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

PATENT OWNER'S RESPONSE PURSUANT TO 37 C.F.R. § 42.120

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TABLE OF EXHIBITS

Exhibit	Description
2001	Declaration of Dr. Giuseppe Caire
2002	RESERVED
2003	U. Madhow, *Fundamentals of Digital Communication*, Cambridge University Press 2008
2004	R.G. Gallager, *Principles of Digital Communication*, Cambridge University Press 2008
2005	Eroz et al., *New DVB-S2X constellations for improved performance on the satellite channel*, Int. J. Satell. Commun. Network 2016; 34:351–360, Published online 14 September 2015 in Wiley Online Library (wileyonlinelibrary.com)
2006	RESERVED
2007	N.S. Login et al., *Non-Uniform Constellations for ATSC 3.0*, IEEE Transactions on Broadcasting, Vol. 62, No. 1, March 2016
2008	P. Gill, W. Murry, M. Wright, *Practical Optimization*, Emerald Group Publishing Limited (1982)
2009	RESERVED
2010	RESERVED
2011	RESERVED
2012	Curriculum Vitae and Publication List of Dr. Giuseppe Caire
2013	RESERVED
2014	RESERVED
2015	Giuseppe Caire, Giorgio Taricco, and Ezio Biglieri, *Bit-Interleaved Coded Modulation*, IEEE Transactions of Information Theory, vol. 44, no. 3, May 1998 (“Caire”)
2016	RESERVED
2017	RESERVED
2018	Board's June 26, 2023 Email Authorizing Patent Owner Submission Of Limited *Fintiv* Paper
2019	District Court’s 05-03-2023 Third Amended Docket Control Order - Jury Selection set for 7-5-2023 09-00AM
2020	Petitioner-Defendant LGs June 28 2023 Email Identifying Final Election Of Invalidity Theories And Prior Art In District Court
2021	LG’s 03-14-2023 Final Election of Asserted Prior Art for District Court
2022	District Court’s 04-04-2022 Docket Control Order

Exhibit	Description
2023	District Court's 02-28-2023 Markman Order
2024	Statutory Disclaimer of Claims 2-3, 12-13, and 22-23 of US Patent No. 10,693,700

I. Summary

Patent Owner Constellation Designs has statutorily disclaimed all challenged claims of the ’700 Patent except for claims 5, 15, and 25. The Board should find that Petitioner LG failed to prove that any of the remaining challenged claims are unpatentable because:

(1) the Board’s Institution Decision acknowledged that Petitioner’s asserted references “are only prior art to the ’700 patent if the ’700 patent ***cannot*** claim priority to Barsoum;”[1] and

(2) the Board’s Institution Decision determined that ***the ’700 Patent does properly claim priority to Barsoum for claims 5, 15, and 25***, and therefore, the Petition’s asserted references “are not prior art to claims 5, 15, and 25, and the Petition does not establish a reasonable likelihood that claims 5, 15, and 25 are obvious.”[2]

As correctly described in the Institution Decision, the challenged ’700 Patent “states that it is a continuation of the ’777 Patent (aka Barsoum)” and “Petitioner challenges this claim to priority, arguing that features of the challenged claims do not have written description support in Barsoum.” (Institution Decision at 10). The Board then analyzed Petitioner’s written description assertions by breaking the

[1] Institution Decision at 10; 16-17 (emphasis added).
[2] Institution Decision at 15, 17.

challenged claims into two groups: (1) challenged claims 2, 3, 12, 13, 22, and 23 (the subject of the Petition's Ground 1A); and (2) challenged claims 5, 15, and 25 (the subject of the Petition's Ground 1B).

Ground 1A - Disclaimed Claims 2, 3, 12, 13, 22, and 23: The first set of challenged claims included limitations concerning one or more types of QAM constellations. (Institution Decision at 11, 13-14). The Board determined that in light of these limitations, Petitioner had established a reasonable likelihood of succeeding on its written description/priority argument for at least some of these claims, and the Board instituted ***solely*** on that basis. (Institution Decision 13-14, 16-17).

But to streamline these proceedings, Patent Owner Constellation has now statutorily disclaimed each of these claims that were the subject of Ground 1A and that formed the Board's only basis for instituting the Petition. As a result of this statutory disclaimer, claims 2, 3, 12, 13, 22, and 23 are treated as if they "never existed," and the Board need not and should not address their patentability in this IPR proceeding. *Guinn v. Kopf*, 96 F.3d 1419, 1422 (Fed. Cir. 1996); *Apple Inc. v. MPH Techs. Oy*, IPR2019-00826, Paper 25 at 10-11, 2020 WL 6494252, at *5 (PTAB Nov. 4, 2020) (Final Written Decision); *Intel Corp. v. VLSI Tech. LLC*, IPR2018-01040, Paper 36 at 16, 2020 WL 719058, at *6 (PTAB Feb. 12, 2020) (Final Written Decision).

Ground 1B – Remaining Challenged Claims 5, 15, and 25: In contrast to the set of (now disclaimed) claims that were the subject of Ground 1A, the Board's Institution Decisions found that the Petition did ***not*** establish a reasonable likelihood of success as to the remaining challenged claims 5, 15, and 25.

Challenged claims 5, and 15, and 25 do not include the QAM constellation limitations that were the subject of the Board's Ground 1A analysis. Instead, these claims recite a communication system having a plurality of constellations, where each constellation is capable of providing greater parallel decoding capacity at a specific signal-to-noise ratio (SNR) than the other constellations in the plurality:

> 5. 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 other symbol constellations in the plurality of*** multidimensional symbol constellations at the same SNR.

(Ex. 1001, '700 Patent, at claims 5, 15, and 25).[3]

Petitioner's entire Ground 1B hinges on its argument that this limitation is not described in Barsoum and, therefore, that the challenged '700 Patent cannot claim priority to Barsoum for claims 5, 15, and 25. But in the Institution Decision, the Board properly rejected Petitioner's argument:

> Patent Owner correctly points to the specific examples of [Barsoum's] Figures 11b, 13b, 15b, and 17b as ***each showing a plurality of constellations, each optimized for a particular SNR than the other***

[3] Unless otherwise noted, all emphases in this response are added.

> ***symbol constellations in the plurality***. … More specifically, Figure 13b shows five constellations (i.e. a plurality), each optimized for a particular identified SNR that will perform better at that particular SNR than the other constellations, which have not been optimized at that particular SNR.

(Institution Decision at 15).

As a result, the Board preliminarily found:

- "For these reasons, we preliminarily determine that Petitioner has not shown that claims 5, 15, and 25 lack written description support in Barsoum" (Institution Decision at 15); and
- "As we have preliminarily determined that Barsoum is not prior art to claims 5, 15, and 25, the Petition does not establish a reasonable likelihood that claims 5, 15, and 25 are obvious over the combination of Barsoum and ATSC327" (Institution Decision at 17).

As established below, the Board's preliminary analysis was correct and there has been no change to the evidentiary record (and indeed, there cannot be any such change because Petitioner is limited to its original Petition and Grounds and cannot now present any new evidence or arguments on this issue). The Board should therefore confirm its original analysis and find that Petitioner failed to prove claims 5, 15, and 25 are unpatentable.

II. Patent Owner's Supplemental Mandatory Notices

In accordance with 37 C.F.R. § 42.8(a)(3), Patent Owner provides the

following supplemental mandatory notices regarding Related Matters:

Related Matters

In the following administrative proceeding, Patent Owner has statutorily disclaimed claims that are challenged in the present *Inter Partes* Review Proceedings (*see* new EX2024 submitted herewith), and therefore the following administrative proceeding may affect or be affected by a decision in this proceeding:

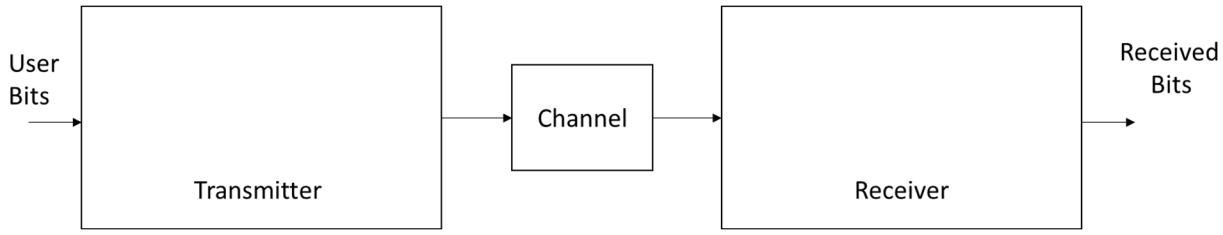
- US Patent No. 10,693,700 (Granted from US Application No. 16/726,037), *see, e.g.,* Statutory Disclaimer in A Patent Under 37 C.F.R. § 1.321(a) filed October 2, 2023 (EX2024).

III. Using "Constellations" In Digital Communications

The challenged '700 patent concerns an improved method and system for using "constellations" in a digital communication system. A digital communication system is used to transmit digital bits (sequences of 0s and 1s) from one device (a transmitter) to another (a receiver). As explained below in more detail, a "constellation" point is a carrier signal value (such as amplitude and/or phase) that can be used to represent a longer sequence of bits. Transmitting information using an appropriate constellation point signal value can make a data communication system faster and more efficient.

A. Overview of a Digital Communication System

A digital communication system typically includes a transmitter that sends information to a receiver over a wireless or wired channel. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

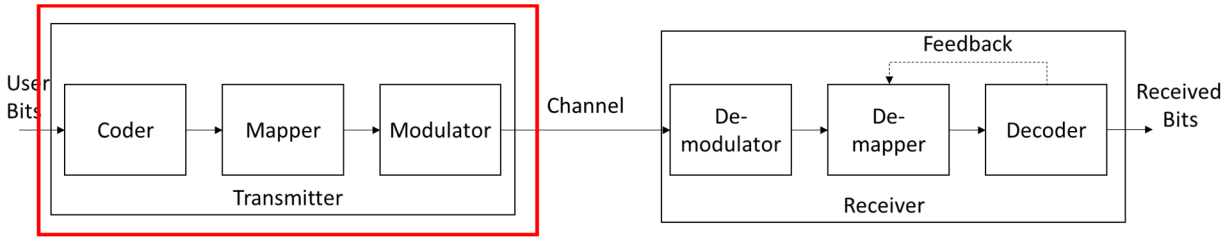


As illustrated in the above overview, information in the form of user bits (sequences of 0s and 1s) is input to the transmitter, which first converts those bits into an electromagnetic signal and then transmits that electromagnetic signal over the channel to the receiver. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209). As the electromagnetic signal passes through the channel, bits and data can be lost or corrupted; in this manner, the channel introduces "noise" (signal loss) to the transmission. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209). The receiver receives the electromagnetic signal (along with any noise introduced by its passage through the channel) and converts the received signal back into bits. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

Each digital communication system has a measurable "capacity," which is the maximum amount of information that the system can reliably send over the channel. (EX2001 at 8; EX2003 at 252; EX2004 at 253-254, 311-312).

1. The Transmitter

In a digital communication system, the transmitter typically includes three main components: a coder, a mapper, and a modulator. (EX2001 at 8; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).



The **coder** is used to transform the input user bits into a longer sequence of output bits according to error-correcting codes to enable later error correction by the receiver. (EX2001 at 8; EX2003 at 2-3; EX2004 at 11, 298). For example, the coder may add additional redundant bits to the input user bits that would later enable the receiver's decoder to use error-correcting codes (such as turbo codes or Low Density Parity Check (LDPC) codes) to help detect or recover user bits lost to noise during transmission. (EX2001 at 8; EX2003 at 2-3; EX2004 at 11, 298). The amount of expansion in the number of bits from the input user bits to the longer sequence of output bits is referred to as the code rate. (EX2001 at 9). The code rate is a ratio of the relative length of the input user bits to the length of the output bits.

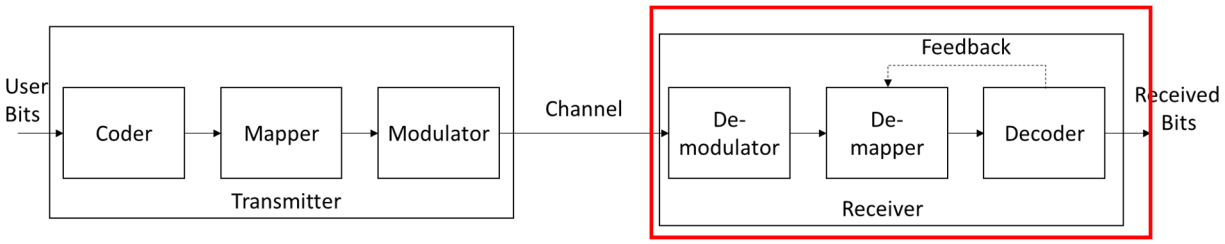
(EX2001 at 9). For example, a code rate of 1/2 indicates that for every bit in the sequence of input user bits, there are 2 bits in the sequence of output bits. (EX2001 at 9). Similarly, a code rate of 3/5 indicates that for every 3 bits in the sequence of input user bits, there are 5 bits in the sequence of output bits. (EX2001 at 9).

The resulting new bit sequence is input to the **mapper**, which maps this new sequence to constellation points, which are one or more carrier signal values (such as amplitude and/or phase) that can be used to represent a longer sequence of bits. (EX2001 at 9; EX2003 at 7; EX2004 at 181-209). Such mapping and constellations are a focal point of the challenged claims and are discussed in more detail in the following "Constellation Mapping and Demapping" section. (EX2001 at 9).

Next, the mapper provides these constellation values to the **modulator,** which creates a signal to be modulated to reflect the constellation values provided by the mapper and then to be sent through the channel. (EX2001 at 9; EX2003 at 2-3; EX2004 at 181-209). There are numerous different ways for a modulator to apply such information to a carrier signal. (EX2001 at 9; EX2003 at 2-3; EX2004 at 181-209). For example, in a Pulse Amplitude Modulation (PAM), the modulator can modify (modulate) the amplitude of the carrier signal so that the signal's different amplitudes will represent different bit sequences. (EX2001 at 9-10; EX2003 at 45; EX2004 at 184-196).

2. The Receiver

In a digital communication system, the receiver typically mirrors the transmitter and includes: a de-modulator, a demapper, and a decoder. (EX2001 at 20; EX2003 at 2-4; EX2004 at 1-5, 11, 95, 181-183, 208-209).



The **de-modulator** receives the transmitted signal via the channel and attempts to extract the signal values that are indicative of the transmitted constellation points. (EX2003 at 3-4; EX2004 at 189).

The extracted signal values are then input to the **demapper**, which is used to help identify which bit sequence corresponds to the extracted constellation signal values. (EX2001 at 10; EX2003 at 3-4; EX2004 at 181-209). Such demapping is discussed in more detail in the following "Constellation Mapping and Demapping" section.

Next, the **decoder** uses information from the demapper and the structure of the error-correcting code to try to identify the appropriate bit sequence and recover any of the user bits lost or corrupted due to noise during transmission. (EX2001 at 10; EX2003 at 3-4, EX2004 at 11).

B. Constellation Mapping and Demapping

1. Constellation Point Locations and Labels

As discussed above, the transmitter's coder provides sequences of bits (such as the original user bits plus error correcting bits) to the mapper. The mapper then maps each sequence to constellation points.

A constellation point has at least two characteristics: (1) it is a value associated with a variable characteristic of the signal transmitted over the channel; and (2) it represents a unique bit sequence. (EX2001 at 11). As explained below, the former is a constellation point's "location," and the latter is its "label." (EX2001 at 11).

Signal characteristics that may be used as constellation point locations include amplitude, phase, and frequency. (EX2001 at 11; EX2003 at 2-3, 45; EX2004 at 181-209). The particular signal characteristic (or characteristics) used as constellation point locations can depend on the type of modulation performed by the modulator. (EX2001 at 11; EX2003 at 2-3, 45; EX2004 at 181-209). For example, recall that if a modulator uses pulse amplitude modulation (PAM) to apply information to the carrier signal, the resulting signal's different amplitudes are used to represent different bit sequences. (EX2001 at 11; EX2003 at 45; EX2004 at 184-196). In such a system, the signal's different amplitudes may serve as constellation point locations.

To illustrate, if the transmitter can send a high frequency signal having pulses of any amplitude between 0 and 1.0 volts, then any amplitude between 0 and 1.0 volts can be chosen and used as a constellation point. (EX2001 at 12). For example, if four constellation points are needed, each of 0, .33, .66, and 1.0 volts could be used as an individual constellation point. (EX2001 at 12). Where a particular constellation point falls on the spectrum of available values is called its "location." (EX2001 at 12).

To continue this simplified illustration, if each sequence of bits to be communicated from the transmitter to the receiver comprises a series of shorter 2-bit sequences (00, 01, 10, and 11), then each of those 2-bit sequences can be assigned to a corresponding constellation point. (EX2001 at 12). For example, using the constellation points identified above, the 01 sequence could be assigned any one of the 0, .33, .66, and 1.0 volt constellation points. (EX2001 at 12). The sequence to which a constellation point is assigned is its "label." (EX2001 at 12).

To complete this simplified example, the following depicts the location and labels for four constellation points. (EX2001 at 13). The first constellation point is located at 0.0 volts and is labeled to "00," the second is located at .33 volts and is labeled to the "01," and so on. (EX2001 at 13).

Constellation Label	Constellation Location
"00"	0

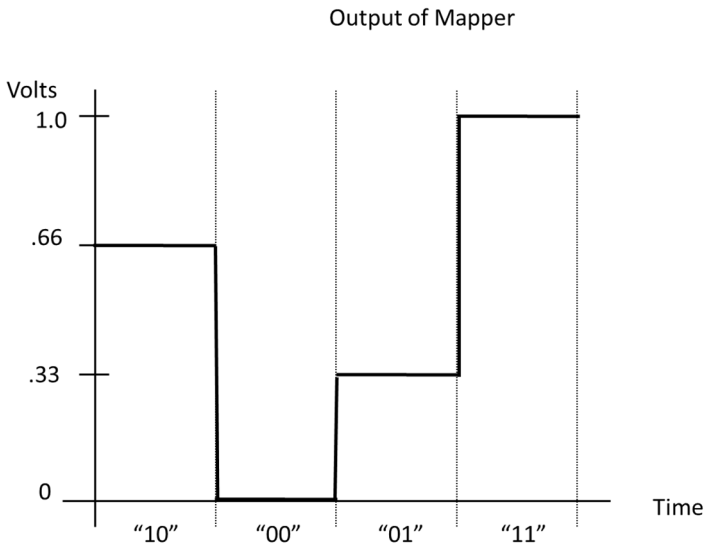
"01"	.33
"10"	.66
"11"	1.0

2. The Mapper

The transmitter's mapper uses these constellation labels and locations to map a bit sequence to a corresponding sequence of constellation points. (EX2001 at 13; EX2003 at 7; EX2004 at 181-209). For example, to send sequence "10000111", the mapper would take each 2-bit sequence, and map it to its corresponding constellation point. (EX2001 at 13). Applying the locations and labels from the below table using the PAM example, the sequence "10000111" would be broken into its composite bit sequences 10, 00, 01, and 11, which would be mapped to the voltages .66, 0.0, .33, and 1.0 respectively. (EX2001 at 13).

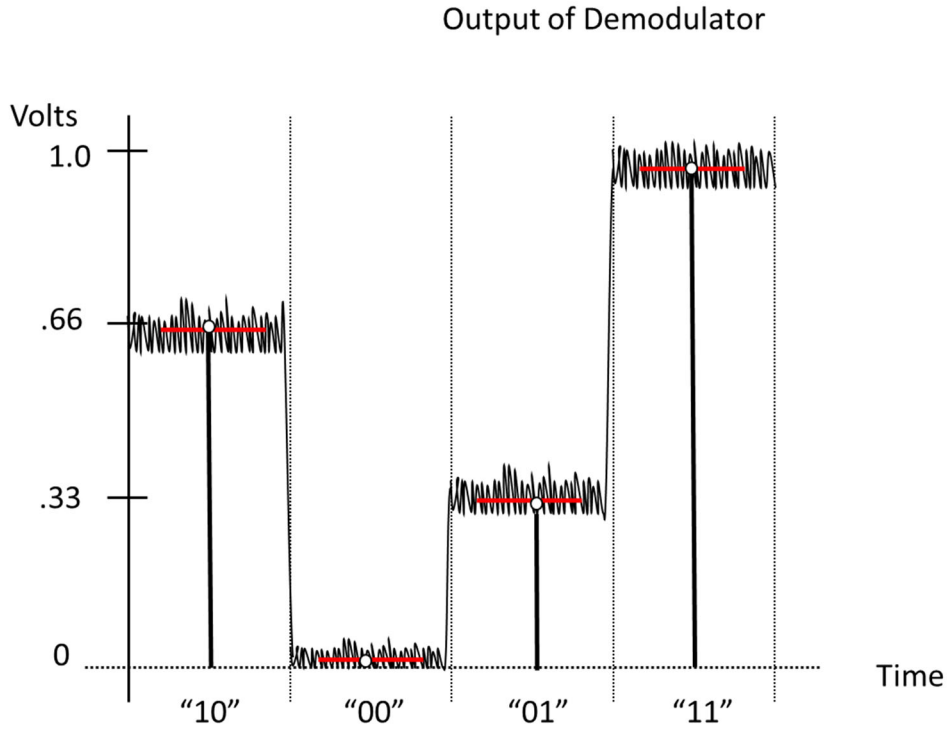
Constellation Label	Constellation Location
"00"	0
"01"	.33
"10"	.66
"11"	1.0

The resulting output of the example mapper is the sequence 0.66, 0.0, 0.33. and 1.0 shown in the following figure, in which the y-axis represents voltage and the x-axis represents time. (EX2001 at 14). For reference, the transmitted bit sequence is shown for each time slot below the figure.



3. The Demapper

On the receiver side, the demodulator receives and demodulates the received signal, which is a noisy version of the transmitted signal, in an attempt to extract the transmitted constellation point signal values. (EX2001 at 14; EX2003 at 3-4; EX2004 at 181-209). But because noise results from the transmission, the demodulated signal may not be identical to the constellation points output from the mapper (as shown above) but might include errors. (EX2001 at 15; EX2003 at 3-4; EX2004 at 181-209). An example output of the demodulator is shown below, in which a time-dependent continuous waveform is shown in black including noise, the average of the time-dependent continuous waveform is shown in red, the output of the demodulator is shown as discrete time values in black, and the figure is again annotated with the corresponding bit sequence:



This demodulated signal is then sent to the demapper so that the demapper can convert the demodulated signal values back to bits based on the constellation points. (EX2001 at 15; EX2003 at 3-4; EX2004 at 181-209). But because of the noise introduced during transmission, the signal characteristic (*e.g.*, amplitude, phase, frequency) values of received pulses may not exactly match the assigned constellation point locations. (EX2001 at 15-16; EX2003 at 3-4; EX2004 at 181-209). Accordingly, in some implementations, the demapper uses a predetermined

set of signal characteristic (e.g., amplitude, phase, frequency) ranges to attempt to determine the corresponding bit sequence[4]. (EX2001 at 16; EX2003 at 127).

Continuing the ongoing example, the demapper could use the following amplitude ranges to map the received signal to a corresponding bit sequence:

Output of Demodulator (y)	Bit Sequence
y <= .25	"00"
.25 < y <= .5	"01"
.5 < y <= .75	"10"
.75 <= y	"11"

Applying this demapping scheme:

- if the output of the demodulator is less than or equal to .25 volts, then the bit sequence is "00";
- if the output of the demodulator is greater than .25 but less than or equal to .5, then the bit sequence is "01";
- if the output of the demodulator is greater than .5 but less than .75, then the bit sequence is "10"; and

[4] For the purpose of illustrating the basic operation of a demapper, the described example illustrates a demapper that performs "hard" decisions, that is, outputs actual decisions on which bit sequence corresponds to the input signal. (EX2001 at 16). In many implementations, the demapper performs "soft" decisions, that is, outputs probabilities on which bit sequence corresponds to the input signal. (EX2001 at 16).

- if the output of the demodulator is greater than .75, then the bit sequence is "11". (EX2001 at 17).

Using this mapping, the example output from the demodulator (shown in the figure above) would be demapped to "10" for the first pulse, demapped to "00" for the second pulse, demapped to "01" for the third pulse, and demapped to "11" for the fourth pulse. (EX2001 at 17). Put together, these component bits result in the sequence "10000111."[5] (EX2001 at 17).

IV. Prior Art Approaches

Digital communications systems and constellations as described above were generally known in the art. A primary—and wholly unrealized—goal in designing such systems was to design systems able to perform very close to the ultimate limit for reliable transmission of information, which is established by Shannon channel coding theorem and is known as the Shannon channel capacity limit.

In designing these prior art systems, conventional wisdom dictated that constellation locations must be equally spaced apart so that that each constellation point is as far as possible from its neighboring points. But this and all other prior art approaches fell far short of their "holy grail," the Shannon limit.

[5] To simplify the illustrative example, it does not include any error correction coding.

A. The Shannon Channel Capacity Limit

Each digital communication system has a measurable "capacity," which is the maximum amount of information that the system can reliably send over the channel. (EX2001 at 18; EX2003 at 252; EX2004 at 253-254, 311-312). As detailed in the challenged '700 Patent, two different ways of measuring capacity are "joint capacity" and "parallel decode capacity." (EX1001 at 5:6-8; 6:42-7:30).

Regardless of which measure is used, each communication channel's capacity is constrained by the Shannon channel capacity limit, which represents the theoretically best capacity a channel could possibly achieve in light of physically unsurmountable limits on error correction methods. (EX2001 at 21-22; EX2003 at 252-255, 263-264; EX2004 at 1,184-187, 253). Just as nothing can move faster than the speed of light, no channel's capacity can exceed the Shannon capacity limit. (EX2001 at 22; EX2003 at 252-255, 263-264; EX2004 at 1).

Shannon calculated this capacity limit by determining the maximum possible efficiency of error correcting methods. (EX2001 at 22; EX2003 at 252-255, 263-264; EX2004 at 1,184-187, 253). This maximum amount of error correction is then compared to the levels of noise and data corruption to determine the Shannon limit, which is the maximum amount of data that can reliably transmitted over a given communication channel using error correcting methods of the maximum possible

efficiency. (EX2001 at 48; EX2003 at 252-255, 263-264; EX2004 at 1,184-187, 253).

B. Prior Art Approaches Failed To Achieve the Shannon Limit

Claude Shannon first published the Shannon channel capacity limit in 1948. (EX2004 at 6). But although Shannon's limit formed a critical foundation to information theory, he did not describe any practical method for achieving this capacity limit. (EX2004 at 6). Thus, for the next 60 years, achieving a channel capacity near or equaling this limit became the ultimate goal for communication systems designers. (EX2004 at 6). But until the invention disclosed and claimed in the '700 Patent, no designers were able to even come close.

Nearly every prior approach had at least two things in common: (1) equally spaced constellations; and (2) a focus on improving joint capacity.

1. Constellation Point Locations That Are Equally Spaced

The '700 Patent's Background explains that the most prevalent (by far) approach at the time of the invention was to locate constellation points with equal spacing between points to maximize the distance between neighboring constellation points. (EX1001 at 1:46-50).

As already discussed and illustrated above, noise is introduced when constellation points are sent from the transmitter to the receiver. (EX2001 at 23; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

The prevailing wisdom was that if constellation points were located close together (for example, if one constellation point at 0.7 volts and another at 0.6), then there was a greater chance that noise would cause the demapper to mistake one transmit signal value for another, resulting in the wrong bit sequence being selected and output. Thus, to minimize the chances of noise resulting in the demapper erroneously selecting the wrong bits, it was well accepted that constellation points should be spaced equally apart, to maximize the distance between any two neighboring locations. (EX1001 at 1:44-52).

Accordingly, most viable systems spread constellation locations evenly over the range of values that the locations could take, putting as much distance between any two points as the range of values allowed, and resulting in equal spacing between constellation points. (EX1001 at 1:44-52; 2:6-17; 7:61-63). At the time of the invention, such "equally spaced" locations were well accepted as the best approach with no drawbacks to be improved upon. (EX1001 at 1:44-52, 2:6-17; 7:61-63).

After 60 years of this approach, however, there still existed a tremendous gap between the achieved capacities and the Shannon limit. Specifically, even after the development of LDPC codes in the 1990s, a large and seemingly insurmountable "Shannon gap" of at least 1.53 dB remained.

V. The Challenged '700 Patented Inventions

But after others tried and failed for 60 years, the '700 Patent inventors succeeded, developing a system and approach that finally closed the gap and achieved capacity approaching the Shannon limit. They did so by going against the conventional wisdom. Instead of trying to improve error-correcting methods used to transmit constellations, they tried to improve the constellations themselves. Instead of keeping constellation points uniformly spaced, they experimented with changing both the locations and labels of the constellations. The inventors further recognized and described techniques for using different constellations at different code rates, where each constellation was optimized for use at its respective code rate. By selecting the appropriate constellation for a code rate, the inventors described systems that can utilize multiple constellations, each optimized for use with a particular code rate.

The result was revolutionary. The '700 Patent inventors developed a technique for optimizing constellation points, varying their locations and labels to arrive at a non-uniformly spaced set of constellations that are optimized for capacity. The resulting communication systems were astronomical improvements over the prior art, providing never before seen levels of performance that finally achieved the holy grail sought for 60 years, the Shannon channel capacity limit.

And the impact was wide-spread. The inventions were eventually incorporated into a new standard for satellite digital broadcasting, known as DVB-S2X, resulting in improvements that were reported as "extraordinarily large" by Mustafa Eroz – the same author of the *Eroz* reference relied upon by Petitioner in related IPR2023-00228, also challenging the '700 patent and now denied. (EX2005 at 353-534).

And Petitioner LG took notice, too. It previously conceded that the inventors were the first to describe the claimed use of non-uniform constellations optimized for capacity and marveled that the inventive constellations yielded performance gains "well above the famous [Shannon] shaping gain limit of 1.53 dB." (EX2007 at 197)

A. The Development of the Inventive Technology

The inventions described in the '700 patent were made with the support of the U.S. government and NASA, and co-inventor Dr. Christopher Jones worked at NASA for over five years as a renowned expert in the development of the type of error correcting codes deemed so important to improving joint capacity. (EX1001 at 1:30-34). A focus of Dr. Jones's NASA work was developing communications systems and error-correction methods used for deep space robotic probes to Mars, including the Mars Reconnaissance Orbiter, Mars Science Lander, Mars Volatile Evolution Explorer, and the Mars Perseverance Rover.

As of 2006, Dr. Jones's NASA experiences led him to conclude that real world limitations on error-correcting methods were preventing him from achieving the desired capacity gains. He also concluded that attempts to cure these limitations by further improving error-correcting methods would be prohibitively complex.

Accordingly, Dr. Jones joined with co-inventor Maged Barsoum, and together they took a very different tack. Rather than focusing on improving error-correcting methods, the inventors instead moved their focus to improving constellation capacity. And to do so, they took an even more unconventional approach: rather than following the convention of maximizing the distance between constellation points, they experimented with freely varying those locations and labels.

Counter-intuitively, they discovered that constellation points unequally spaced in each degree of freedom with appropriately assigned labels could achieve superior performance to equally spaced constellations. Based on this discovery, they developed innovative approaches for freely assigning the locations and labels of constellation points using optimization, allowing them to choose constellations that, among other things, optimized a system's capacity.

The results exceeded all expectations. Systems utilizing their inventions not only overcame the real-world limitations of error-correcting methods, they achieved never before seen levels of capacity.

B. The Patent's Improved Approach to Implementing Non-Uniform Constellations

Thus, the '700 Patent inventors bucked prevailing wisdom to develop revolutionary methods for freely assigning constellation point locations and labels, including optimizing those locations and labels in order to optimize capacity. The resulting innovations and combinations of innovations disclosed in the '700 Patent's specification include:

- Instead of predetermining constellation locations, the inventors optimized those locations, varying them in all dimensions to find the combination of locations that resulted in an optimized solution;
- In addition to optimizing using constellation point locations, the inventors also optimized the constellation labels, varying which locations were associated with which bit sequences to find the best combinations of locations and labels that resulted in an optimized solution;
- The inventors recognized that different systems and capacity measures would require different optimized constellation point locations and labels, and taught tailoring each set of constellation points to a specific system and capacity,

including freely assigning locations and labels in order to optimize parallel decode capacity; and

- The inventors developed an approach of optimizing for different operating conditions (such as signal to noise ratio, error correcting codes) that allow for reducing the gap to the Shannon limit across a wide variety of conditions.

1. Optimizing Constellation Locations and Labels

The ’700 Patent discloses that one way to freely assign constellation point locations and labels is to optimize those locations and labels. (EX1001 at 2:30-34, 2:51-53, 3:7-10, 3:15-17, 3:22-24; *see also, e.g.,* EX1015 at 2:14-20, 2:39-41, 2:59-63, 2:67-3:8).

In general, 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 24; EX2008 at 20).

In the optimization approach disclosed in the ’700 Patent, the objective function to be optimized can be the system’s capacity, such as its parallel decode capacity. (EX1001 at 6:42-63). In addition, the independent variables that may be iteratively changed until an optimized capacity is achieved include the constellation locations and labels. (*E.g.*, EX1001 at 3:4-12; 7:10-19; *see also, e.g.,* EX1015 at 2:56-63, 6:56-7:1).

The patent also 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 at 3:4-12; *see also, e.g.,* EX1015 at 2:56-63). 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 at 2:51-55; *see also, e.g.,* EX1015 at 2:37-41). In other examples, the optimized solution is achieved when the constellation results in a "predetermined improvement" over an equally spaced constellation. (*E.g.*, EX1001 at 2:6-12; *see also, e.g.,* EX1015 at 1:59-65). 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 at 8:23-24).

2. The '700 Patent Describes Optimizing Single-Dimension and Multi-Dimension Constellations

The '700 patent teaches that both single dimension constellations (such as PAM) and multi-dimension constellations (such as QAM) can be optimized. (EX1001 at 10:8-13; *see also, e.g.,* EX1015 at 9:50-55). One approach disclosed by the '700 patent for optimizing a multidimensional QAM constellation is to

directly optimize over each degree of freedom. (EX1001 at 13:2-11; *see also, e.g.,* EX1015 at 12:39-48). Another disclosed approach to optimizing a multidimensional QAM constellation is to first optimize a PAM constellation, then apply that PAM constellation to both of the in-phase and quadrature components. The '700 Patent describes this approach as orthogonalizing the PAM constellation into a second dimension to form the QAM constellation. (EX1001 at 3:25-34; 12:42-67; *see also, e.g.,* EX1015 at 3:9-19, 12:11-37). This results in a constellation that has a number of points that is equal to the square of the number of PAM points, for example a PAM-8 is orthogonalized to a QAM-64 (8 x 8). (EX1001 at 3:25-34; 12:42-67; *see also, e.g.,* EX1015 at 3:9-19, 12:11-37). Further, the QAM-64 includes the same PAM-8 spacing among points in both dimensions, that is, in the in-phase dimension and the quadrature dimension.

The '700 illustrates an example of this orthogonalizing approach in Figure 21, showing that a PAM-8 constellation optimized for capacity at a user bit rate per dimension of 1.5 bits per second can be used to construct a QAM-64 constellation. As shown below in annotated Figures 13b and 21, orthogonalizing a capacity optimized PAM-8 includes replicating a full PAM-8 constellation 8 times. (EX1001 at 3:25-34; 12:42-67; *see also, e.g.,* EX1015 at 3:9-19, 12:11-37).

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

FIG. 13b

PAM-8 replicated 8 times to form QAM-64

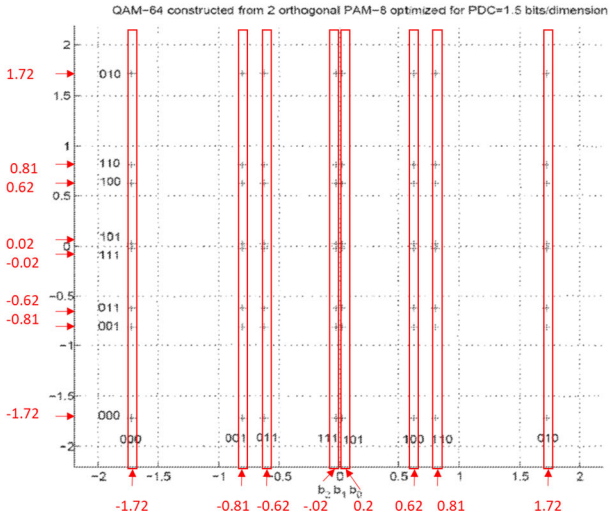


FIG. 21

The resulting combination is similarly spaced in both dimensions (i.e., the in-phase and quadrature). That is, the spacing of points in both the x and y-axis of Figure 21 are distributed according to the PAM-8 optimized locations. The distribution of the x-axis is highlighted in the above annotated figure 21. The distribution of the y-axis is highlighted in the below annotated figure 21.

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

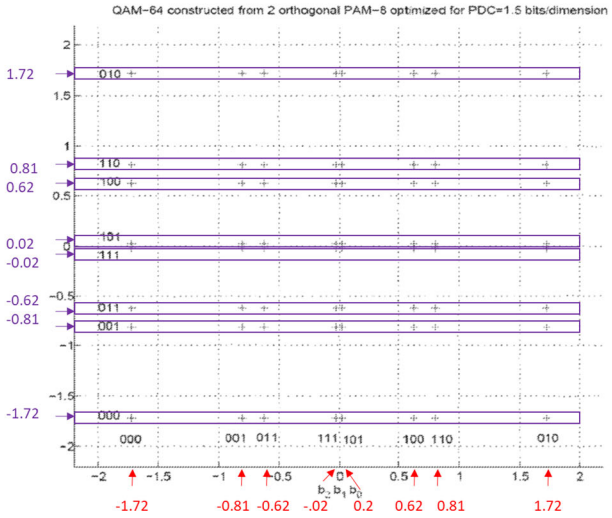


FIG. 21

This approach uses the same 8 point PAM locations, which were optimized for capacity, to produce 64 point QAM locations that have been optimized for capacity.

3. Non-Uniform Constellations Optimized For Particular Code Rates

The ’700 Patent discloses that optimization of constellation points can yield different constellations depending on the signal to noise ratio (SNR) and code rate for which they are optimized. (EX1001 at 5:11-16; *see also, e.g.,* EX1015 at 4:62-66). For example, the ’700 Patent teaches that in many instances, a constellation optimized for one code rate can achieve gains that cannot be achieved at another code rate. (EX1001 at 5:16-25; *see also, e.g.,* EX1015 at 4:66-5:7). Put another way, a given non-uniform constellation will not enable the best possible

performance across all code rates. (EX1001 at 5:16-21; *see also, e.g.,* EX1015 at 4:66-5:7). As an example, a constellation optimized for a code rate of 1/2 provides gains when used with a code rate of 1/2, but may not provide the same gains at other code rates, such as 2/3 code rate. Instead, when using a code rate of 2/3, a different constellation may be used – a constellation optimized for use at 2/3 code rate.

As a result, the inventors disclosed a number of example different constellations, each of which is optimized at different operating conditions, including a respective coding rate and SNR. For example, the ’700 Patent discloses a number of tables identifying a plurality of different symbol constellations that are capable of providing a greater capacity at a specific code rate and SNR than the other symbol constellations for the same code rate. For example, Figs. 11b, 13b, 15b and 17b all disclose constellations that are optimized for parallel decode capacity for use at a specific SNR and code rate. FIG. 11b is illustrated below. The table provides the constellation locations (x_0, x_1, x_2, x_3), the corresponding SNR, and the user bit rate. As acknowledged by the Petition, the code rate can be easily determined from the user bit rate. (Petition at 6). The code rate can be determined from a well-known equation relating the number of user bits per dimension to the code rate and which is described in the ‘319 Application. (EX1010 at 2). The equation is given by:

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

where η is the number of user bits per dimension, R is the code rate, M is the number of constellation points, and N_{dim} is the number of signal dimensions. (EX1010 at 2). Rearranging this equation one can compute the code rate (R) as a function of the user bits per dimension as follows:

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

As an example, in order to compute the equivalent code rate for a QAM-16 for the user bits per dimension (η) listed in figure 11b, we would take the number of dimension (N_{dim}) to be 2, the number of constellation points (M) to be 64, and the user bits per dimension (η), which is listed in figure 11c, as [0.50, 0.75, 1.00, 1.25, 1.50]. The resulting code rates can easily be computed as [2/8, 3/8, 4/8, 5/8, 6/8]. Note that similar calculations can be performed for each constellation size (e.g., QAM-64 (from PAM-8), QAM-256 (from PAM-16), QAM-1024 (from PAM-32), etc.).

The below figure has been annotated with these code rates for a corresponding QAM-16 built by orthogonalizing the PAM-4 optimized constellations. Each column of the table provides a different, unique constellation.

PAM-4 constellations optimized for parallel decoding capacity at different

(CR_{QAM16})	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$
(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

4. Using Multiple Optimized Constellations for a System Having Multiple Code Rate and SNR Operating Points

In light of the inventors' recognition that optimization results in different non-uniform constellations for a given code rate and/or SNR, the '700 Patent discloses communication systems that can "adapt location of points in a constellation in response to changes in channel conditions, changes in code rate, or changes in the target user data rate." (EX1001 at 4:62-5:11; *see also, e.g.,* EX1015 at 4:47-62). As an example, the '700 Patent describes a communication system that can select an information rate that meets the end user rate goal, and then use a

capacity-optimized constellation that provides gains for the selected rate that meets the end user rate goal. (EX1001 at 11:50-12:12; *see also, e.g.,* EX1015 at 11:22-49). The optimized constellation can be selected from a set of code rate and constellation pairs, where each constellation has been optimized for capacity at its respective code rate. (EX1001 at 10:21-24; *see also, e.g.,* EX1015 at 9:63-65).

To illustrate this concept, an annotated Figure 10c is provided below. The x-axis has been annotated to show the code rates for a QAM-16 built by orthogonalizing the PAM-4 constellations shown in Figure 10c. As an example, a system utilizing multiple optimized constellations for different code rates can initialize at an operating code rate of 4/10, at which point the communication system can utilize the constellation point locations indicated in the locus plot at the 4/10 code rate. In the example, if the system then changes to a code rate operating point of 6/10, the system can utilize the constellation point locations indicated in the locus plot at the 6/10 code rate. Using this technique, the ’700 patent teaches that a system can adapt to any desired code rate (e.g., based on changing channel conditions, target user rate) and utilize the disclosed optimized constellation according to its respective code rate.

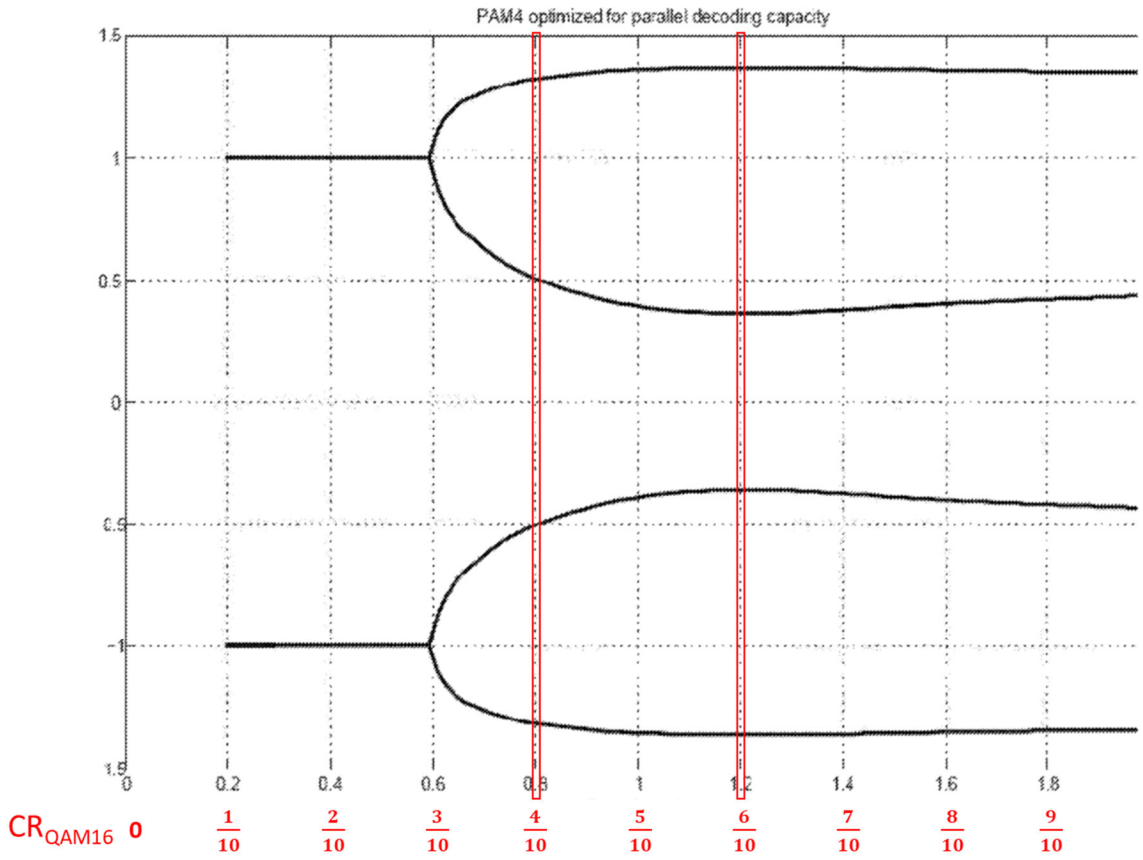
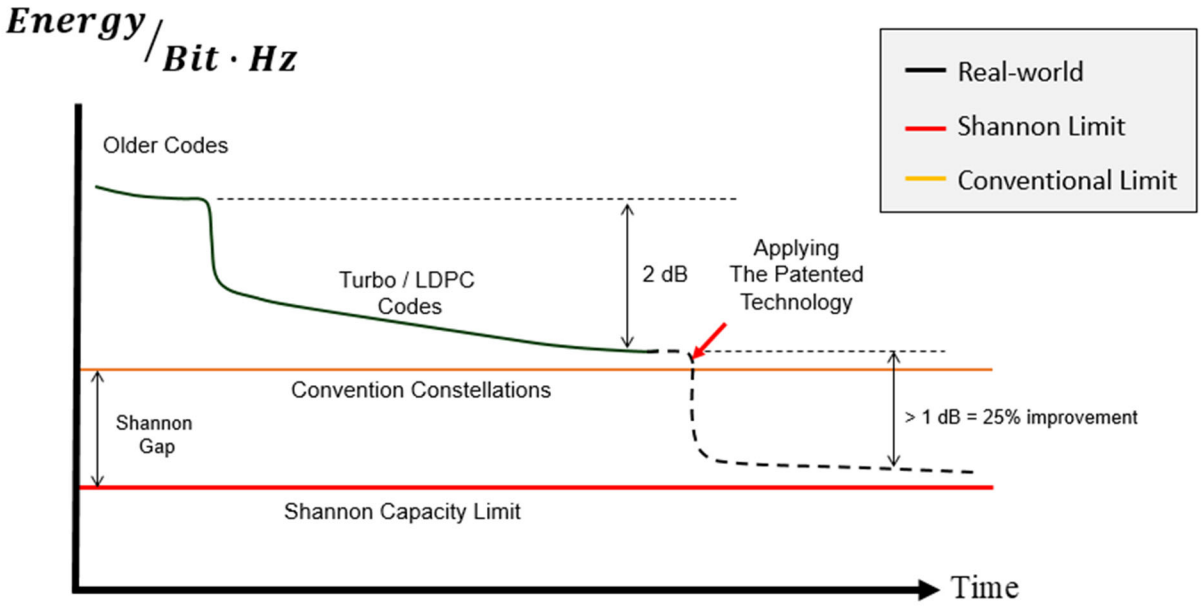


FIG. 10c

C. The Revolutionary Results

The inventor's unusual approach of freely assigning labels and locations in order to optimize capacity produced spectacular results. And when freely assigning locations and labels specifically to optimize parallel decode capacity, the results were even more spectacular—capacity increased so much that the holy grail, the Shannon capacity limit, was approached. (EX1001 at 1:55-56; 2:21-25; *see also, e.g.,* EX1015 at 1:42-43, 2:7-10).

As reported in the ’700 Patent, despite all of the years and resources applied to improving conventional approaches and the error-correcting codes used therein, capacity had plateaued and remained over 1 dB away from the Shannon capacity limit. (EX1001 at 1:55-56; 2:21-25; *see also, e.g.,* EX1015 at 1:42-43, 2:7-10). But as shown in ’700 Patent Figure 8a, when the ’700 Patent techniques were applied to freely assign constellation locations and labels to optimize parallel decode capacity, an improvement of 1.5 dB over existing systems was achieved, effectively closing the gap and effectively achieving the Shannon capacity limit after 60 years of trying. (EX1001 at 1:55-56; 2:21-27, 10:10-38; *see also, e.g.,* EX1015 at 1:42-43, 2:7-12). As illustrated below, this improvement represented a 25% improvement over conventional approaches and constellations.



Thus, when inventors Jones and Barsoum presented their techniques and results in 2007, the communications world took notice. The techniques were replicated and validated by others and eventually incorporated into a new standard for satellite digital broadcasting, known as DVB-S2X. A leading commentator Mustafa Eroz – the same author of the *Eroz* reference relied upon by Petitioner in related IPR20203-00228 – described that in this new improved standard, "NUCs [Non Uniform Constellations] have been optimized, which aim at maximizing the [parallel decode] capacity of the AWGN channel," resulting in improvements that are "extraordinarily large." (EX2005 at 353-534).

D. The Challenged Claims

The foregoing innovative approaches are embodied in the remaining challenged claims 5, 15, and 25, each of which requires a plurality of multidimensional constellations having constellation points non-uniformly spaced in each degree of freedom, and where the receiver is capable of selecting a code rate and constellation pair from a plurality of predetermined code rate and constellation pairs and 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.

For example, each of these limitations is present and highlighted in the following exemplary claim 5, which depends from claim 1:

> 1. 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.***
>
> 5. 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***.

VI. The Petition Does Not Establish That Any Remaining Challenged Claims Are Unpatentable

LG's Petition asserts the following Grounds 1A and 1B:

Ground	References	Basis	Challenged Claims
1A	'777 Patent and ATSC322	§ 103	2-3, 12-13, 22-23
1B	'777 Patent and ATSC327	§ 103	5, 15, 25

The Board need not address Ground 1A because all of its challenged claims were statutorily disclaimed by the Patent Owner after institution.

The Board should find that Petitioner has not proven that claims 5, 15, and 25 are unpatentable under Ground 1B because that ground hinges on Petitioner's argument that those claims cannot claim priority to Barsoum, which the Board has already correctly rejected.

A. Ground 1A: The Board Should Not Address Ground 1A Because the Patent Owner Has Disclaimed All of Ground 1A's Challenged Claims

Following institution, Patent Owner filed statutory disclaimers for all of the '700 Patent claims challenged in Ground 1A, i.e., claims 2-3, 12-13, 22-23. (EX2024). Accordingly, the Board need not address Ground 1A and the patentability of those disclaimed claims because those claims are treated as if they never existed. *See Guinn*, 96 F.3d at 1422 ("A statutory disclaimer under 35 U.S.C. § 253 has the effect of canceling the claims from the patent and the patent is viewed as though the disclaimed claims had never existed in the patent."); *see also*

Apple Inc. v. MPH Techs. Oy, IPR2019-00826, Paper 25 at 10-11, 2020 WL 6494252, at *5 (PTAB Nov. 4, 2020) (Final Written Decision); *Intel Corp. v. VLSI Tech. LLC*, IPR2018-01040, Paper 36 at 16, 2020 WL 719058, at *6 (PTAB Feb. 12, 2020) (Final Written Decision).

Instead, where "some, but not all, challenged claims have been disclaimed after institution, [the Board addresses] the patentability only of the remaining claims." *Apple*, 2020 WL 6494252, at *5; *see also Intel*, 2020 WL 719058, at *6. Thus, in view of Patent Owner's statutory disclaimers (EX2024), the Board need only address Ground 1B's challenge to the patentability of claims 5, 15, and 25.

B. Ground 1B: Petitioner Has Not Established That Challenged Claims 5, 15, or 25 Are Unpatentable Because It Has Failed To Prove That the Ground 1B References Are Prior Art

In Ground 1B, the Petitioner "argues that dependent claims 5, 15, and 25 are obvious over the combination of Barsoum and ATSC327." (Institution Decision at 10). But because these two references are only prior art to claims 5, 15, and 25 if those claims cannot claim priority to Barsoum, Ground 1B necessarily fails if Petitioner's priority argument fails. (Institution Decision at 10, 15, 16-17).

And Petitioner's priority argument does fail. As the Board already preliminarily determined, Petitioner's argument that the limitations of claim 5, 15, and 25 lack written description in Barsoum are baseless and contrary to the record. Therefore, both Petitioner's priority arguments and its Ground 1B should be

rejected, and the Board should confirm its preliminary decision that Petitioner has not proven that claims 5, 15, and 25 are unpatentable.

1. Ground 1B Depends on Petitioner's Baseless Priority Argument

As the Board previously recognized, Ground 1B relies solely on the Barsoum reference as providing most of the limitations of challenged claims 5, 15, and 25: "Each of the Petition's grounds ***relies entirely on Barsoum*** to teach or suggest each limitation of independent claims 1, 11, and 21, upon which the challenged claims depend." (Institution Decision at 16).

But as the Board also previously recognized, Barsoum is only prior art to the challenged claims if Petitioner's written description/priority argument is correct:

> The '700 patent states that it is a continuation of the '777 patent (aka Barsoum). Ex. 1001 code (63). Petitioner challenges this claim to priority, arguing that features of the challenged claims do not have written description in Barsoum. Pet. 2-19. Patent Owner disagrees. Prelim. Resp. 35-38. ***All three references (Barsoum, ATSC322, ATSC327) relied on by Petitioner are only prior art to the '700 patent if the '700 patent cannot claim priority to Barsoum***.

(Institution Decision at 10).

Thus, because Ground 1B "relies entirely on Barsoum" to provide many of the required limitations of the challenged claims 5, 15, and 25, and because Barsoum and the other references are only prior art to those claims if the claims cannot claim priority to Barsoum, Ground 1B hinges on Petitioner's argument that

Barsoum does not include adequate written description of claims 5, 15, and 25—if that written description argument fails, so does Ground 1B.[6] (*See* Institution Decision at 17 ("As we have preliminarily determined that Barsoum is not prior art to claims 5, 15, and 25, the Petition does not establish a reasonable likelihood that claims 5, 15, and 25 are obvious over the combination of Barsoum and ATSC327.)).

2. Petition's Priority Challenge (and Ground 1B) Fails Because Challenged Claims 5, 15, And 25 Properly Claim Priority to Barsoum

Challenged claims 5, 15, and 25 recite a communication system having, among other things, a plurality of constellations, where each constellation is capable of providing greater parallel decoding capacity at a specific signal-to-noise ratio (SNR) that the other constellations in the plurality. (*See* Ex. 1001, '700 Patent, at claims 5, 15, and 25).For example, claim 5 reads as follows:

> 5. 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 other symbol constellations in the plurality of*** multidimensional symbol constellations at the same SNR.

[6] Patent Owner does not concede that the challenged claims are not entitled to the priority date of the '319 Provisional. However, because Ground 1B relies on Barsoum, Patent Owner need only show that the challenged claims are entitled to priority to the Barsoum to wholly defeat Ground 1B.

(Ex. 1001, '700 Patent, at claims 5, 15, and 25). "Claims 15 and 25 are substantively similar." (Institution Decision at 15).

Petitioner's entire priority argument regarding claims 5, 15, and 25 is that Barsoum does not provide adequate written description for this limitation.[7] But the Board already rejected this argument, preliminarily finding that "Petitioner has not shown that claims 5, 15, and 25 lack written description support in Barsoum." (Institution Decision at 15). As the Board determined:

> Patent Owner correctly points to the specific examples of [Barsoum's] Figures 11b, 13b, 15b, and 17b as ***each showing a plurality of constellations, each optimized for a particular SNR that provide a greater parallel decoding capacity at that specific SNR than the other symbol constellations in the plurality***. … More specifically, Figure 13b shows five constellations (i.e. a plurality), each optimized for a particular identified SNR that will perform better at that particular SNR than the other constellations, which have not been optimized at that particular SNR.

(Institution Decision at 15).

And the Board's determination remains correct and well-supported because Barsoum clearly describes that each of the plurality of unequally spaced constellations is capable of providing greater parallel decoding capacity when

[7] Petitioner provides no proposed claim construction or any claim construction analysis for this (or any other) limitation. To the extent Petitioner attempts to argue that claims 5, 15, and 25 require a comparison between groups of constellations, rather than between each constellation in a plurality of constellations, Petitioner has not identified any basis for such a construction, which is contrary to the explicit language of the claims.

operated at a symbol constellation operating SNR than the other constellations when operated at the same SNR. This reflects the disclosed techniques providing optimized non-uniform constellations that provide greater capacity at a respective operating SNR than other non-uniform constellations at that respective operating SNR.

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***.

(*Id.* at 8:47-56).

Therefore, for each operating SNR, an unequally spaced constellation performs best at that operating SNR compared to the other unequally spaced constellations that may be used but may not provide the same gains as those other constellations at different operating SNR. (*See* EX1015 at 4:62-5:11, 6:15-22, 7:26-29, 8:47-56). Accordingly, the constellation optimized at a given SNR performs better than the other constellations optimized at different SNRs for that given SNR. Conversely, all other constellations, which are optimized for different operating SNR, perform worse at the given SNR.

In addition to the disclosure of the written description, 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. Figures 11b and 13b are shown below.

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

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

FIG. 13b

Thus, a system using a PAM-8 (or orthogonalized to QAM-64) operated at an SNR of 5.27 dB would utilize a constellation having points located at the positions indicated in the second column of figure 13b, and this constellation would provide greater capacity than all other PAM-8 (or QAM-64) constellations at that operating SNR of 5.27 dB. If the system switches to an operating SNR of

9.00 dB, then the system would utilize a constellation having points located at the positions indicated in the third column of figure 13b, and this constellation would provide greater capacity than all other PAM-8 (or QAM-64) constellations at that operating SNR of 9.00 dB, including the constellation defined by the locations indicated in the second column of figure 13b (i.e., the optimized constellation for an operating SNR of 5.27 dB).

Accordingly, Barsoum discloses 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. The combination of the written description and figures "clearly allow[s] persons of ordinary skill in the art to recognize that [the inventor] invented what is claimed." *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010).

Thus, Petitioner's argument that the limitations of claim 5, 15, and 25 lack written description in Barsoum are baseless and contrary to the record. Therefore, both Petitioner's priority arguments and its Ground 1B should be rejected, and the Board should confirm its preliminary decision that Petitioner has not proven that claims 5, 15, and 25 are unpatentable.

VII. Conclusion

For the foregoing reasons, the Board should reject the remaining Ground 1B and find that Petitioner failed to prove that challenged claims 5, 15, or 25 are unpatentable.

Dated: October 2, 2023

Respectfully submitted,

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. §42.24(d), Patent Owner hereby certifies, in reliance on the word count of the word-processing system (Microsoft Office Word 2010) used to prepare this Patent Owner response, that the number of words in this paper is 8,671. This word count excludes the tables of contents, tables of authorities, certificate of word count, certificate of service, and table of exhibits.

Dated: October 2, 2023

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CERTIFICATE OF SERVICE

I certify that copies of Patent Owner's Response and accompanying Constellation Exhibit 2024 are being served by electronic mail on the following counsel of record:

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