* in conjunction with a code rate to meet specific performance requirements...” LGE1015, 5:35-43; 13:37-38; 5:54-6:4. LGE1003, ¶[187].

Limitation [21b]

See supra [1e]; LGE1003, ¶[188].

Limitation [21c]

See supra [1f]; LGE1003, ¶[189].

Claims 12, 22

See supra [1pre]-[2c]; LGE1003, ¶¶ [174-176,190-192].

Claim 13, 23

See supra [3a]-[3f]; LGE1003, ¶¶ [177-182,193-198].

B. Ground 1B: the '777 patent in view of ATSC327

1. Overview of the ATSC327

ATSC327 is titled *Guidelines for the Physical Layer Protocol* and states that it is a supplement to the ATSC322 reference. LGE1023. LGE1003, ¶[199].

“This document provides recommended practices for the ATSC 3.0 physical layer protocol standards 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." LGE1022, 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." LGE1022, 1. Where ATSC322 "provides distinct features and description of the physical layer technologies," ATSC327 teaches the implementation of those technologies. LGE1022, 6. LGE1003, ¶[200].

As ATSC327 teaches that channel coding methods are used 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." LGE1022, 6. LGE1003, ¶[201].

ATSC327 uses a fixed number of these channel coding schemes by limiting the modulation and code rate (ModCod) combinations to 120. LGE1022, 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." LGE1023 42. LGE1003, ¶[202].

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. LGE1022, 19. LGE1003, ¶[203].

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				✓		✓	✓	✓	✓	✓	✓	✓

LGE1022, 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.” LGE1022, 18. LGE1003, ¶[204].

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

LGE1022, Table 4.3-4.4, 18

2. 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. LGE1015, 4:60-5:11, 5:35-43, FIG. 3; LGE1022, 18-19. Since A327 is a guideline to A322, it can be understood that the constellations are optimized. This is especially true since the ATSC322 Standard discloses that, “[f]or efficiency, new forward error correcting options with the adoption of non-uniform constellations has brought the operation of the BICM closer to the theoretical Shannon Limit; offering over 1dB of gain compared to the use of

uniform constellations using the same operating parameters.” LGE1023, 10.

Hence, the ATSC322 addresses coding and modulation optimizations that are similar to those disclosed in the ’777 patent. LGE1003, ¶[205-206].

In the combination, the ’777 Patent 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.” LGE1015, 5:45-49. The ’777 Patent explains that PAM constellations can be paired with specific code rates to optimize capacity. LGE1015, 9:52-10:3; LGE1003, ¶[207].

Also in the combination, the ’777 patent describes “[p]rocesses for selecting capacity optimized constellations to achieve increased coding gains based upon a specific coding rate.” LGE1015, 5:4-7. In addition, the ’777 patent provides a number of one dimensional constellation design tables. LGE1015, 3:61-64, 4:5-21, FIGs. 11a, 11b, 13a, 13b, 15a, 15b, 17a, 17b. In the combination, the ’777 patent 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. LGE1015, 5:4-7; 10:25-11:13. For the PAM-4 and PAM-8 constellations, the ’777 patent 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. LGE1015, 10:47-55, FIGs. 11a, 11b, 10:58-62, FIGs. 13a, 13b. The '777 Patent also explains to a POSITA that that *QAM* constellations can be derived from *PAM* constellations. LGE1015, 3:9-19, 12:11-16; LGE1003, ¶[208].

Also in the combination, the system of the '777 patent is modified with the teachings of ATSC327 to pair multidimensional *QAM* constellations with specific code rates and compare the SNR. LGE1022, 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.” LGE1022, 32. In this table, “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination.” LGE1022, 32. LGE1003, ¶[209].

In the combination, the communication system of the '777 patent 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):

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

LGE1022, Table 4.3-4.4, 18

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. LGE1022, 19; LGE1003, ¶[210].

3. Reasons to Combine the '777 patent with ATSC327

It would have been obvious for a POSITA to modify the teachings of the '777 patent with the teachings of ATSC327 for a number of reasons. LGE1003, ¶[211]. First, ATSC327 is a technical standards document that 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.” LGE1022, 1. Thus, a POSITA working with a communication system such as the communication system of the ’777 patent would have looked to ATSC327 to identify solutions to problems in the field. LGE1003, ¶[211].

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.” LGE1022, 1; LGE1003, ¶[212]. 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. LGE1022, 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 suits the needs of the system designed by the POSITA. LGE1003, ¶[212].

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 communication systems in the industry and likely to achieve greater adoption in the market. LGE1003, ¶[213].

4. Manner in which the '777-ATSC327 combination renders the Challenged Claims obvious

Claim 5

Limitation [5]

The '777 patent discloses several features of claim 5 for the reasons set forth above. *See* [1pre] to [1f]. However, the '777 patent does not disclose *wherein each of the plurality of different non-uniform multidimensional symbol constellations is capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR*. LGE1003, ¶[214].

In the '777-ATSC327 combination, ATSC327 discloses these limitations of [5]. LGE1022, 18, Table 4.3, 4.4. ATSC327 is used to enable the communication system to have “a look-up table with the defined constellation mapping for each ModCod combination.” LGE1022, 32. In this table (e.g., Table 4.3), “[t]here is one non-uniform constellation (NUC) defined for each ModCod combination.” LGE1022, 32. LGE1003, ¶[214].

A POSITA would have understood how to implement Table 4.3 (reproduced below) as a look-up table that includes a *plurality of different non-uniform multidimensional symbol constellations* that are optimized for capacity at a

specific SNR. LGE1022, 18, Table 4.3, 4.4; LGE1003, ¶[216]. 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 their respective optimized 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 the SNR) *providing a greater capacity than the other symbol constellation*. LGE1022, 18, Table 4.3, 4.4; LGE1003, ¶[216].

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

LGE1022, Table 4.3-4.4, 18

For example, Table 4.3 (annotated above) shows *a first plurality of non-uniform multidimensional QAM-16 constellations* (annotated in the red box) with code rates 4/15-5/15 *and another plurality multidimensional QAM-16 constellations* (annotated in the blue box) with code rates 7/15-9/15. LGE1003, ¶[217]. *When comparing the capacity of each* of the multidimensional constellations in the first plurality (red box) relative to the multidimensional constellations of the second plurality (blue box) *at the same SNR* of 2.82dB, *each*

of the plurality of constellations in the first plurality non-uniform multidimensional QAM (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. LGE1003, ¶[217-218].

It would have been obvious to a POSITA that when choosing to assign each NUC constellation to a code rate in Table 4.3, the pairing would be based off of maximum efficiency and therefore would maximize the capacity for each constellation code rate pair at a given SNR. LGE1024, 199; LGE1003, ¶[219]. Further, the empirical evidence for this is available in appendixes B and C of ATSC327, where the threshold C/N values are calculated then the Simulation, Lab, and Field values for SNR are compared. LGE1022, 98-118. LGE1003, ¶[219]. With the aid of the empirical data, a POSITA would organize Table 4.3 in such a way to maximize capacity of each constellation at the given SNRs. LGE1003, ¶[219].

With Table 4.3 organized for capacity, it would have been obvious to a POSITA that an optimized constellation and code rate pair for a given SNR, would no longer be optimized when one of the parameters (SNR) changes. A POSITA would understand that when moving a constellation and code rate from the optimized parameters and comparing it to any other constellation and code rate pair, that each of the still optimized constellation code rate pairs would have a

greater capacity than the “no longer optimized” constellation code rate pair when compared at the same SNR. LGE1003, ¶[220].

A POSITA’s understanding of the constellation/rate pairs in Table 4.3 would be that every constellation in that table has been optimized to work well with the paired code rate, and the corresponding SNR listed in that table. So moving across a row in that table, even though the constellations are all "16-QAM", they are all unique differently-spaced constellations. Annex C of the ATSC322 document lists the point-locations of all the constellations, indexed by code rate. For QPSK, the constellations are all the same, independently of code rate. For 16-QAM, the constellations differ for each code rate. 64-QAM all differ, and so on. LGE1003, ¶[221].

For example, a POSITA would understand that to take a 16-QAM constellation from the right side of the table (that was optimized for the rate 10/15 code), and try to use it on the left (with, say, rate = 5/15 code), then one is pairing a constellation on the right with a code rate on the left. This mismatched-pair would presumably do worse than the constellation matched with the rate 5/15 code for the SNR listed on the table (2.82 dB). Similarly, pairing a 16-QAM constellation optimized for rate 5/15 with a code of rate = 10/15 would do worse than the 16-QAM constellation that was optimized for rate 10/15 code at SNR listed on table 4.3 (8.36). LGE1003, ¶[222].

A POSITA would have found it obvious that when two pluralities of constellations that have each been optimized for capacity in particular ranges of SNRs, 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, ¶[223].

Therefore, the limitations of [5] would have been obvious to a POSITA in view of the '777-ATSC327 combination. LGE1003, ¶[224].

Claims 15, 25

See supra [5]; LGE1003, ¶[225-226].

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

Patent Owner ("Constellation") filed an infringement action against LGE involving seven patents. *See* LGE1020 (Complaint). The action, assigned Case No. 2:21-cv-00448 ("the Related Litigation"), is concurrently pending in the Eastern District of Texas before the Honorable Judge Rodney Gilstrap. LGE1019.

In *Apple Inc. v. Fintiv, Inc.*, the Board enumerated six factors that provide a "holistic view" as to "whether efficiency, fairness, and the merits support the exercise of authority to deny institution." IPR2020-00019, Paper 11 at 2-3 (PTAB

“precedential” Mar. 20, 2020) (“*Fintiv*”). In June 2022, the USPTO issued updated discretionary denial guidance in view of the *Fintiv* factors and expressly noted that “*the PTAB will not discretionarily deny institution in view of parallel district court litigation*” where a petitioner presents a stipulation not to pursue in a parallel proceeding the same grounds or any grounds that could have reasonably been raised before the PTAB.” LGE1018, 3, 7-8.

Here, Petitioner has eliminated any risk of duplicated effort by voluntarily stipulating to counsel for Patent Owner that, if the Board institutes an IPR, Petitioner will not pursue, in the District Court proceedings with respect to claims 2-3, 5, 12-13, 15, 22-23, and 25 of the ’700 Patent, the grounds asserted in this IPR petition or on any other ground that was raised or could have been reasonably raised by Petitioner in an IPR. LGE1012; *Sotera Wireless, Inc. v. Masimo Corp.*, Case IPR2020-0109, Paper 12 (PTAB Dec. 1, 2020). Because Petitioner is submitting a *Sotera*-style stipulation in these proceedings, 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 '700 Patent is the subject of a civil action, *Constellation Designs, LLC*
v. LG Electronics, Inc. et al., 2:21-cv-00448, E.D. Tex., Dec. 9, 2021 (LGE1020).
Petitioner is not aware of any disclaimers, or reexamination certificates for the
'700 Patent. Petitioner has filed another IPR petition in IPR2023-00228
addressing claims 1, 4, 6-11, 14, 16-21, 24, and 26-30 of the '700 Patent.

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

Petitioner provides the following designation of counsel.

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D. Service Information

Please address correspondence/service to the above-listed address. LGE
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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 13,935 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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