UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS, INC.

Petitioner

v.

CONSTELLATION DESIGNS, LLC

Patent Owner

US Patent No. 10,693,700

Issue Date: June 23, 2020

Title: Receivers Incorporating Non-Uniform Multidimensional Constellations and Code Rate Pairs

Inter Partes Review No.: IPR2023-00319

SECOND DECLARATION OF DR. BERTRAND HOCHWALD

LGE 1029
LG Electronics, Inc. v. Constellation Designs, LLC
IPR2023-00319

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I. Introduction

[0001] I previously submitted a declaration (LGE1003) in support of the petition submitted in IPR2023-00319. Counsel (Fish and Richardson) for Petitioner has informed me that the petition was instituted, and the Patent Owner submitted a Patent Owner Response (POR) in which claims 2, 3, 12, 13, 22, and 23 were disclaimed, leaving only claims 5, 15, and 25 at issue. Counsel also informed me that Patent Owner has argued that claims 5, 15, and 25 have written description support in the challenged patent, U.S. Patent No. 10,693,700 (the "**'700 Patent**"). For the reasons noted below[1], I disagree.

II. Claims 5 and 1

[0002] Claim 5 is a dependent claim, that depends from claim 1. For convenience, I have reproduced claims 5 and 1 below.

[0003] Claim 5 recites:

> The communication system of claim 1, wherein each of the plurality of different non-uniform multidimensional symbol

[1] Although my remarks in this second declaration focus on claim 5, unless otherwise stated, they also apply to claims 15 and 25, which recite similar features as claim 5.

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.

[0004] Claim 5 depends from claim 1, which recites:

A communication system, comprising:

a receiver capable of receiving signals via a communication channel having a channel signal-to-noise ratio (SNR), wherein the receiver comprises:

a demodulator capable of demodulating a received signal into a demodulated signal;

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

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;

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;

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.

[0005] A POSITA would have understood that a "multidimensional symbol constellation," as recited in claim 5, refers to a constellation with more than one dimension, such as a two-dimensional (2-D) or larger symbol constellation. LGE1001, 14:65-15:3.

III. The '700 Specification is Deficient

[0006] The specification of the '700 patent only provides guidance on how to *construct* 2-D (two-dimensional) constellations by example, and explains that the "capacity characteristics of the resulting QAM-64 constellations are identical to that of the PAM-8 constellations ***on a per-dimension basis***." (emphasis added)

LGE1001, 12:63-67 (Emphasis added.) Hence, a POSITA would understand that the QAM-64 constellations constructed from PAM-8 constellations would inherit the capacity-achieving properties of the PAM-8 constellations ***on a per-dimension basis***, but not necessarily have the multidimensional characteristics called for in the claim language (e.g., "each … non-uniform multidimensional symbol constellations … providing greater parallel decoding capacity at a specific SNR than the other symbol constellations"). Indeed, the specification suggests that optimizing multidimensional symbol constellations requires significant effort beyond that disclosed in the specification. For example, the '700 patent explains that "[i]n general it is possible to design N-dimensional constellations and associated labelings. The complexity of the optimization step grows exponentially in the number of dimensions as does the complexity of the resulting receiver de-mapper. Such constructions constitute embodiments of the invention and simply require more 'run-time' to produce." LGE1001,13:6-11. However, no details of such optimizations are presented.

[0007] Indeed, when the specification is considered as a whole, a POSITA would not have been guided on how to produce multidimensional symbol constellations that are capable of providing "a greater parallel decoding capacity" as stated in Claim 5. Rather, the POSITA would, at best, have been guided towards 2-D constellations that are constructed from PAM (single-dimensional)

constellations and that provide a certain capacity per dimension when used for these 2-D constellations. No mention is made of constellations higher than two dimensions in this regard.

IV. 2D Optimization is not Necessarily the Same as 1D Optimization

[0008] In my experience, optimization of 1D symbol constellations does not necessarily translate to optimization of 2D symbol constellations that are formed using optimized 1D constellations. There certainly was no such disclosure in the '700 patent or any examples of 2D symbol constellations that had been optimized such that "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," as recited in claim 5.

[0009] I agree that *some* constellations designed and optimized as a one-dimensional symbol constellation (e.g., PAM-8) may produce capacity characteristics in a QAM-64 constellation that are similar to a PAM-8 ***on a per-dimension basis***, as described in the '700 patent. LGE1001, 12:64-67. However, the '700 patent does not describe that its multidimensional symbol constellations (e.g., QAM constellations constructed through orthogonalization of PAM constellations), considered as a whole, have the same capacity characteristics to that of the PAM constellations used to construct them. In fact, it is known in the

art that single dimensional and multidimensional constellations do not have the same capacity characteristics. For example, Fuentes explains that "2D-NUCs [(Non-Uniform Constellations)] are always ***a better option than 1D-NUCs from the capacity point of view***. … First, the ***BICM capacity gain increases with the constellation order, regardless of the type of NUC used***. Second, the relative gain between 2D- and 1D-NUCs is always higher for the medium range of SNRs in which each order of constellation works. Logically, ***the SNR range also increases with the constellation order***."[2] (emphasis added) LGE1030, 75-77. Thus, Fuentes explains that a 1D-NUC (Non-Uniform Constellation) and 2D-NUC do not necessarily have the same capacity characteristics when 1D constellations and 2D constellations (as a whole) are compared. Indeed, Fuentes teaches that the opposite is true and that SNR and capacities of 1D and 2D constellations can be different. For instance, the difference between the dashed lines and the solid lines in Fuentes' FIG. 3.16 (reproduced below) show how different the BICM or parallel decoding capacities for various 1D and 2D NUC QAM constellations can be at

[2] Bit-Interleaved Coded Modulation (BICM) and parallel decoding capacity are terms that are used interchangeably in the art, as acknowledged by the Patent Owner. *LG Electronics Inc. v Constellation Designs, LLC*, IPR2022-01482, Paper 7 at 35 (Jan. 24, 2023).

various SNRs. Consequently, the parallel decoding capacity and SNR at which a 1D constellation may be configured and optimized for, are not necessarily the same as the parallel decoding capacity and SNR of a 2D constellation formed from the 1D constellation.

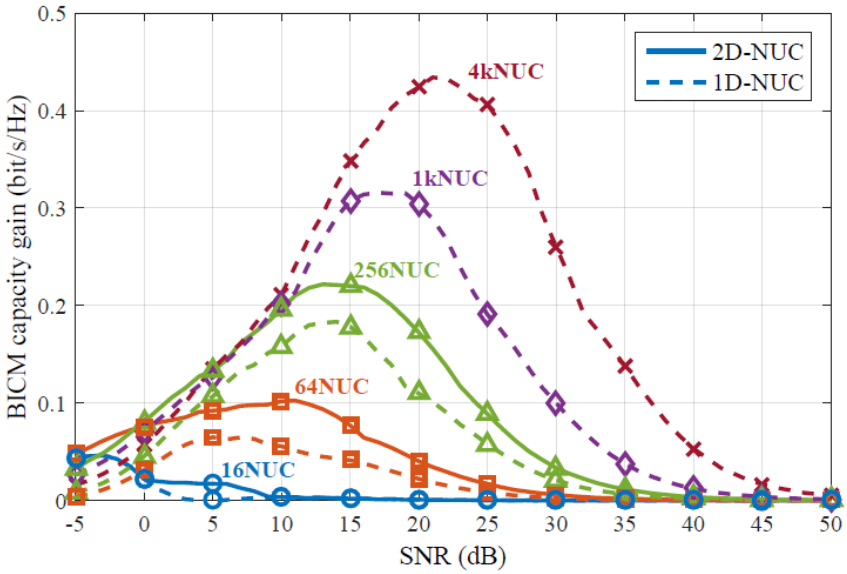


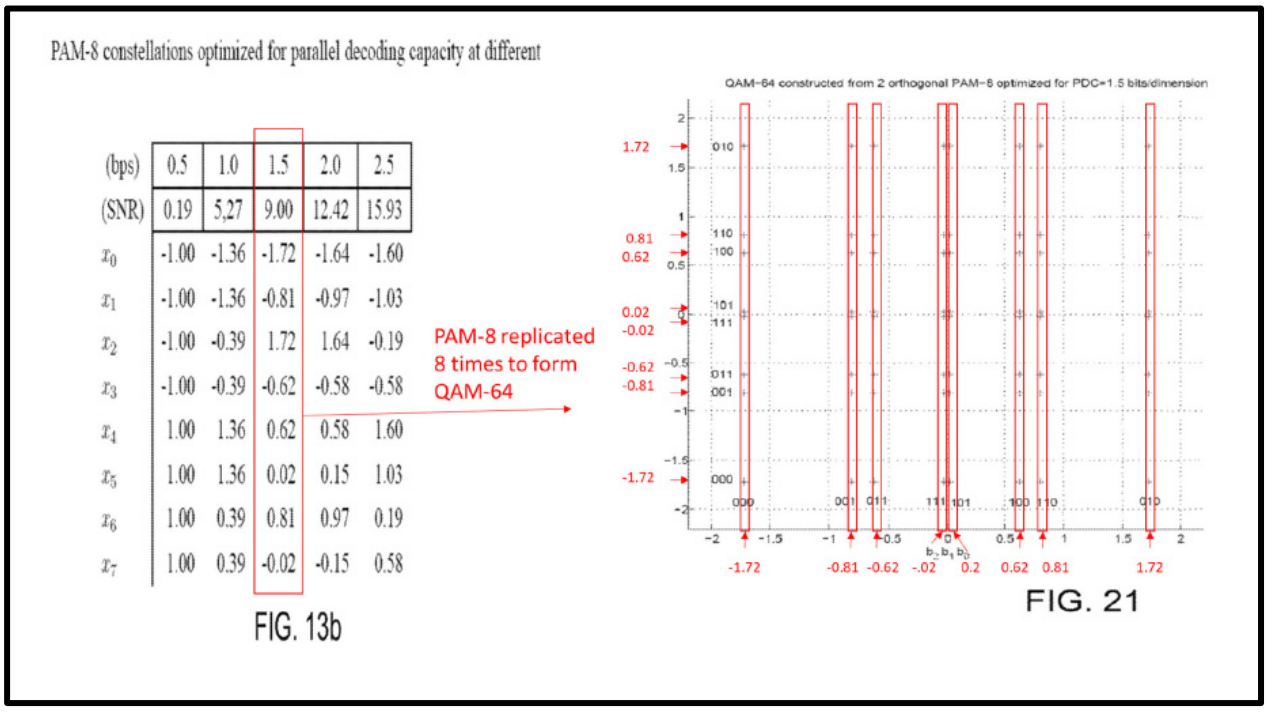
Figure 3.16: Gain of 1D/2D-NUC over QAM, for the i.i.d. Rayleigh channel model, and a range of SNR values between -5 and 50 dB.

LGE1030, FIG. 3.16.

[0010] The'700 patent also does not provide any examples of optimizing the multidimensional constellations after being constructed from PAM constellations, or any subsequent optimization of such multidimensional constellations. A POSITA would have known that a PAM constellation can be optimized based on amplitude and 1D spacing between points, whereas a QAM constellation can be optimized based on amplitude and phase, among other factors. Thus, after using

an optimized 1D constellation (e.g., PAM) to generate a multidimensional symbol constellation, the generated multidimensional symbol constellation would not necessarily have ***phase*** and amplitude values that are optimized.

[0011] Patent Owner attempts to link the optimization of a 1D constellation to a 2D constellation, for example as shown in FIGS. 13B and 21 on page 27 of the POR. However, these figures and Patent Owner's annotations merely reinforce that the 2D constellation is, at best, a collection of replicated PAM constellations individually optimized in one-dimension, not an optimized multidimensional constellation. EX2001, 25-28; POR, 26-28.



POR, 27.

[0012] Moreover, a QAM constellation created from PAM constellations may have different parallel decoding capacity and SNR characteristics, as a whole, compared to the individual PAM constellations used to create the QAM constellation. The different characteristics of a multidimensional symbol constellation created from a one-dimensional symbol constellation can be attributed to various factors, such as, for example, the nature of noise disturbances at the receiver, the presence of interference, nonlinearities in the transmitter or receiver hardware, bit assignments to the constellation points, and the channel characteristics, especially if there is fading. For example, as the '700 patent notes, the complexity of the demapper increases with the number of dimensions. LGE1001, 13:1-10. One example of the increased complexity can be appreciated from Patent Owner's annotated figure (reproduced below) and can arise when the spacing between two symbols in a QAM constellation are located within close proximity to one another.

PAM-8 constellations optimized for parallel decoding capacity at different

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

QAM-64 spacing in each dimension is equal to PAM-8 spacing in 1-dimension

FIG. 13b

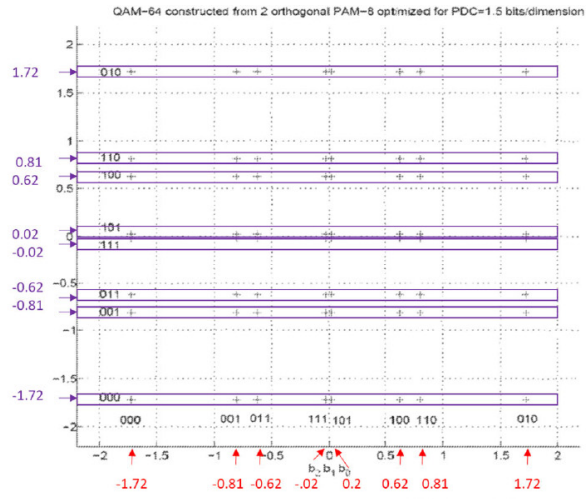


FIG. 21

POR, 28.

[0013] A zoomed-in version of the POR's annotated FIG. 21 shows that where the PAM constellation originally had two constellation symbol locations (0.62 and 0.81) within a close proximity, the created QAM constellation now has four corresponding symbol locations within close proximity.

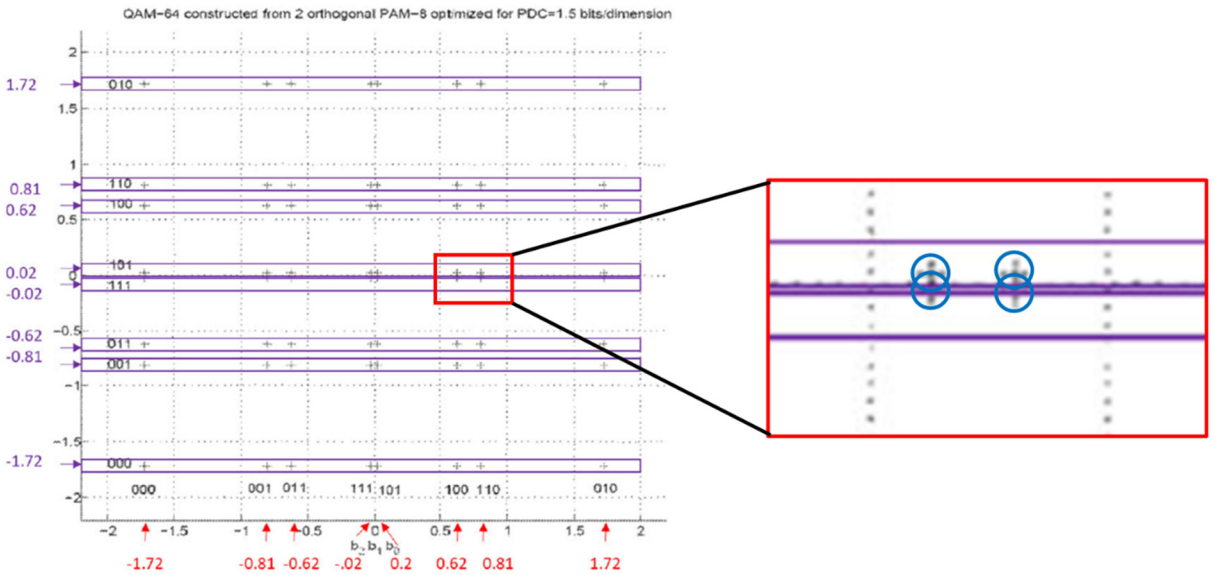


FIG. 21

POR, 28 (annotated).

[0014] In such circumstances, it can become more difficult for the demapper to correctly identify symbol locations. Indeed, due to the presence of noise or other signal distortions, such symbol locations can often be incorrectly determined by the receiver resulting in different characteristics of the demapped QAM. The risk of such overlaps is greater in higher order constellations, and thus, additional processing and circuitry is desired to correctly demap symbols.

[0015] Indeed, the above example merely reinforces what is well-understood in the art—that optimization in 1D symbol constellations is not the same as optimization in 2D symbol constellations. As such, a POSITA would have understood that using a PAM symbol constellation optimized for a particular parallel decoding capacity and SNR to generate a QAM would not have

necessarily yielded a QAM such that the parallel decoding capacity and SNR characteristics of the QAM (considered as a whole) would have the same or similar parallel decoding capacity and SNR characteristics as the optimized PAM.

[0016] Thus, it would not have been obvious to a POSITA nor does the '700 Patent disclose that a series of constellations optimized in one dimension, when orthogonalized into two dimensions, would retain capacity characteristics relative to each other as those of the original constellations.

[0017] Based on the remarks above, I will now address the specific features recited in claim 5 and explain why a POSITA would have not found sufficient written description support for the features recited in claims 5, 15, and 25.

V. The '700 Patent does not describe "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".

[0018] Patent Owner contends that there are two approaches for optimizing multidimensional QAM constellations. POR, 25-26. The first approach "for optimizing a multidimensional QAM constellation is to directly optimize over each degree of freedom." POR, 25-26. The second approach "is to first optimize a PAM constellation, then apply that PAM constellation to both of the in-phase and quadrature components." POR, 26 (citing to EX1001 at 3:25-34; 12:42-67 and EX1015 at 3:9-19, 12:11-37); EX2001, 26.

[0019] With respect to the first approach, the ’700 patent is devoid of any details for directly optimizing each degree of freedom. As I previously noted, the ’700 patent explicitly states “[t]he ***complexity of the optimization step grows exponentially*** in the number of dimensions as does the complexity of the resulting receiver de-mapper.” (emphasis added) LGE1001, 13:1-11. The ’700 patent provides no details of the additional complexity of the receiver demapper or other details of the complex optimization steps. Patent Owner relies on one paragraph to argue that this first approach is supported, *see* LGE1001, 13:1-11, but this paragraph fails to describe or explain whether the optimization is for uniform or non-uniform multi-dimensional constellations, and whether there is any difference in optimizing the two types of constellations. Thus, such disclosure cannot be relied upon as written description support for claim 5, which is directed to “non-uniform multidimensional symbol constellations.”

[0020] The POR focuses on the second approach for its assertion of written description support for claim 5. POR, 25-33, 42-45. However, as I have stated, a careful review of the ’700 patent, reveals that ***even the second optimization approach is not described in the ’700 patent***.

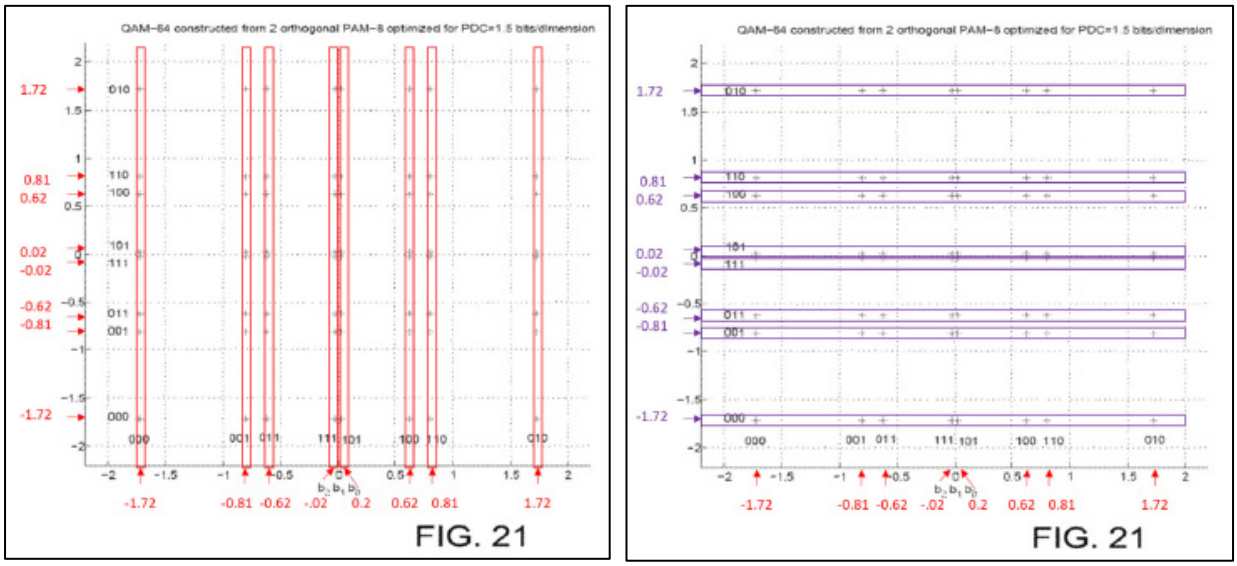
[0021] For example, for the second approach, Patent Owner focuses on two portions of the ’700 patent, but these portions disclose how a QAM constellation can be ***created*** from a PAM constellation, not how a QAM constellation is

optimized. LGE1001, 3:25-34 ("creating an orthogonalized PAM constellation using the geometrically shaped PAM constellation, and combining the geometrically shaped PAM constellation and the orthogonalized PAM constellation to produce a geometrically shaped QAM constellation"), 12:42-67. The mere disclosure of ***creating*** a QAM constellation from a PAM constellation does not teach ***optimizing*** a multidimensional QAM constellation. As I explain below, none of the descriptions of the creation of a multidimensional QAM constellation from orthogonalized single-dimension PAM constellations discloses optimizing the created multidimensional QAM constellation.

A. The '700 patent provides no description of optimizing a multidimensional symbol constellation that is created from a one-dimensional symbol constellation

[0022] The '700 patent explains that "[d]ue to the orthogonality of the in-phase and quadrature components the capacity characteristics of the resulting QAM-64 constellation are identical to that of the PAM-8 constellation ***on a per-dimension basis***." (emphasis added) LGE1001, 12:64-67. The newly created QAM constellation is not an optimized multidimensional constellation, but a multidimensional constellation that includes individual rows or columns that were optimized. Patent Owner does not acknowledge this distinction, and conflates optimization per dimension to mean the same thing as optimizing over all dimensions jointly.

[0023] It was well-known in the art that 2D constellations, such as a QAM constellation, could be created by orthogonalizing two 1D constellations, such as a PAM constellation. Indeed, using the annotated figures Patent Owner produced in the POR as shown below, when a column of a QAM constellation is compared to a row of a QAM constellation ("per-dimension basis"), the capacity characteristics can be the same.



POR, 27-28 (showing annotated FIG. 21 of LGE1001).

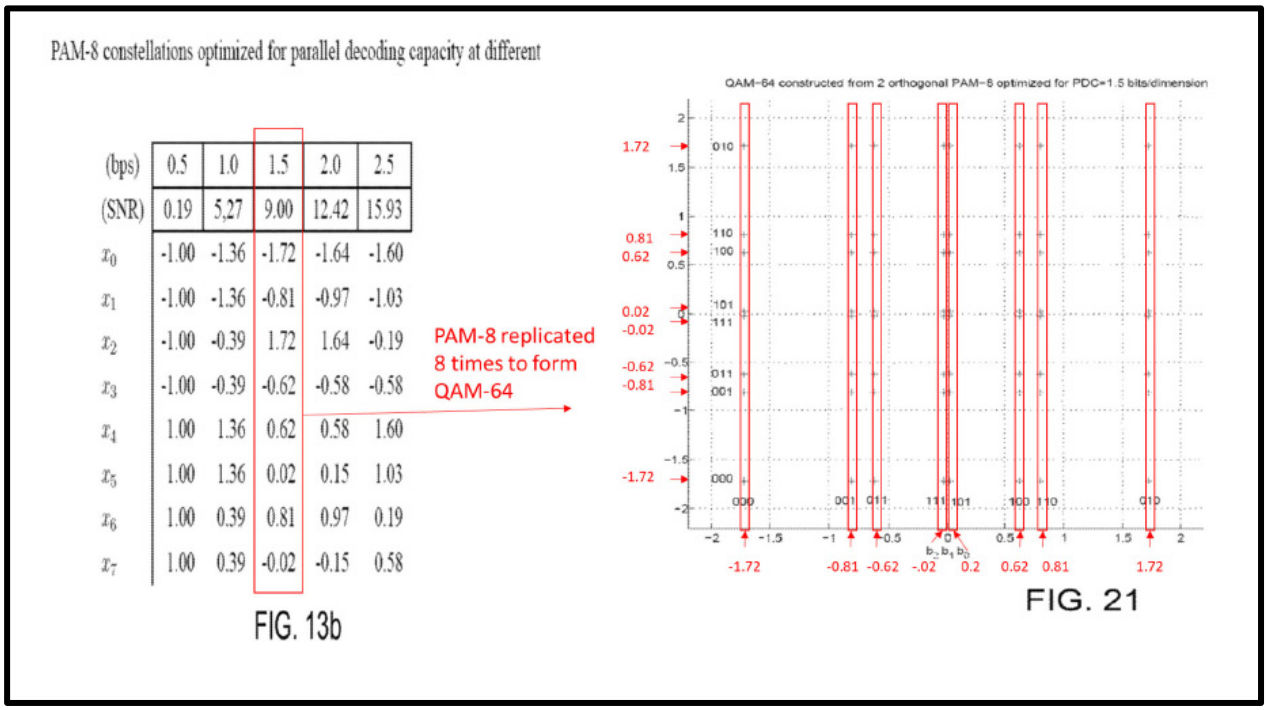
[0024] Similarly, when a singular column or row of the QAM constellation is compared to the original PAM constellation used to create the QAM the constellation, that row or column has the same capacity characteristics as the PAM. As shown above, the individual highlighted rows or columns are repeated copies of the PAM constellation. Thus, "the capacity characteristics of the resulting QAM-

64 constellation are identical to that of the PAM-8 constellation **on a per-dimension basis.**" (emphasis added) LGE1001, 12:64-67.

[0025] **However, the QAM constellation, as a whole, is not necessarily optimized**. Indeed, it is ***necessarily incorrect*** that the capacity characteristics of a PAM and a QAM are the same. In the example of PAM-8 and QAM-64, the PAM-8 constellation has 3 bits per symbol and the QAM-64 constellation has 6 bits per symbol. Thus, their respective capacity characteristics are necessarily different. Yet, the statement in 12:64-67 of the '700 patent holds true ***only when*** the two constellations are compared "***on a per-dimension basis.***" That is, when the capacity characteristics of a singular column or row of the QAM-64 constellation are compared to the capacity characteristics of the PAM-8 constellation used to form the QAM-64 constellation, the capacity characteristics are identical for that ***column or row***.

[0026] Patent Owner attempts to link the optimization of a 1D constellation to a 2D constellation, for example as shown in FIGS. 13B and 21 on page 27 of the POR. However, these figures and Patent Owner's annotations merely reinforce that the constellations are, at best, a collection of replicated PAM constellations optimized in one-dimension, not a "non-uniform multidimensional symbol constellations [] 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", which is what the claims require. LGE1001, 14:65-15:3; EX2001, 25-28; POR, 26-28.



POR, 27.

[0027] Thus, throughout the POR and as reflected in Patent Owner's figure above, the '700 patent, at best, discloses optimized 1D symbol constellations used to create a 2D constellation. As seen above, the "replication" of a PAM-8 (eight times) shows the use of individual constellations that have been optimized. The created QAM-64 is optimized on a "per dimension basis" only. And because there is no disclosure of the multidimensional symbol constellation being optimized, the '700 patent does not describe "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."

B. The '700 patent fails to disclose that an optimized PAM used to form a QAM yields an optimized QAM.

[0028] The '700 patent does not disclose that using optimized one-dimensional constellations to produce two-dimensional constellations would also result in optimized two-dimensional constellations. Indeed, as shown below, throughout its disclosure, the '700 patent focuses on optimizing desired capacity on a per dimension basis. I provide some example excerpts below.

- "selecting an appropriate constellation size and ***a desired capacity per dimension***, estimating an initial SNR at which the system is likely to operate, and iteratively optimizing" (emphasis added) (LGE1001, 3:4-24);
- "[t]hroughout the description of the present invention SNR is defined as the ratio of the average constellation energy ***per dimension*** to the average noise energy ***per dimension***. In most cases the capacity can be set to equal the target user bit rate per symbol ***per dimension***" (emphasis added) (LGE1001, 7:51-56); and
- "the SNR at which the optimized M-ary constellation provides the desired capacity ***per dimension*** η (SNR_{out}) is determined (emphasis

added) (LGE1001, 8:13-15).

[0029] Far from disclosing that 1D constellation optimization would also apply to 2D constellation optimization, the ’700 patent discloses the opposite. In particular, the ’700 patent reveals that:

> The minimum distance (d_{min}) between constellation points is indicative of the capacity of a constellation at high signal-to-noise ratios (SNRs). Therefore, constellations used in many communication systems are designed to maximize d_{min}. **Increasing the dimensionality of a constellation allows larger minimum distance for constant constellation energy per dimension**. (emphasis added) LGE1001, 1:45-54.

[0030] This disclosure clearly indicates that the d_{min} used to optimize capacity at a high SNR ***for a single dimensional symbol constellation*** could be ***different*** for a d_{min} associated with a constellation with increased dimensionality (i.e., ***multidimensional constellation***). Consequently, any optimization of a parallel decoding capacity at a specific SNR for a single dimensional symbol constellation, such as a PAM, would not necessarily be the same or applicable for a non-uniform multidimensional symbol constellation, such as a QAM, even if that QAM were formed using an optimized PAM.

[0031] The above-disclosure and the omission of any statement in the ’700 patent (or any evidence submitted by Patent Owner) disclosing that the parallel decoding capacities and SNRs of a PAM and a QAM formed using the PAM are the same, demonstrate that the ’700 patent has no written description support for claims 5, 15, and 25.

[0032] The patent description seems to infer that optimizing a single-dimensional constellation and using this constellation to make a multidimensional constellation carries optimality properties over to the multidimensional constellation. However, a POSITA would understand that the behavior of noise at the receiver, the impairments imposed by the channel between the transmitter and receiver, imperfections in the hardware at the transmitter and receiver, and bit assignment differences between the single and multidimensional constellations will confound this reasoning. Hence, any ordering in performance among single-dimensional constellations will not necessarily be preserved in their corresponding multidimensional constellations. As I explained above in Section IV, available literature (LGE1030 (Fuentes), 75-77) also corroborates this understanding.

[0033] Moreover, a POSITA would have understood that SNR and parallel decoding optimizations of PAM constellations would involve amplitude and/or 1D spacing optimizations, whereas optimizations of QAM constellations would also involve phase considerations and spacing along radial directions. But there is no

disclosure of phase optimization in the ’700 patent (with respect to a multidimensional symbol constellation (e.g., QAM) created from one-dimensional symbol constellations (PAMs)). Indeed, even in the instance of generating a multidimensional symbol constellation (e.g., QAM) from single dimensional symbol constellations (e.g., PAM), the ’700 patent provides no discussion of how phase or radial distance from the center are considered with other parameters when optimizing SNR, parallel decoding capacity, or any other capacity characteristic of a multi-dimensional symbol constellation. A QAM constellation constructed from PAM does not account for interference and noise related to phase when the previous optimization was based on 1D amplitude and spacing. LGE1031, 887. Thus, the ’700 patent fails to explain how a multi-dimensional QAM constellation generated using optimized PAMs is itself optimized. It is thus not surprising that the ’700 patent also fails to disclose the relationship of the SNR of a one-dimensional constellation (e.g., PAM-8) to the SNR of a multi-dimensional constellation (e.g., QAM-64) formed by orthogonalizing the one-dimensional constellation.

C. Patent Owner only points to evidence of 1D constellations being optimized

[0034] In attempting to defend the lack of support of claims 5, 15, and 25 in the ’700 patent, Patent Owner turns to evidence that addresses optimizations in 1D.

For instance, Patent Owner turns to Figures 11b, 13b, 15b, and 17b, 10:8-13, and other portions of the ’700 patent in support of claim 5. POR, 42-45. But none of these disclosures teach optimization of a multidimensional symbol constellation. As one example, even if FIG. 13b discloses optimizing a PAM-8 constellation for parallel decoding capacity at a particular SNR, such information would not be understood as disclosing an optimization of a QAM-64 constellation such that “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. Indeed, the ’700 patent does not explain whether a multidimensional constellation, created from one dimensional constellations, is already optimized or needs to be further optimized for the code rate, SNR, capacity, or other characteristics.

[0035] Focusing on the example of FIG. 13b which Patent Owner highlights in its POR, as shown below, Patent Owner attempts to link FIG. 13b to the multi-dimensional constellation shown in FIG. 21. POR, 27-28. But the title of FIG. 21 states “QAM-64 constructed from **2 orthogonal PAM-8 optimized** for PDC=1.5 bits/**dimension.**” (emphasis added) The ’700 patent does not describe the QAM-64 constellation as optimized, nor is there any information in the disclosure about the parallel decoding capacity or SNR of the QAM-64 constellation. With no

description of the SNR or parallel decoding capacity of the non-uniform multi-dimensional symbol constellation shown in FIG. 13b or in any other multi-dimensional constellation, the '700 patent fails to provide written description support for claims 5, 15, and 25.

PAM-8 constellations optimized for parallel decoding capacity at different

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

PAM-8 replicated 8 times to form QAM-64

FIG. 13b

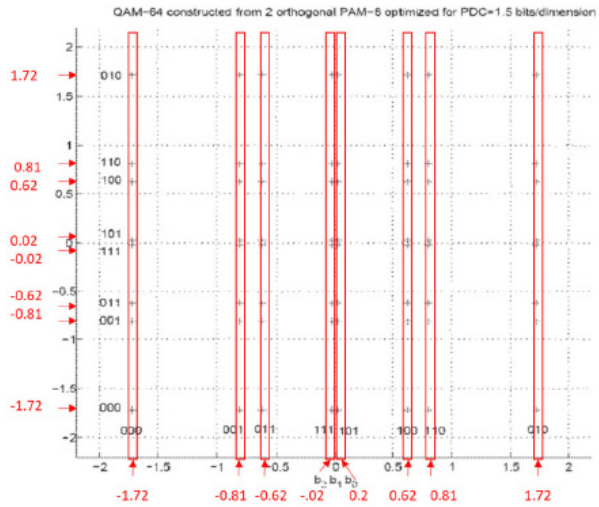


FIG. 21

POR, 27.

[0036] Moreover, throughout the POR, Patent Owner mischaracterizes the alleged supporting disclosure. For instance, Patent Owner contends that:

> the specification includes ***a number of tables identifying*** a plurality of different non-uniform ***multidimensional*** symbol constellations that 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 at the same SNR. ***For example, Barsoum's Figs. 11b, 13b, 15b and 17b all disclose constellations*** that are capable of providing the greatest parallel decoding capacity at a specific SNR. (emphasis added) POR, 43.

[0037] But none of Figs. 11b, 13b, 15b and 17b are related to multi-dimensional constellations. As I show below, the same holds true for various other disclosure Patent Owner points to as allegedly supporting the claim features at issue. Each of these disclosures fails to show or teach multidimensional optimization.

> For example, Barsoum describes determining optimized constellations for each operating SNR:
>
> > As is discussed further below, direct optimization of the constellation points of a communication system utilizing a capacity approaching channel code, can yield different constellations ***depending on the SNR for which they are optimized***. Therefore, the ***same constellation is unlikely to achieve the same coding gains applied across all code rates; that is, the same constellation will not enable the best possible performance across all rates***. In many instances, a constellation at one code rate can achieve gains that cannot be achieved at another code rate."
>
> (EX1015 at 4:62-5:11).
>
> > ***Optimizing a constellation for a specified capacity*** often involves an iterative process, because ***the optimal constellation depends upon the SNR*** at which the communication system operates.
>
> (*Id.* at 7:26-29).
>
> > The optimization process typically ***finds the constellation that gives the largest PD capacity or joint capacity at a given SNR***. The optimization process itself often involves an iterative numerical process that among other things considers several constellations and ***selects the constellation that gives the highest capacity at a given SNR***.

POR, 42.

[0038] Throughout its arguments, Patent Owner relies on an assumption that the characteristics of non-uniform 1D constellations would necessarily also apply to non-uniform 2D constellations, which, as I noted above, is incorrect. To the extent there could be circumstances in which such an assumption would hold true, the '700 patent provides no description of such circumstances and it certainly would not apply to "each" of different non-uniform multidimensional

constellations. Thus, none of the evidence provided by the Patent Owner provides written description support for claims 5, 15, and 25.

D. The '700 patent provides no comparison of parallel decoding capacity between different non-uniform multidimensional symbol constellations

[0039] The '700 patent (e.g., Figs. 10a-17b) also fails to provide any description regarding a comparison of the parallel decoding capacity of non-uniform ***multidimensional*** symbol constellations. For instance, even if one were to orthogonalize the various PAM-8 constellations of FIG. 13b into various corresponding QAM-64 constellations, the '700 patent does not disclose the parallel decoding capacities of these corresponding QAM-64 constellations. Specifically, the '700 patent states "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***." LGE1001, 6:64-7:1. Then when describing the complexity of multidimensional optimization, the '700 patent states that "[t]he complexity of the optimization step ***grows exponentially in the number of dimensions as does the complexity of the resulting receiver de-mapper***." (emphasis added) LGE1001, 13:7-10. As noted above, the '700 patent does not disclose the design of the more complex de-mapper or how such multidimensional optimization would be implemented. Thus, the parallel decoding capacity of a multidimensional

constellation system utilizing an "exponentially" more complex de-mapper is not shown to be the same as that of a one dimensional (PAM) de-mapper. For this additional reason, the features of claims 5, 15, and 25, namely "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" do not have written description support. (emphasis added) LGE1001, 14:65-15:3.

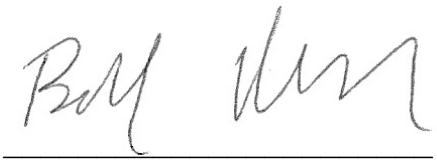
[0040] To the extent other comparisons are disclosed in the '700 patent, the comparisons are between the capacity of a non-uniform constellation and the capacity of a constellation that maximizes d_{min} (i.e., uniform constellation). LGE1001, 2:51-55, 3:25-34, 6:25, 8:24-29. In fact, even when producing a QAM constellation, the '700 patent discloses "obtaining a geometrically shaped PAM constellation with a constellation size that is the square root of said given constellation size" of the QAM constellation, and then comparing the capacity of the PAM to "a PAM constellation that maximizes d_{min}." LGE1001, 3:25-34. Thus, the '700 patent discloses comparing the capacity of a geometrically shaped PAM constellations to constellations maximized for d_{min}, which is not the same as comparing the parallel decoding capacity at a particular SNR of a non-uniform multidimensional symbol constellation to "other symbol constellations in the

plurality of multidimensional symbol constellations at the same SNR," as claimed in claims 5, 15, and 25.

VI. Conclusion

[0041] For the reasons I have provided above, the features recited in claims 5, 15, and 25 are not described in the '700 patent.

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code.

Date: 12/22/2023 BY: 

Bertrand Hochwald