

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS, INC.,
Petitioner,

v.

CONSTELLATION DESIGNS, LLC,
Patent Owner.

Case No. IPR2023-00319
U.S. Patent No. 10,693,700

**SECOND DECLARATION OF GIUSEPPE CAIRE FOR *INTER PARTES*
REVIEW OF U.S. PATENT NO. 10,693,700**

TABLE OF CONTENTS

I.	Introduction	2
II.	Materials Considered.....	2
III.	Barsoum Provides Written Description for the Challenged Claims.....	3
A.	First Approach Satisfies Written Description for Claims 5, 15, and 25, and is Disclosed.....	3
B.	Second Approach Also Satisfies Written Description for Claims 5, 15, and 25	6
1.	QAMs of Second Approach are Optimized	6
2.	Further Optimizing A QAM Created from Optimized PAM Not Required Because QAMs of Second Approach Provide Improved Capacity Characteristics.....	14
3.	Petitioner Argument Regarding Different Spacing Between 1-Dimensional and 2-Dimensional Constellations is Beside the Point and Draws a Flawed Conclusion	14
4.	Barsoum Discloses Differences in Parallel Decoding Capacity Between Different Non-Uniform Multidimensional Symbol Constellations And Fuentes Confirms Barsoum’s Disclosure	15

I, Dr. Giuseppe Caire, hereby declare as follows:

I. Introduction

1. I previously submitted a declaration (EX2001) in support of the Patent Owner Preliminary Response submitted in IPR2023-00319. Counsel for Patent Owner has informed me that the Petition was instituted, and that Petitioner has argued that claims 5, 15, and 25 allegedly lack written description support in the challenged patent, U.S. Patent No. 10,693,700 (the “’700 Patent”). For the reasons noted below, I disagree.

II. Materials Considered

2. In preparing this declaration, I have reviewed the specification and claims of U.S. Patent No. 10,693,700 (“’700 Patent” (EX1001)) and the file history of the ‘700 patent (EX1002). I understand the ‘700 patent was issued on June 23, 2020 from U.S. Patent Application No. 16/726,037, which forms part of a chain of continuations including application Ser. No. 12/156,989 filed Jun. 5, 2008 and issued on Jul. 12, 2011 as U.S. Pat. No. 7,978,777, which claimed priority to U.S. Provisional Application 60/933,319 filed Jun. 5, 2007. (EX1010).

3. I have also reviewed the Petition, Petitioner Reply, and all publications and exhibits cited in the Petition and in the Petitioner Reply.

III. Barsoum Provides Written Description for the Challenged Claims

4. Barsoum (EX1015) describes techniques providing a plurality of different non-uniform multidimensional symbol constellations where “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.” This disclosure of Barsoum conveys to the POSITA that the Patent Owner was in possession of a system as recited in the challenged claims.

5. Barsoum describes two approaches to achieve optimized multidimensional constellations. The first approach Barsoum discloses to achieve optimized multi-dimensional constellations is to directly optimize over each degree of freedom. (EX1015 12:38-48). The second approach to achieve optimized multi-dimensional constellations is to optimize a constellation in a first dimension, then orthogonalize to additional dimensions. (EX1015 12:11-37).

A. First Approach Satisfies Written Description for Claims 5, 15, and 25, and is Disclosed

6. Barsoum explicitly describes optimizing over each degree of freedom (N-degrees of freedom). For example, Barsoum discloses:

N-Dimensional Constellation Optimization

Rather than 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. In 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.

(EX1015 12:38-48).

7. I understand that Petitioner argues that such disclosure cannot be relied upon for written description because the disclosure is allegedly devoid of any details for the first approach, including being unclear whether Barsoum is referring to optimizing uniform or non-uniform constellations and whether there is any difference between the two. (Petitioner Reply at 3).

8. But a POSITA would understand Barsoum’s disclosure (to extend the optimizing of a constellation at a given SNR to directly optimizing in N-degrees of freedom) demonstrates that the patentee was in possession of the challenged claims because, as explained by Barsoum, extending optimization in a first degree (e.g., of a PAM) to N-degrees “simply requir[es] more ‘run-time’ to produce”. (EX1015 12:47-48).

9. Barsoum also provides additional details. For example, Barsoum describes how to optimize constellations including the use of unconstrained or

constrained non-linear optimization. (EX1015 8:34-37). Barsoum provides possible objective functions for the optimization. (EX1015 8:37-40, 49-56). Barsoum discloses that point locations are varied. (EX1015 8:41-42, 49-56). Barsoum describes running the optimization process iteratively. (EX1015 8:49-56). Barsoum identifies various optimization constraints. (EX1015 2:37-41, 2:55-66, 8:23-24, 8:57-9:2). Barsoum even includes a detailed flow diagram (FIG. 5) of an example optimization process. (EX1015 7:10-8:23).

10. Therefore, for the first approach, Barsoum (1) discloses how to optimize constellations over at least one dimension and (2) explains that iteratively performing such optimizations over each degree of freedom permits the design of optimized N-dimensional optimized constellations. Ignoring these teachings, Petitioner focuses on the alleged lack of details regarding the “additional complexity” of such an approach. *See* Petitioner Reply, 3. But Petitioner misunderstands Barsoum’s reference to the “complexity.” Barsoum explains that the “complexity” is the increased time spent performing the disclosed optimization for each added dimension. (EX1015 12:39-48 (“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.***”) (emphasis added)).

11. These teachings of how to optimize a constellation coupled with the teaching that extending optimization to N-degrees “simply requir[es] more ‘run-time’ to produce” informs the POSITA that the patentee was in possession of the challenged claims. Such detail in Barsoum contradicts the Petitioner’s assertion that the patent is “devoid of any details for directly optimizing each degree of freedom.” (Petitioner Reply at 3).

B. Second Approach Also Satisfies Written Description for Claims 5, 15, and 25

1. QAMs of Second Approach are Optimized

12. As I explained in my prior declaration, “optimization requires choosing an objective function (such as a system’s capacity) and then repeatedly (iteratively) changing variables (such as constellation locations and labels) until an optimized solution for the objective function is achieved.” (EX2001 at 53).

13. Further, the challenged Patent identifies numerous different ways for defining the “optimized” solution. For example, in one optimization embodiment, achieving the optimized solution requires varying constellation points until a maximized capacity is achieved. (*E.g.*, EX1001 3:4-12; *see also, e.g.*, EX1015 2:56-63; EX2001 at 54-55). In another embodiment, the optimized solution is reached when constellation points provide “a given capacity at a reduced signal-to-noise ratio compared to” an equally spaced constellation. (*E.g.*, EX1001 2:51-55; *see also*,

e.g., EX1015 2:37-41; EX2001 at 54-55). In other examples, the optimized solution is achieved when the constellation results in a “predetermined improvement” over an equally spaced constellation. (E.g., EX1001 2:6-12; *see also*, e.g., EX1015 1:59-65; EX2001 at 54-55). In another example, an optimized solution is reached when a performance of each iteration of an optimization process have converged; in other words, when additional iterations of the process does not result in a meaningful performance improvement. (E.g., EX1001 8:23-24; EX2001 at 54-55).

***a. Petitioner Does Not Argue that the Disclosed QAMs
Created from Disclosed PAMs Do Not Provide
Improved Capacity Characteristics***

14. Petitioner does not assert that the QAMs that Barsoum describes using the second approach (created from a PAM) does not provide an improved capacity when compared to a non-optimized QAM. Indeed, Petitioner’s argument amounts to an assertion that QAM and PAM capacities are not the same. (Petitioner Reply at 6-7, 13. EX1029 at 12).

15. That 1-dimensional and 2-dimensional constellations have different capacities is acknowledged by Barsoum. Barsoum explains that increasing dimensionality by orthogonalizing a PAM to create a QAM will increase capacity because the resulting QAM capacity will be identical to that of the PAM on a per-dimension basis, and QAM symbols send two real dimensions per symbol time (because there are 2 dimensions rather than 1), the capacity in bits/second is doubled

with respect to the capacity in bits/second of the corresponding PAM constellation. (“[d]ue to the orthogonality of the in-phase and quadrature components the capacity characteristics of the resulting QAM-64 constellation are identical that of the PAM-8 constellation on a per-dimension basis.” EX1001 12:64-67, EX1015 12:33-37).

16. But more importantly, Petitioner makes the wrong comparison by comparing 2-dimensional to 1-dimensional constellations. Instead, what is required if one imports the Petitioner’s unwarranted “optimized” limitation, is choosing an objective function (such as a system’s capacity) and then repeatedly (iteratively) changing variables (such as constellation locations and labels in one or more dimensions) until an optimized solution is found.

17. In the second approach described by Barsoum, an objective function is chosen (capacity), parameters are varied (locations in a first dimension), and an optimized solution (e.g., QAM created by orthogonalizing the locations in the first dimension) is found when the resulting nonuniform (QAM) constellation provides an improvement. Petitioner argues 1-dimensional constellations have different capacities than 2-dimensional constellations. (Petitioner Reply at 6-7, 13. EX1029 at 12). A fact noted by both the challenged Patent and Barsoum, and which is unrelated to whether or not a constellation is optimized.

b. Disclosed QAMs of the Second Approach Do Provide Improved Capacity Characteristics and are Optimized

18. The disclosed QAM constellations of the second approach are optimized because they do provide improved capacity characteristics. As explained by Barsoum, this is at least “[d]ue to the orthogonality of the in-phase and quadrature components the capacity characteristics of the resulting QAM-64 constellation are identical that of the PAM-8 constellation on a per-dimension basis.” LGE1001 12:64-67, LGE1015 12:33-37).

19. An optimized PAM (e.g., a PAM-8 as disclosed in FIG. 13b), provides a certain capacity, which at certain SNRs provides a greater capacity than an equally spaced PAM. When the unequally spaced PAM is orthogonalized into a QAM and labeled according to the approach described in Barsoum, that resulting QAM will have the same capacity on a per-dimension basis. Because the QAM has twice the dimensions (2-dimensions) of the PAM (1-dimension), the QAM will have twice the capacity. Similarly, this logic applies to an equally spaced PAM, and an equally spaced QAM, which is an orthogonalized equally spaced PAM. Thus, if the unequally spaced PAM is optimized, it will provide a greater capacity than an equally spaced PAM. If a QAM is created by orthogonalizing that unequally spaced and optimized PAM, it will necessarily result in an optimized QAM because that QAM will necessarily have a greater capacity than the equally spaced QAM.

c. Petitioner Fundamentally Misunderstands Fuentes Because Fuentes' "1D-NUCs" Are 2-Dimensional Optimized QAMs

20. Petitioner cites a new document, Fuentes, in support of its assertion that 1-dimensional and 2-dimensional constellations have different capacities. (Petitioner Reply 7-9). Petitioner argues that it is necessarily incorrect that the capacity characteristics of a PAM and a QAM are the same and relies on Fuentes' comparison of "1D-NUCs" and "2D-NUCs" to support this proposition. (Petitioner Reply at 6-7). But Petitioner fundamentally misunderstands the disclosure of Fuentes.

21. Fuentes uses the term "1D NUCs" to describe QAMs created by optimizing the in-phase component location in 1 dimension and then orthogonalizing those locations to the quadrature component (the second dimension). (EX1030 19-20, 62-63). Fuentes uses the term "2D NUCs" to describe a QAM created by directly optimizing both the in-phase and quadrature components of a single sector and imposing a symmetry constraint around the in-phase and quadrature axes. (EX1030 19-20, 62-63). Importantly, the "1D NUCs" of Fuentes ***are not 1 dimensional PAM constellations.***

22. This is clearly shown within Fuentes in figure 1.2, reproduced below and annotated, which illustrates an equally spaced QAM (left), a "1D-64NUC" (middle)(created by optimizing in 1-dimension then orthogonalizing to the second

dimension), and a “2D-64NUC” (right)(created by optimizing in both in-phase and quadrature dimensions). (EX1030 20).

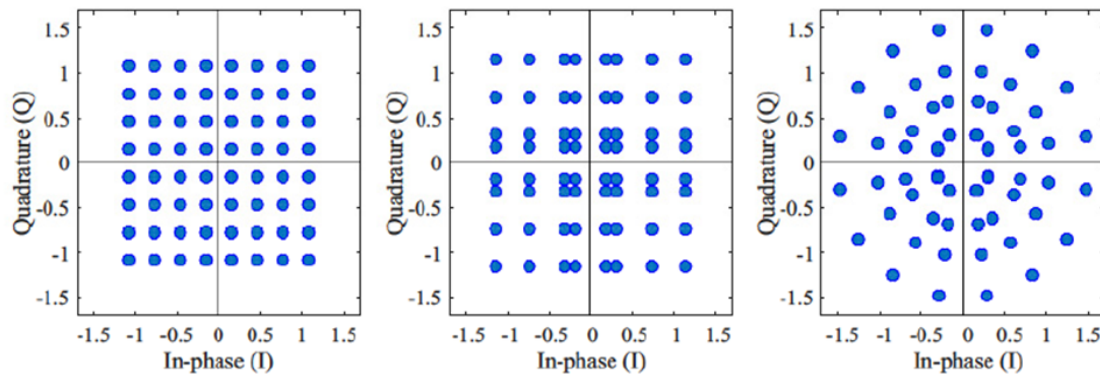


Figure 1.2: Different constellations considered. Uniform 64QAM (left), 1D-64NUC (center) and 2D-64NUC (right) **optimized** for a SNR of 10 dB and AWGN channel.

23. But Petitioner ignores this disclosure of Fuentes, instead arguing that the “1D-NUCs” of Fuentes are 1-dimensional constellations. (Petitioner Reply 7-8).

24. Because Fuentes’ “1D-NUCs” are not 1-dimensional constellations, figure 3.16, relied upon by Petitioner (Petitioner Reply at 9), is thus ***not*** comparing capacity of 1-dimensional constellations and 2-dimensional constellations as Petitioners incorrectly argue. Rather, Figure 3.16 is comparing two types of 2-dimensional constellations. Both types are QAM constellations, ***and both types are optimized.***

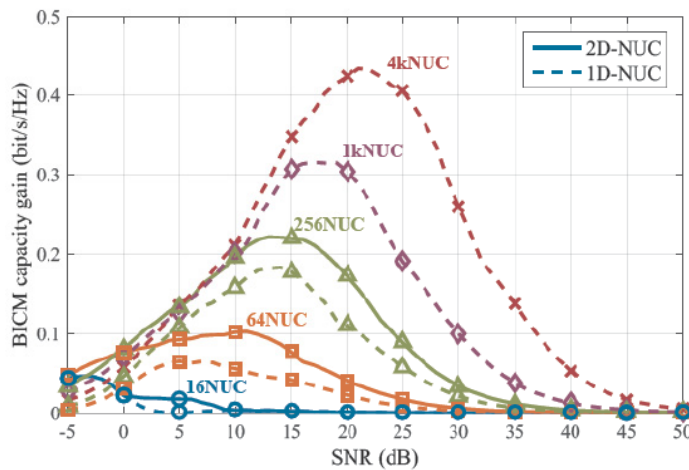


Figure 3.16: Gain of 1D/2D-NUC over QAM, for the i.i.d. Rayleigh channel model, and a range of SNR values between -5 and 50 dB.

25. And Fuentes confirms that the so called “1D-NUCs”, which are QAMs, are optimized:

- “The use of one-dimensional NUCs has different advantages when optimizing.”
- “it is possible to optimize a 1D-16NUC...”
- “It can be observed that 16NUCs optimized for very low SNRs provide higher gains than the rest.”
- “Figure 3.4: Different one-dimensional 16NUCs, optimized for SNRs of 0, 3, and 6 dB...”
- “Optimizing in one dimension maximizes the BICM capacity...”
- “With NUCs, the constellation symbols are optimized by means of signal shaping techniques to provide an improved performance...”

(EX1030 19-20, 62-63, 66, 70-71)

d. Fuentes Confirms that the Disclosed QAMs of the Second Approach Are Optimized Multidimensional Constellations That Provide Improved Capacity Characteristics

26. Figure 3.16 of Fuentes shows the capacity gain of respective 2-dimensional constellations created by orthogonalizing respective 1-dimensional constellations that have been optimized at a respective given SNR (denoted as “1D-NUC” in the figure). The y-axis shows the capacity gain as compared to an equally spaced QAM. Thus, since the “1D-NUC” lines (dotted lines) have a range of SNR where the lines are above zero, these 2-dimensional constellations created by orthogonalizing respective 1-dimensional constellations do in fact provide an increase in capacity as compared to an equally spaced QAM. And Fuentes confirms that, for a given SNR, there is one nonuniform multidimensional constellation (“1D-NUC”) that provides for a greater capacity at a given SNR than the other nonuniform multidimensional constellations (“1D-NUCs”). (EX1030 75 “at any SNR, there is always a particular NUC that maximizes the greatest BICM capacity”).

27. Thus, figure 3.16 of Fuentes, when properly interpreted, supports the exact fact upon which the Petitioner is trying to cast doubt – that each 2-dimensional constellation created by orthogonalizing respective 1-dimensional constellations,

which each have been optimized at a given SNR, will provide a greater capacity at that SNR than other 2-dimensional constellations created by orthogonalizing 1-dimensional constellations optimized at different SNRs.

2. Further Optimizing A QAM Created from Optimized PAM Not Required Because QAMs of Second Approach Provide Improved Capacity Characteristics

28. Petitioner argues that description of further optimizing a QAM that is created from a 1-dimensional PAM is required. (Petitioner Reply at 5-11). But no further optimization of a QAM is required in order for a QAM created from an optimized PAM to be optimized. This is because, as noted above, the QAMs created with the second approach do provide an improvement in capacity at their respective SNRs and are already optimized. Thus a QAM created by the second approach is an optimized QAM.

29. As noted above, this too is confirmed by Fuentes, who refers to a QAM created by optimizing in 1-dimension as an optimized constellation (so called “1D-NUCs”). (EX1030 19-20, 62-63, 66, 70-71)

3. Petitioner Argument Regarding Different Spacing Between 1-Dimensional and 2-Dimensional Constellations is Beside the Point and Draws a Flawed Conclusion

30. Petitioner relies upon Barsoum’s discussion that increasing dimensionality of a constellation allows for larger minimum distance to conclude that Barsoum discloses that a 1-dimensional constellation optimization would not

apply to a 2-dimensional constellation. (Petitioner Reply at 12). The Petitioner's rationale is that Barsoum has described that the $d_{\min}$ for a 1-dimensional constellation is different than the $d_{\min}$ for a 2-dimensional constellation. However, this rationale cannot be applied to orthogonalization because orthogonalization increases the number of constellation points.

31. In more detail, the description in the '700 patent "[i]ncreasing the dimensionality of a constellation allows larger minimum distance for constant constellation energy per dimension" is describing an increase in dimensionality for a fixed number of constellation points. For example, the $d_{\min}$ of a PAM-4 will be smaller than the $d_{\min}$ of a QAM-4. This logic does not apply when comparing, as the Petitioner does, the capacity characteristics of a PAM to a QAM created by orthogonalizing the PAM because the QAM will have a number of constellation points equal to the square of the PAM constellation points (e.g., QAM-64 results from orthogonalizing PAM-8).

4. **Barsoum Discloses Differences in Parallel Decoding Capacity Between Different Non-Uniform Multidimensional Symbol Constellations And Fuentes Confirms Barsoum's Disclosure**

32. Barsoum describes that optimizing a constellation for capacity at a first SNR also teaches that other constellations optimized for a different SNR will not provide the same benefits at the first SNR. Such disclosure is not limited to single

dimension constellations. Moreover, Fuentes confirms that optimizing a 2-dimensional constellation for capacity at a first SNR also teaches that other constellations optimized for a different SNR will not provide the same benefits at the first SNR. Fuentes states “[e]ach NUC performs better at its design SNR than its uniform variant... [m]oreover, at any SNR, there is always a particular NUC that maximizes the greatest BICM capacity.” (Ex. 1030 75).

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, and 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.

Dated: February 7, 2024



Dr. Giuseppe Caire