

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. IPR2023-00228
U.S. Patent No. 10,693,700

**PATENT OWNER'S PRELIMINARY RESPONSE
PURSUANT TO 37 C.F.R. § 42.107(a)**

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In re Kahn, 441 F.3d 977 (Fed. Cir. 2006)*passim*

Other Authorities

35 U.S.C. § 103 31

TABLE OF EXHIBITS

Exhibit	Description
2001	Declaration of Dr. Giuseppe Caire
2002	Declaration of Dr. Guillen i. Fabregas
2003	U. Madhow, <i>Fundamentals of Digital Communication</i> , Cambridge University Press 2008
2004	R.G. Gallager, <i>Principles of Digital Communication</i> , Cambridge University Press 2008
2005	Eroz et al., <i>New DVB-S2X constellations for improved performance on the satellite channel</i> , 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., <i>Non-Uniform Constellations for ATSC 3.0</i> , IEEE Transactions on Broadcasting, Vol. 62, No. 1, March 2016
2008	P. Gill, W. Murry, M. Wright, <i>Practical Optimization</i> , Emerald Group Publishing Limited (1982)
2009	RESERVED
2010	RESERVED
2011	RESERVED
2012	Curriculum Vitae and Publication List of Dr. Giuseppe Caire
2013	Curriculum Vitae and Publication List of Dr. Guillen i. Fabregas
2014	RESERVED
2015	Giuseppe Caire, Giorgio Taricco, and Ezio Biglieri, <i>Bit-Interleaved Coded Modulation</i> , IEEE Transactions of Information Theory, vol. 44, no. 3, May 1998 (“Caire”)
2016	Alexander Schretz, and Chris Weck, <i>Hierarchical modulation – the transmission of two independent DVB-T multiplexes on a single frequency</i> , European Broadcasting Union Technical Review, April 2003, pages 1-13.
2017	RESERVED

I. Introduction

The challenged claims and subject matter are not merely patentable over the prior art, they are revolutionary. For over 60 years prior to the '700 Patent's inventions, experts strove to design digital communication systems that could perform near the ultimate limit for reliable transmission of information, known as the Shannon channel capacity limit. They all failed.

But where others failed for 60 years, the '700 Patent inventors succeeded, developing a system and approach that did the unthinkable and finally achieved capacity near or equal to the Shannon limit. They did so by going against all conventional wisdom in digital communications design. 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 result was revolutionary. The inventors of the '700 Patent developed techniques for optimizing signal constellations 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 Petitioner LG took notice. It previously marveled that the inventive constellations yielded performance gains “well above the famous [Shannon] shaping gain limit of 1.53 dB.” (EX2007 at 202). Petitioner LG also previously conceded that the inventors were the first to describe the use of optimizing a constellation for capacity. (EX2007 at 197).

But now that LG is accused of infringing these acknowledged inventions, it is singing a different tune. The Board should deny institution, however, because LG’s Petition fails to establish the required reasonable likelihood of success under any of the asserted grounds for at least the following reasons:

- Petition fails to provide any evidence that the combination of *Eroz* and *DVB-T* meets the “where each ... different non-uniform multidimensional symbol constellation is only included in one of the ... code rate constellation pairs” limitation recited in each challenged claim, much less enough evidence to meet Petitioner LG’s burden; and
- Petition attempts to cure this deficiency by relying on *De Gaudenzi*, but the Petition fails to explain **how** the proposed combination could be made or **why** a person of ordinary skill in the art would have a reasonable expectation of success in making the proposed combination.

No Reasonable Likelihood of Success with Respect to *Eroz* and *DVB-T*

Combination: As explained below, each challenged claim of the Patent Owner Constellation Design's '700 Patent is directed to a data communication system and requires that "each ... different non-uniform multidimensional symbol constellation is only included in one of the ... code rate constellation pairs." But the Petition fails to even attempt to identify this limitation in either *Eroz* or *DVB-T*. Instead of providing this necessary evidence, the Petition provides a number of conclusory statements that it would be obvious to optimize each constellation. But the Petition (1) fails to recognize that there is no clear highest efficiency constellation in a hierarchical constellation, which represents two data streams, because increasing spectral efficiency and/or improving SNR performance for one data stream necessarily reduces spectral efficiency and/or reduces SNR performance for the other data stream; and (2) the proposed modification goes against *DVB-T*'s teaching of providing flexibility to control constellations and code rates based on different transmission requirements.

No Reasonable Likelihood of Success with Respect to *Eroz*, *DVB-T*, and *De Gaudenzi* Combination: Acknowledging the weakness of the *Eroz-DVB-T* combination, the Petition relies upon *De Gaudenzi* as allegedly teaching the "each ... different non-uniform multidimensional symbol constellation is only included in one of the ... code rate constellation pairs." **But the author of *De Gaudenzi* has**

submitted a declaration confirming that his work and article could not be

easily applied to DVB-T's hierarchical QAM constellations. For example,

author Dr. Guillén i Fàbregas, has confirmed:

- Recognizing that configuring constellation and code rate pairs that have been optimized for SNR or spectral efficiency would have been desirable is one thing. Finding the system to achieve this goal is a very different thing. Indeed, in my opinion it is not straightforward how someone could modify the combination of references cited in the Petition to optimize for SNR or spectral efficiency. (Fabregas Declaration at 2, 13).
- “My co-authors and I did not develop nor did we describe optimizing rectangular QAM constellations. We only worked on multi-ring APSK constellations. Moreover, the techniques we did describe in *De Gaudenzi* could not be easily applied to a rectangular QAM constellation.” (Fabregas Declaration at 10).
- “My co-authors and I did not develop and did not describe optimizing hierarchical constellations. Instead, our optimization process only considered non-hierarchical APSK constellations in which a single data stream is represented and which only has one code rate associated with it at any one time. In my opinion, it is not clear or

straightforward how anyone could apply the techniques I disclosed in *De Gaudenzi* to a hierarchical system. For instance, my techniques were directed towards improving capacity for a constellation representing a single data stream that could only be used with a single code rate at any one time. A hierarchical constellation, such as those described in *DVB-T*, represent two data streams and can used with two different code rates at any given time.” (Fabregas Declaration at 12).

- “I recall, during that symposium in Nice France, thinking that the presentation of the work by Barsoum, Jones and Fitz was genuinely original and interesting. I was impressed by the scope of the work: embarking into a full constellation optimization to result in non-uniform (in all degrees of freedom) constellations is a challenging and commendable project. I recall speaking to a colleague regarding the concepts described during the presentation. Despite having worked on the subject for a number of years, I did not make a connection between the materials presented in Nice France and my own work as described in *De Gaudenzi*.” (Fabregas Declaration at 6).

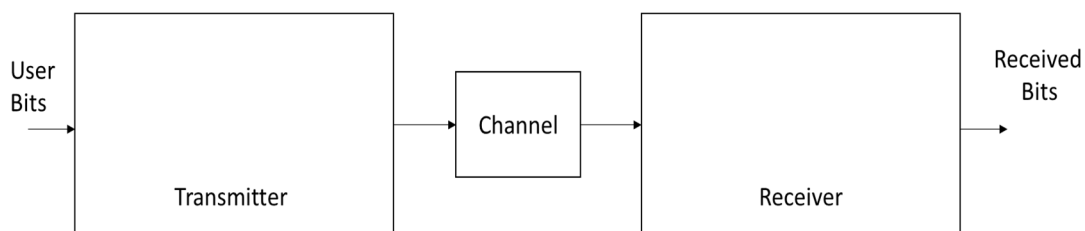
For at least these reasons, the Petition should be denied.

II. Using “Constellations” In Digital Communications

The challenged 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 Communications

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



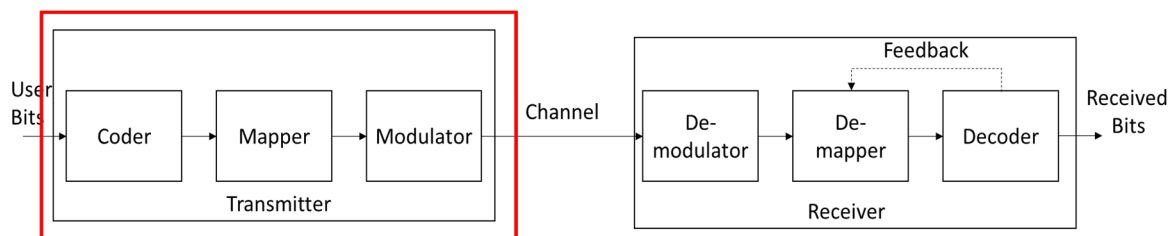
As illustrated in the above overview, information in the form of user bits (sequences of 0s and 1s) is input to the transmitter, which first converts those bits into an electromagnetic signal and then transmits that electromagnetic signal over the channel to the receiver. (EX2001 at 5; EX2003 at 2-4; 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 5; 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 5-6; 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 6; 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 6; 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 6; 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 6; EX2003 at 2-3; EX2004 at 11, 298).

The code rate is a ratio of the relative length of the input user bits to the length of the output bits. 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.

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.

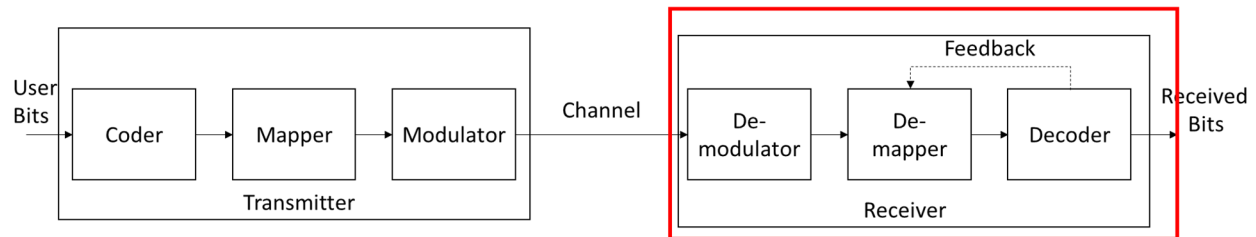
The resulting new bit sequence is input to the **mapper**, which maps this new sequence to constellation points, which are one or more carrier signal values (such as amplitude and/or phase) that can be used to represent a longer sequence of bits. (EX2001 at 7; EX2003 at 7; EX2004 at 181-209). Such mapping 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 7).

Next, the mapper provides these constellation values to the **modulator**, which creates a signal to be modulated to reflect the constellation values provide by the mapper and then be sent through the channel. (EX2001 at 19; 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 7; 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 7-8; 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 8; EX2003 at 2-4; EX2004 at 1-5, 11, 95, 181-183, 208-209).



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 22; EX2003 at 3-4; EX2004 at 181-209). Such demapping is discussed in more detail in the following “Constellation Mapping and Demapping” section. (EX2001 at 8).

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 8; 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. (EX2001 at 9).

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 9). As explained below, the former is a constellation point's "location," and the latter is its "label." (EX2001 at 9).

Signal characteristics that may be used as constellation point locations include amplitude, phase, and frequency. (EX2001 at 9; 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 9; 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 9; 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 9-10). 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 10). Where a particular constellation point falls on the spectrum of available values is called its “location.” (EX2001 at 10).

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 10). 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 10). The sequence to which a constellation point is assigned is its “label.” (EX2001 at 10).

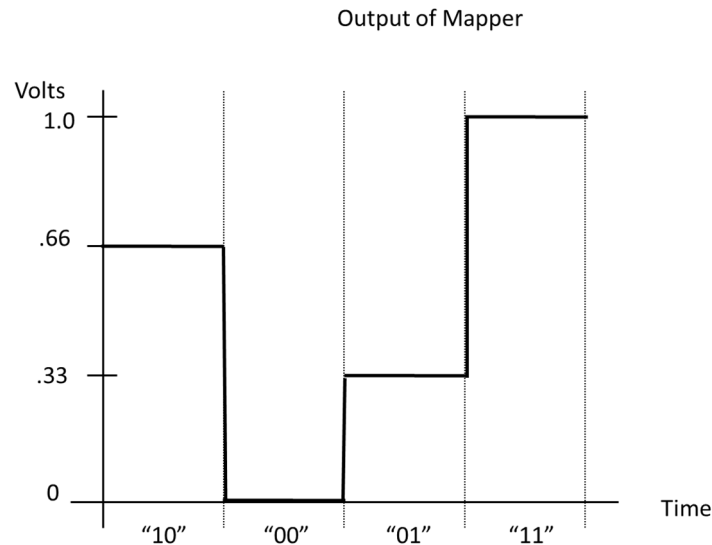
2. The Mapper

The transmitter’s mapper uses these constellation labels and locations to map a bit sequence to a corresponding sequence of constellation points. (EX2001 at 11; 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 11). 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 11).

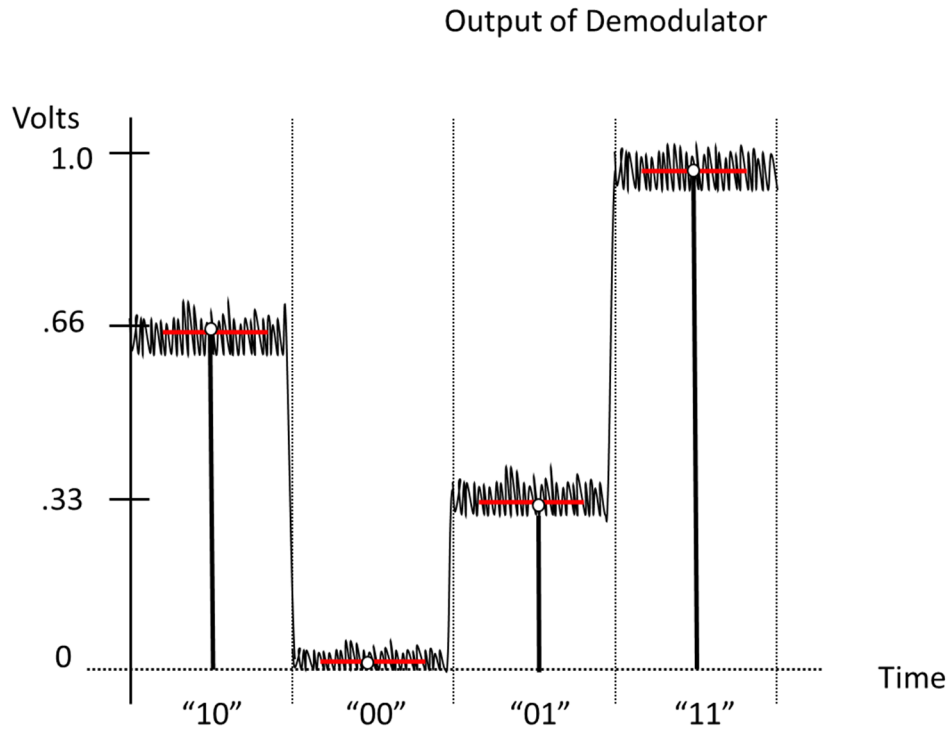
Constellation Label	Constellation Location
“00”	0
“01”	.33
“10”	.66
“11”	1.0

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 11-12). 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 12; 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 12 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 13; 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 13; 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 sequence¹. (EX2001 at 13-14; 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
$y \leq .25$	“00”
$.25 < y \leq .5$	“01”
$.5 < y \leq .75$	“10”
$.75 \leq y$	“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

¹ 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 14). In many implementations, the demapper performs “soft” decisions, that is, outputs probabilities on which bit sequence corresponds to the input signal. (EX2001 at 14).

- if the output of the demodulator is greater than .75, then the bit sequence is “11”. (EX2001 at 15).

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 15). Put together, these component bits result in the sequence “10000111.”² (EX2001 at 15).

C. Hierarchical Communications

The digital communication systems and techniques discussed so far have all related to typical non-hierarchical systems in which the communication system transmits a single stream of bits. However, one class of communication systems multiplex two data streams into a single channel, effectively creating two separate data streams. (EX2001 at 15; EX2016 at 2-3). This approach is referred to as hierarchical modulation and finds applicability in digital television broadcast where television broadcasters can enable improved capabilities to adapt the network to changing requirements. (EX2001 at 15; EX2016 at 2-3). Hierarchical systems can also provide a lower-quality fallback signal in the case of weak signals that allows

² To simplify the illustrative example, it does not include any error correction coding.

for a graceful degradation instead of a complete signal loss. (EX2001 at 15; EX2016 at 2-3).

Hierarchical modulation also allows for varying levels of quality of service. (EX2016 at 2-4). For example, a hierarchical system provides higher data rates (e.g., higher resolution video, additional channels) for a smaller coverage area closer to the transmitter, while providing lower data rates (e.g., basic service) to a larger coverage area. (EX2001 at 16; EX2016 at 2-4).

In hierarchical modulation, different bits are provided with varying levels of reliability or error protection. (EX2001 at 16; EX2016 at 2-4). This can include creating a high priority data stream, which is more robust, and a low priority data stream, which is less robust. (EX2001 at 16; EX2016 at 2-4). Fundamental to hierarchical systems is that in order to provide the increased robustness for the high priority data stream, the robustness of the lower priority data stream must be decreased. (EX2001 at 16; EX2016 at 2-4). That is to say, that a hierarchical system does not provide for more reliable communication for all bits being transmitted, rather, hierarchical systems increase the robustness of some data at the cost of reducing the robustness of other data, as compared to an equivalent non-hierarchical system. (EX2001 at 16; EX2016 at 2-4).

Hierarchical modulation also does not increase the overall data transmission rate of a communication system. (EX2001 at 16). To the contrary, the net data rate

of the low priority and the high priority data streams will actually be less than an equivalent non-hierarchical system due to the overhead required in implementing the hierarchical communications. (EX2001 at 16; EX2016 at 3).

III. 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. (EX2001 at 17).

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. (EX2001 at 17). But this and all other prior art approaches fell far short of their “holy grail,” the Shannon limit. (EX2001 at 17).

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 17; 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; *See also, e.g.*, EX2001 at 17).

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 20-21; 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 21; 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 21; 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 21; 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 1). 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 1). 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 1). 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.

IV. The Challenged '700 Patented Invention

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, 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 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 optimized 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.

The inventors recognized that while optimizing constellations could be applied broadly, any given optimized constellation provided gains over an operating range, such as at or near a particular code rate and/or SNR. As a result, 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.

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 the constellation. And to do so, they took an even more unconventional approach: rather than sticking to the convention of maximizing the minimum distance between constellation points, they experimented with freely varying those locations and labels.

Counter-intuitively, they discovered that unequally spaced constellation points 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.

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 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 measurements 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 code rate) 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.*, EX2001 at 22).

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 22; 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; *See also, e.g.*, EX2001 at 22). 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.*, EX2001 at 22).

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.*, EX2001 at 22). 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.*, EX2001 at 22-23). 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.*, EX2001 at 23). 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; *See also, e.g.*, EX2001 at 23).

2. 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.*, EX2001 at 23). 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.*, EX2001 at 23). 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.*, EX2001 at 23). As an example, a constellation optimized for a code rate of $1/2$ may not have the same performance at a code rate of $2/3$. (EX2001 at 23). Instead, a different constellation optimized for a code rate of $2/3$ may perform better when the system is operating at a code rate of $2/3$ than if the system used the constellation optimized for a code rate of $1/2$. (EX2001 at 23-24).

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. (EX2001 at 24). 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. (EX2001 at 24). 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. (EX2001 at 24).

3. 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

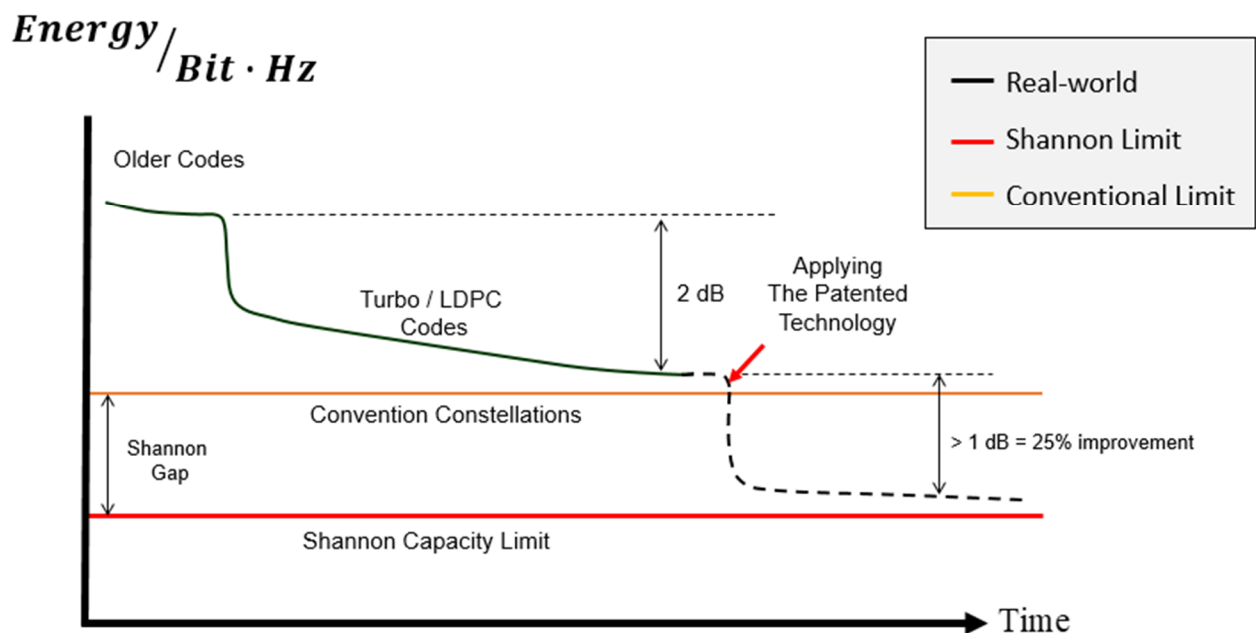
response to changes in channel conditions, changes in code rate, or changes in the target user data rate.” (EX1001 at 4:62-5:11; *See also, e.g.*, EX2001 at 24). As an example, the ’700 Patent describes a communication system that can select an information rate that meets the end user rate goal, and then use a capacity-optimized constellation that provides gains for the selected rate that meets the end user rate goal. (EX1001 at 11:51-12:10; *See also, e.g.*, EX2001 at 24). 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.*, EX2001 at 24-25).

C. The Revolutionary Results

The inventor’s unusual approach of freely assigning locations and labels 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).

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). 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). 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 Eroç – the same author of *Eroç* – 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 challenged claims, 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, where each of the plurality of different non-uniform constellations is only included in one of the plurality of predetermined code rate and constellation pairs.

For example, each of the limitations are present and highlighted in the following exemplary 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.***

V. Petition

LG's Petition asserts the following Grounds:

Ground	References	Basis	Challenged Claims
1A	<i>Eroz</i> in view of <i>DVB-T</i>	§ 103	1, 8, 10-11, 18, 20-21, 28, 30
1B	<i>Eroz</i> in view of <i>DVB-T</i> and <i>DeGaudenzi</i>	§ 103	1, 6, 8, 10-11, 16, 18, 20-21, 26, 28, 30
2A	<i>Eroz</i> in view of <i>DVB-T</i> and <i>Sommer</i>	§ 103	4, 14, 24
2B	<i>Eroz</i> in view of <i>DVB-T</i> and <i>Sommer</i> and <i>DeGaudenzi</i>	§ 103	4, 14, 24
3A	<i>Eroz</i> in view of <i>DVB-T</i> and <i>DVB-S2</i>	§ 103	7, 17, 27
3B	<i>Eroz</i> in view of <i>DVB-T</i> and <i>DVB-S2</i> and <i>DeGaudenzi</i>	§ 103	7, 17, 27
4A	<i>Eroz</i> in view of <i>DVB-T</i> and <i>DVB-TS</i>	§ 103	9, 19, 29
4B	<i>Eroz</i> in view of <i>DVB-T</i> and <i>DVB-TS</i> and <i>DeGaudenzi</i>	§ 103	9, 19, 29

Each and every ground relies on the combination of (1) *Eroz* and *DVB-T*; or (2) *Eroz*, *DVB-T*, and *De Gaudenzi* as allegedly rendering obvious the “where each of the plurality of different non-uniform constellations is only included in one of the plurality of predetermined code rate and constellation pairs” limitation as required by all claims. But *Eroz* and *DVB-T*, alone or in combination with *De Gaudenzi*, does not render any of the challenged claims obvious. Indeed, the Petition fails to show how or why a person of ordinary skill would modify or combine these references to achieve the challenged claims. And all evidence shows that *Eroz* and *DVB-T*, alone

or in combination with *De Gaudenzi*, **could not be combined** to result in the above-referenced limitation required by every challenged claim.

A. *Eroz*

As noted above, at the time of the '700 filing, most communication systems utilized constellations with equally spaced locations, and this was well accepted as the best approach. *Eroz* is no different. (EX2001 at 28).

Eroz describes an elementary non-hierarchical digital communications system in which a transmitter utilizes a traditional equally spaced constellation coupled with LDPC codes. (EX1004, at [0033], [0069]; *See also, e.g.*, EX2001 at 28). *Eroz* teaches a point-to-point (*i.e.*, one-to-one) digital communication system, in which a single transmitter communicates to a single receiver. (EX1004 at [0030], [0033]; *See also, e.g.*, EX2001 at 28). *Eroz*'s one-to-one system is shown in Figure 1, which is reproduced below. (EX1004 at [0030], [0033]; *See also, e.g.*, EX2001 at 28).

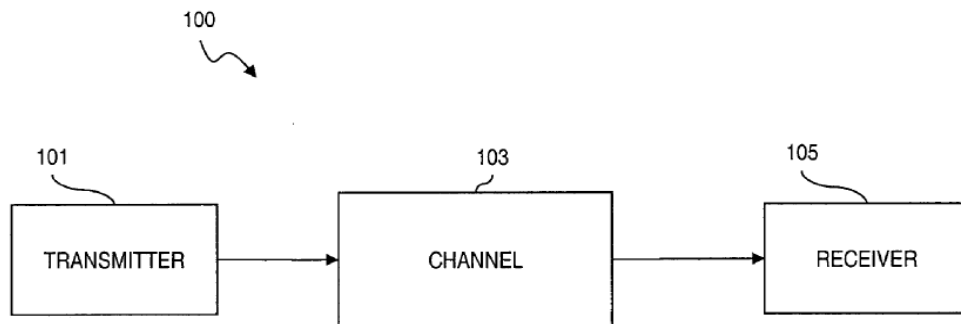


FIG. 1

Eroz's receiver, shown in figure 3 (reproduced below), includes a demodulator 301, a bit metric generator 307 (which performs demapping), and an LDPC decoder 305. (EX2001 at 28). Attempting to improve system performance, *Eroz's* technique utilizes specific LDPC arrangements in the LDPC Decoder that simplifies the encoding with limited performance loss (*e.g.*, enables a lowering of encoding scheme complexity while simultaneously improving data transmission rates). (EX1004 at [0006] and [0007]; *See also, e.g.*, EX2001 at 28-29). Moreover, *Eroz's* approach is non-hierarchical, that is, there is a single data stream and all bits have the same level of error protection. (EX2001 at 29).

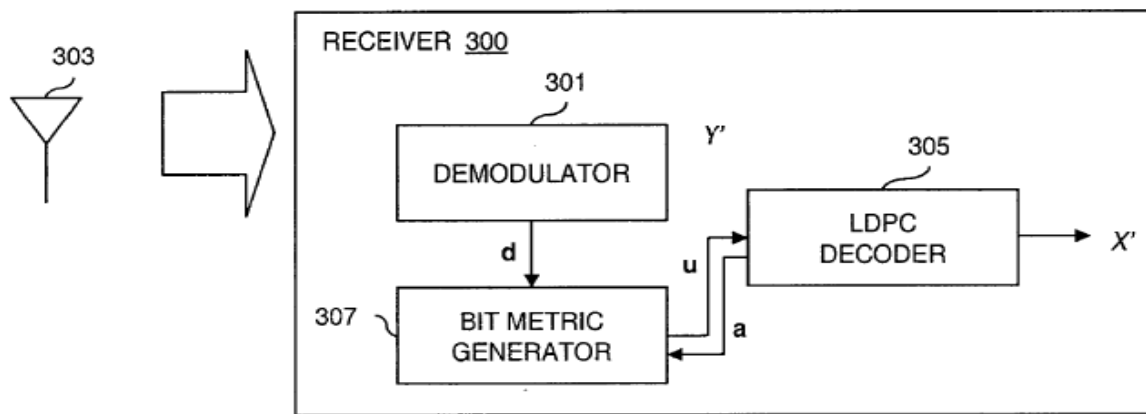


FIG. 3

In order to achieve this lower complexity encoding, *Eroz* describes an embodiment that employs a coding scheme that does not require the performance of iterative decoding iterations. (EX1004 at [0070]; *See also, e.g.*, EX2001 at 29).

B. DVB-T

In contrast to *Eroz*'s one-to-one system, *DVB-T* describes a one-to-many system for digital terrestrial television. *DVB-T* enables hierarchical modulation, in which two data streams having different transmission performance can be made available on a single TV frequency channel. (EX1005 at 9; EX2001 at 29-30; EX2016 at 1).

The hierarchical modulation can provide a lower-quality fallback signal in the case of weak signals, which allows for a graceful degradation instead of a complete signal loss. (EX1005 at 9; EX2001 at 30; EX2016 at 2-3). Further, hierarchical modulation also allows for varying levels of quality of service. (EX1005 at 9; EX2001 at 30; EX2016 at 2-4). For example, a hierarchical system provides higher data rates (e.g., higher resolution video, additional channels) for a smaller coverage area closer to the transmitter, while providing lower data rates (e.g., basic service) to a larger coverage area. (EX2001 at 30; EX2016 at 2-4).

1. DVB-T Was Designed For Hierarchical Broadcast Communications

DVB-T, unlike *Eroz*, is designed to operate with a point-to-multipoint hierarchical digital communication system in which a transmitter may communicate different data streams simultaneously to multiple receivers. (EX2001 at 30). This type of hierarchical communication system requires a

different architecture than *Eroz*. (EX2001 at 30). A brief description of an example *DVB-T* transmitter, reproduced below, is instructive. (EX2001 at 30).

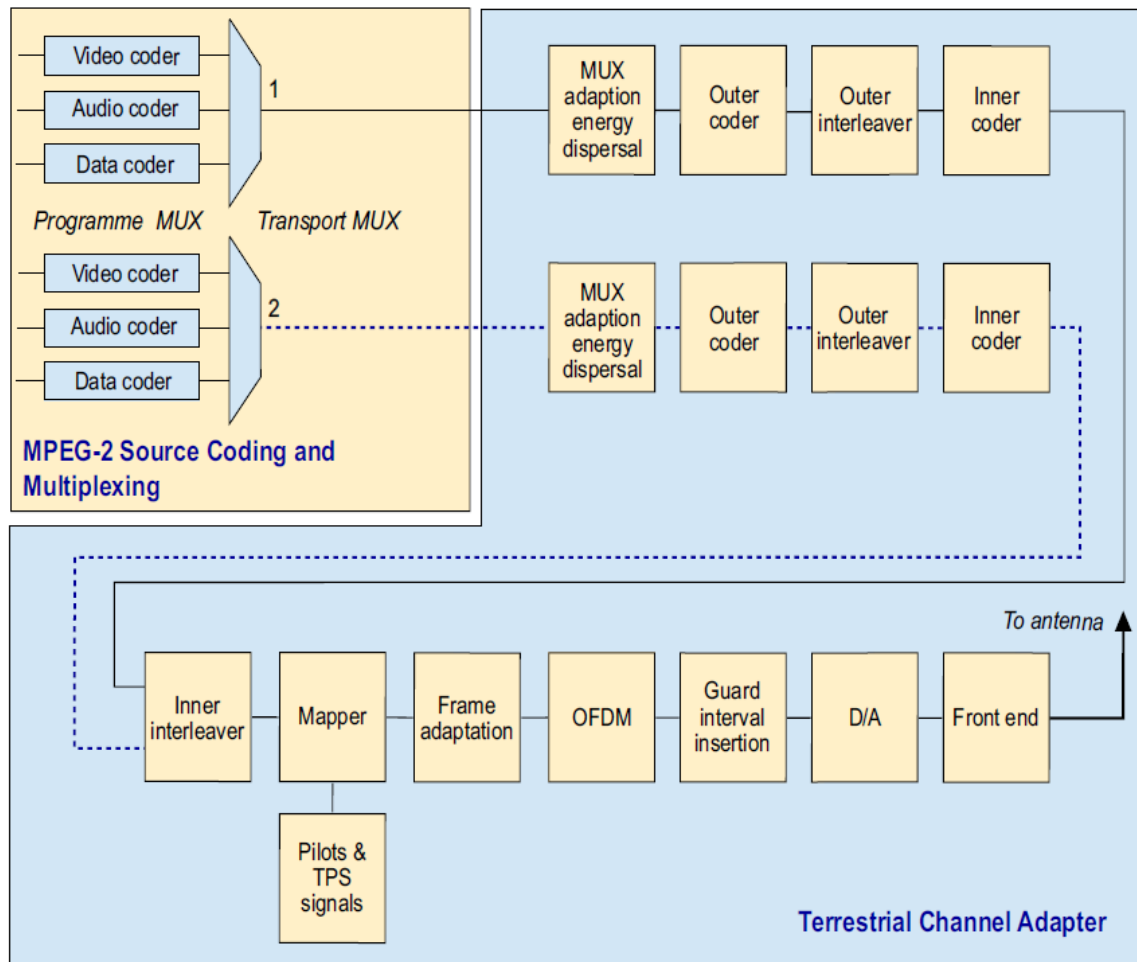


Figure 2
Block diagram of a DVB-T system with hierarchical modulation

(EX2001 at 31; EX2016 at 3; *see also* EX1005 at 10).

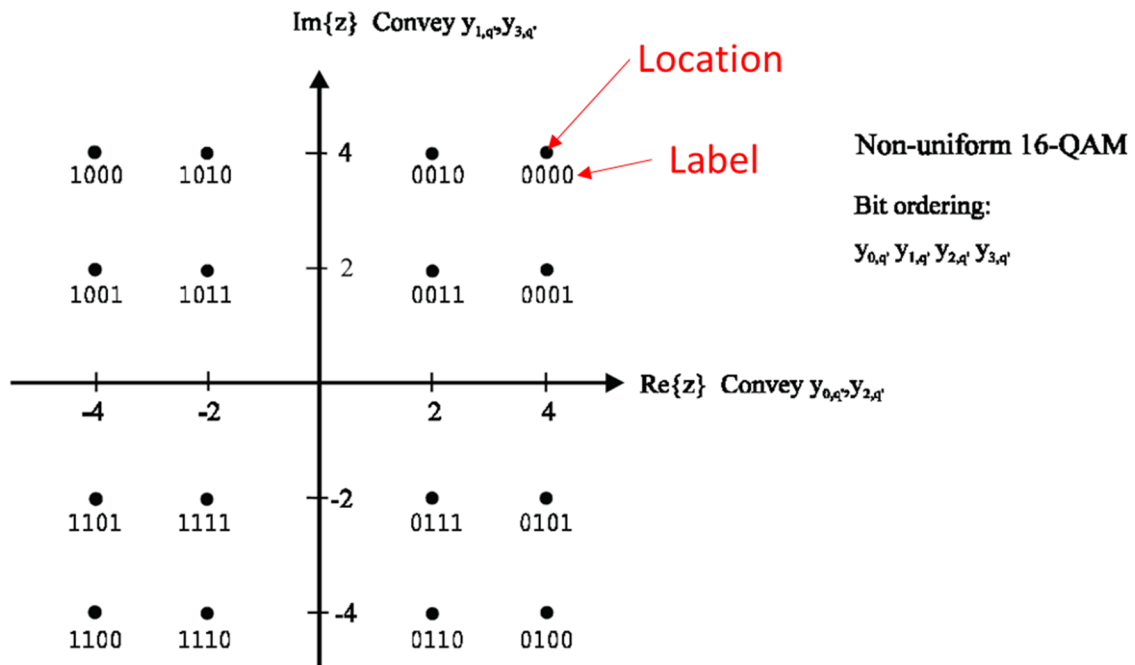
As shown in the Figure above, the transmitter includes two completely separate transport streams, which are combined at an inner interleaver prior to transmission. (EX2001 at 31; EX1005 at 10; EX2016 at 3). The receiver similarly is required to separate the transmission into two data streams.

(EX2001 at 31-32). This is unlike the basic point-to-point digital communication system of *Eroz*, in which a single transmitter transmits data to a single receiver via a dedicated communication channel. (EX2001 at 32).

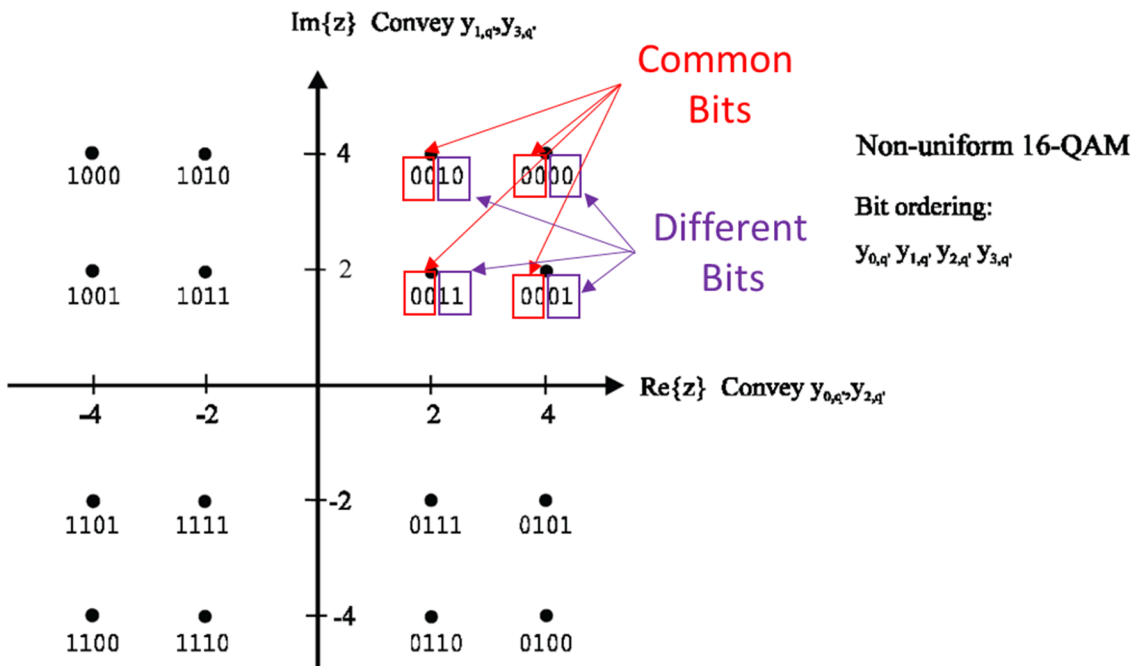
2. Hierarchical Modulation Constellations in *DVB-T*

When using hierarchical modulation, *DVB-T* utilizes constellations in which some bits are common within a quadrant of the in-phase and quadrature plot and some bits are different. (EX1005 at 21-24; EX2001 at 32; EX2016 at 2). The common bits form the high priority data stream, which has increased error protection when compared to a traditional QAM constellation with the same number of points, and the different bits form the low priority data stream, which has decreased error protection when compared to a traditional QAM constellation with the same number of points. (EX1005 at 9, 21-24; EX2001 at 32; EX2016 at 2-4). When a signal is demodulated, the quadrant in which the signal resides can be used to identify the common bits while the precise location within the quadrant can be used to identify the different bits. (EX1005 at 9, 21-24; EX2001 at 32; EX2016 at 2-4).

An example is shown below with the *DVB-T* QAM-16 constellation. As discussed above, each constellation point has a location and a label. (EX2001 at 32).

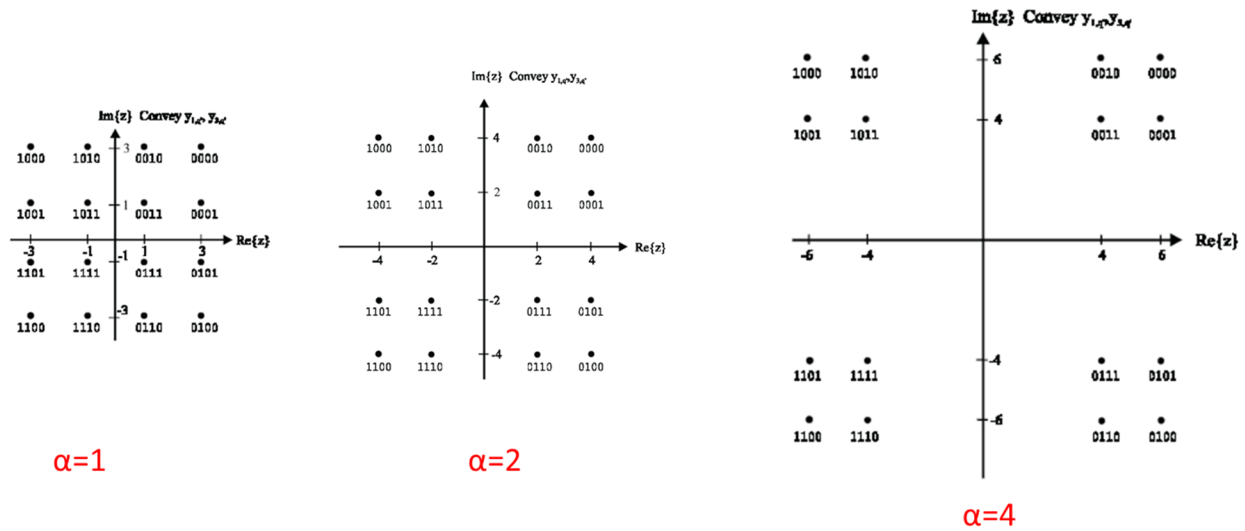


All labels within a quadrant share two bits in common, and two bits that are different. (EX2001 at 33).



When a signal is demapped, the quadrant in which the received signal resides can be used to resolve the two common bits (the high priority data) while the location within the quadrant can be used to resolve the two different bits (the low priority data). (EX1005 at 9, 21-24; EX2001 at 34; EX2016 at 2-4). For example, if a received signal resides within the upper-right quadrant (quadrant I), then the high priority bits can be determined to be “00”. (EX2001 at 34). Where within the upper-right quadrant the received signal resides would inform as to whether the low priority bits should be determined to be “00”, “01”, “10”, or “11”. (EX2001 at 34).

DVB-T provides for three QAM-16 hierarchical constellations that provided varying levels of error protection for the high priority and low priority data streams. (EX1005 at 9, 21-24; EX2001 at 34; EX2016 at 4). Each of the three QAM-16 hierarchical constellations are defined by an alpha parameter (“ α ”), which can take a value of 1, 2, or 4. (EX1005 at 9, 21-24; EX2001 at 34; EX2016 at 4). The QAM-16 hierarchical constellations of *DVB-T* are shown below. (EX2001 at 34).



The alpha parameter represents the spatial distance between neighboring points located in adjoining quadrants. (EX1005 at 9, 21-24, 31; EX2001 at 35; EX2016 at 4). A higher alpha value indicates that neighboring points located in adjoining quadrants are further away from one another and therefore are less easily confused when reception is impaired by noise. (EX1005 at 9, 21-24, 31; EX2001 at 35; EX2016 at 4). A higher alpha value thus improves the high priority bits resilience to noise. (EX1005 at 9, 21-24; EX2001 at 35; EX2016 at 4). On the other hand, a higher alpha value also results in a decrease in the separation of the points within a quadrant, which results in a decrease in resilience to noise for the low priority bits. (EX1005 at 9, 21-24; EX2001 at 35; EX2016 at 4). An alpha value of 1 indicates the constellation is a traditional uniformly spaced constellation. (EX2001 at 35).

Similar constellations are provided for QAM-64, with alpha values of 1, 2, and 4. (EX2001 at 35).

3. ***DVB-T Provides for a Flexible Implementation for Network Operators to Choose Code Rates, Constellations, and Alpha Values Without Limitation***

DVB-T provided implementers with the flexibility to adapt the constellations and code rates at a granular level (e.g., frame-to-frame) using transmission parameter signaling (TPS). (EX1005 at 29-31; EX2001 at 36; EX2016 at 1-2). The TPS signals parameters related to a given transmission scheme on a frame-by-frame basis and conveys:

- (1) the hierarchy information (alpha value, e.g., 1, 2, or 4),
- (2) the constellation (e.g., QAM-16 or QAM-64),
- (3) the low priority code rate, and
- (4) the high priority code rate.

(EX1005 at 29-31; EX2001 at 36; EX2016 at 1-2). Each of the low priority code rate and the high priority code rate can take one of five values ($1/2$, $2/3$, $3/4$, $5/6$, or $7/8$). (EX1005 at 32; EX2001 at 36; EX2016 at 1). The greater the code rate, the higher the effective data rate, but the worse the error protection and, consequently, the lower the coverage radius and/or the service coverage quality. (EX2001 at 36; EX2016 at 1). And for any given frame, the receiver will use the values included in the TPS to demodulate and decode the received signal. (EX2001 at 36).

Notably, *DVB-T* allows for choosing the values of these parameters ***without limitation***. (EX2001 at 37). In other words, any constellation (e.g., QAM-16, QAM-

64) can be combined with any alpha value (e.g., $\alpha=1, 2$, or 4), which can be combined with any high priority code rate (e.g., $1/2, 2/3, 3/4, 5/6$, or $7/8$), which can be combined with any low priority code rate (e.g., $1/2, 2/3, 3/4, 5/6$, or $7/8$). (EX2001 at 37).

This flexibility in choosing the values of these parameters is intentional. (EX2001 at 37). It provides *DVB-T* with a flexibility for use to achieve a wide range of network requirements, some of which may be dynamic and change over time. (EX2001 at 37). For example, changing the code rate of a high priority stream could raise or lower the coverage radius and/or the service coverage quality of any television programs included in the high priority stream. (EX2001 at 37; EX2016 at 1). As another example, increasing the alpha value (e.g., from 2 to 4) can enlarge the high priority coverage area but reduce the low priority coverage area. (EX2001 at 37; EX2016 at 5). And yet another example, changing from one constellation (e.g., QAM-16) to another constellation (e.g., QAM-64) can change the effective data rate (e.g., increase the number of television programs supported without increasing transmission channels) but also impact the coverage area and/or service coverage quality. (EX2001 at 37; EX2016 at 2, 5).

As recognized by the author's of *DVB-T*, there is no clear "best" combination of constellation, alpha value, high priority code rate, and low priority code rate. (EX2001 at 37). Each parameter can be selected to fit the needs of a network.

(EX2001 at 37). And these needs can change over time. (EX2001 at 37-38). For example, if a given television broadcast communication network wished to increase the number of television programs supported by the network, without requiring additional transmission channels, they could change the code rate without changing the alpha value. (EX2001 at 38; EX2016 at 5). Similarly, if a given television network wished to increase the coverage area of the high priority data stream at the expense of the low priority stream, they could change the alpha value to a lower value without changing the code rate. (EX2001 at 38; EX2016 at 5).

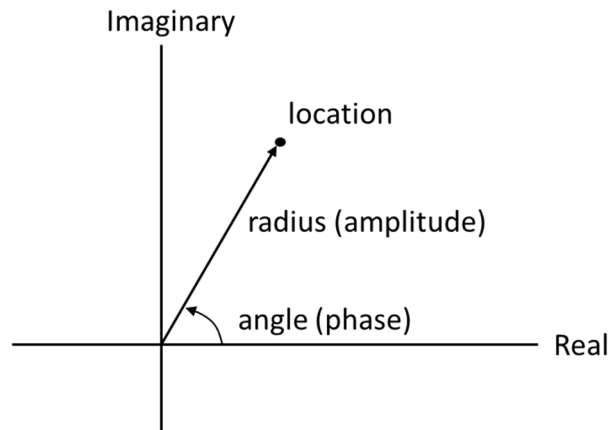
In view of these changing needs of a network, there is no clear predefined code rate and constellation pairings that are most efficient for all scenarios. (EX2001 at 38). As a result, *DVB-T* advantageously allows for the selection of constellation, alpha value, high priority code rate, and low priority code rate without limitation. (EX2001 at 38).

C. *De Gaudenzi*

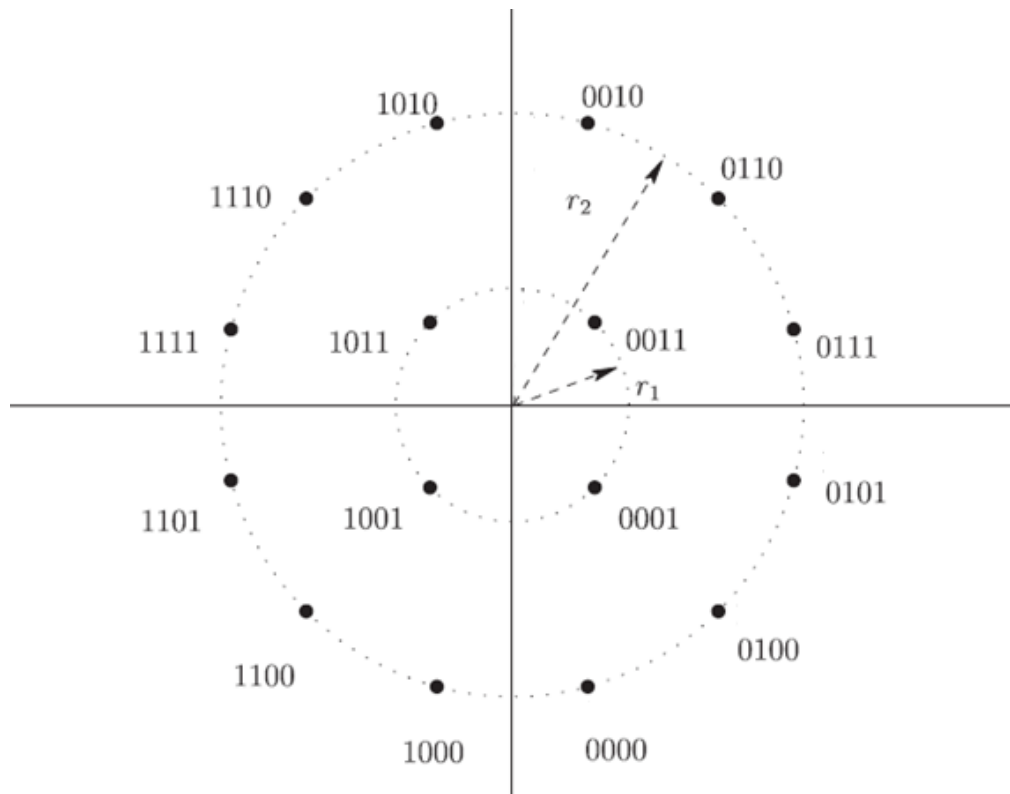
1. *De Gaudenzi* Uses Only APSK Constellations

In a previously discussed illustration of constellations, a constellation point's location was indicated by a single characteristic of the carrier signal, its amplitude. (EX2001 at 38). *De Gaudenzi*, however, concerns Amplitude Phase Shift Keying (APSK) constellations, in which the constellation point locations are indicated by two signal characteristics, amplitude and phase. (EX1014 at 4-5; EX2001 at 38;

EX2002 at 7). To illustrate, the following figure depicts that a constellation point location can be represented in polar coordinates by a radius (the amplitude) and an angle (the phase). (EX2001 at 38-39; EX2002 at 7).



Because both amplitude and phase are used to indicate a constellation point's location, in APSK, different constellation points can have the same amplitude but still be at different locations because they have different phases. (EX2001 at 39; EX2002 at 7). For example, the following figure from *De Gaudenzi* depicts two “rings” of constellation points. (EX2001 at 39; EX2002 at 7-8). Each ring of constellation points has the same amplitude (represented by the radius in the polar coordinates) but each constellation point within the ring has a different phase (represented by the angle in polar coordinates). (EX1014 at 4-5; EX2001 at 39; EX2002 at 8).



Thus, in this illustrated constellation, each of the bit sequences 0001, 0011, 1001, and 1011 have the same amplitude r_1 (and thus are positioned on the inner r_1 ring) but their locations at that amplitude are distinguished by their different respective phases (positioned at 90 degree intervals around the r_1 ring). (EX1014 at 4-5; EX2001 at 40; EX2002 at 8-9). Likewise, the remaining bit sequences (0000, 0100, 0101, etc.) share the same larger amplitude r_2 (and are thus positioned on outer ring r_2) but have different locations because of their different phase positions at that ring/amplitude. (EX1014 at 4-5; EX2001 at 40; EX2002 at 9).

2. ***De Gaudenzi* Describes Maintaining Uniform Phase and Varying a Ring Ratio of an APSK**

As explained above, in *De Gaudenzi*, each constellation point's location is defined by two signal characteristics, namely the signal's amplitude and its phase. (EX1014 at 4-5; EX2001 at 41; EX2002 at 9). As part of its optimization process, *De Gaudenzi* places constraints on the available locations including constraints on the number of constellation points located at each ring (amplitude) and the differences in phase for each of those locations. (EX1014 at 4-8; EX2001 at 41; EX2002 at 9).

For example, *De Gaudenzi* puts restrictions on the phase aspect of the constellation point locations. (EX1014 at 4; EX2001 at 41; EX2002 at 9). At each ring/amplitude, *De Gaudenzi* requires that the constellation points be uniformly spaced in phase. (EX1014 at 4-5; EX2001 at 41; EX2002 at 9). In the above 2-ring embodiment, the 4 constellation points at the inner ring/amplitude must be a uniform 90 degrees apart in phase, even if different phases (and thus different locations) would result in improving capacity. (EX1014 at 4-8; EX2001 at 41; EX2002 at 9). Likewise, the 12 constellation points at the outer ring/amplitude must be a uniform 30 degrees apart in phase, even if different phases (locations) would result in improving capacity. (EX1014 at 4-5; EX2001 at 41; EX2002 at 9-10).

De Gaudenzi then teaches varying a ratio between the rings to assess whether capacity could be improved. This is confirmed by co-author Dr. Guillén i Fàbregas, who states “for each constellation in our optimization process, we preselected the number of points in each ring and required there be a uniform phase spacing between points of each ring. Further, we did not optimize over the individual point locations or labels, only the ring ratio and phase offset.” (EX2002 at 10).

3. *De Gaudenzi’s* Teachings Are Focused on APSK Constellations and Not Rectangular QAM Constellations

The Petition asserts that “DeGaudenzi’s teachings are broad, are not limited to APSKs, and can be applied to ... QAM constellations”. (Petition at 61).

However, this is not true.

De Gaudenzi’s teachings are focused on improving only the capacity of highly constrained multi-ring APSK constellations in which the amplitude and phase of a signal is modulated. (EX2001 at 41-42; EX2002 at 10). The number of points in each amplitude ring are preselected, and *De Gaudenzi* teaches optimizing joint capacity by maintaining uniform phase and varying a ring ratio. (EX2001 at 42; EX2002 at 10).

A QAM constellation modulates (varies) the amplitude of two components of a sinusoid (the in-phase and quadrature components) that are offset in phase by

one-quarter cycle. (EX2001 at 42). But a rectangular QAM constellation, such as those of DVB-T, do not have a ring ratio, rendering the techniques of *De Gaudenzi* inapplicable to a rectangular QAM constellation. (EX2001 at 42).

The Petition quotes *De Gaudenzi*'s statement regarding the design of digital QAM constellations as allegedly supporting the assertion that *De Gaudenzi*'s teachings are broad and can be applied to QAM constellations. (Petition at 61, citing to EX1014, 262-264). But Petitioner takes this statement out of context. This statement in *De Gaudenzi* refers generally to APSK's as related to QAM in that APSK's can be represented in the real and imaginary dimensions. (EX2001 at 42). This statement is – not – an invitation to apply the teachings of *De Gaudenzi* directly to a rectangular QAM nor does it suggest the teachings of *De Gaudenzi* could easily be applied to a rectangular QAM constellation. (EX2001 at 42).

This is confirmed by *De Gaudenzi* co-author, Dr. Guillén i Fàbregas, who states “my co-authors and I did not develop nor did we describe optimizing rectangular QAM constellations. Moreover, the techniques we did describe in *De Gaudenzi* could not be easily applied to a rectangular QAM constellation. Our statement regarding the design of digital QAM constellations does not suggest our techniques should be applied to a rectangular QAM constellation, we merely noted that APSK constellations are related to rectangular QAM in that APSK's can be represented in the real and imaginary dimensions.” (EX2002 at 10-11).

4. ***De Gaudenzi* Describes and is Applicable to Non-Hierarchical Constellations**

Not only are *De Gaudenzi*'s techniques inapplicable to rectangular QAM modulation, they are also inapplicable to hierarchical modulation. (EX2001 at 42).

As noted above, *DVB-T* is a hierarchical system in which two data streams are represented by one constellation. (EX1005 at 9, 21-24; EX2001 at 42; EX2016 at 2). In contrast, *De Gaudenzi* is directed to a non-hierarchical system that supports only one data stream and can only have one associated code rate at a time. (EX2001 at 43). The techniques of *De Gaudenzi*, which sought to improve the capacity of a constellation representing a single data stream, could not easily be applied to a hierarchical constellation in which two data streams are represented. (EX2001 at 43).

Further complicating the matter, *De Gaudenzi* describes optimizing joint capacity for constellations operated at one code rate at a given time. The techniques of *De Gaudenzi* could not easily be applied to *DVB-T*'s constellation operating at two code rates at the same time. (EX2001 at 43).

And this too is confirmed by co-author Dr. Guillén i Fàbregas, who states “My co-authors and I did not develop and did not describe optimizing hierarchical constellations. Instead, our optimization process only considered non-hierarchical APSK constellations in which a single data stream is represented and which only

has one code rate associated with it at any one time. In my opinion, it is not clear or straightforward how anyone could apply the techniques I disclosed in *De Gaudenzi* to a hierarchical system. For instance, my techniques were directed towards improving joint capacity for a constellation representing a single data stream that could only be used with a single code rate at any one time, and could not be used with a hierarchical constellation having two code rates at any one time.” (EX2002 at 12).

VI. The Board Should Deny Institution

The Board should deny institution because the Petition fails to establish the required reasonable likelihood of success under any of the following asserted grounds for at least the following reasons:

- A person of ordinary skill in the art would not find the claimed “each of the plurality of different non-uniform multidimensional symbol constellations is only included in each of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs” obvious in view of *Eroz* and *DVB-T*.
- *De Gaudenzi* does not cure the deficiencies of the *Eroz* and *DVB-T* combination and, as a result, a person of ordinary skill in the art would not find the claimed “each of the plurality of different non-uniform

multidimensional symbol constellations is only included in each of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs” obvious in view of *Eroz*, *DVB-T*, and *De Gaudenzi*.

A. Grounds 1A, 2A, 3A, 4A: The Board Should Deny Institution Because LG’s Petition Fails to Establish a Reasonable Likelihood of Success on the “Where Each ... Different Non-Uniform Multidimensional Symbol Constellations Is Only Included In One Of The ... Pairs” Claim Limitation

Each challenged claim of the ‘700 Patent requires a plurality of different non-uniform multidimensional symbol constellations, namely “each of the plurality of different non-uniform multidimensional symbol constellations is only included in each of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs.” (EX2001 at 43).

LG relies on the combination of *Eroz* and *DVB-T* as allegedly teaching the above limitation. (Petition at 37-39). But *Eroz* and *DVB-T*, individually or in combination, fail to describe or suggest a plurality of different non-uniform multidimensional symbol constellations such that each one of these constellations ***is only included in one of the plurality of predetermined LDPC code rate and multidimensional symbol constellation pairs***. Moreover, the Petition provides no evidence supporting a reasonable finding to the contrary.

1. Petition Admits Claim Limitation Not Found in Prior Art and Provides No Evidence to Support a Conclusion of Obviousness

The Petition concedes that the above-referenced claim limitation is not found in *Eroz* or *DVB-T* and instead asserts that using an optimized set of constellation-code rate pairs would have been obvious to use. (Petition at 37-38).

An obviousness conclusion requires some articulated reasoning with a rational underpinning. (*In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)). No such articulated reasoning is provided in the Petition. Instead, the Petition proffers a list of conclusory assertions - (1) an optimized set of constellation-code rate pairs would have *been obvious and desirable to use* and (2) while it was known in the art that a constellation can be utilized with different code rates and may be configured in various suitable ways, *configuring constellation and code rate pairs* that have been optimized for SNR or spectral efficiency *would have been desirable* so that inferior SNR or inefficient constellation and code rate pairs are not utilized in the systems of *Eroz* and *DVB-T*. (Petition at 37-38).

Just because the Petition asserts that something is “obvious”, hardly makes it so. The Petition needs to support its position with some description or at least a reference to pertinent sections of *Eroz* and *DVB-T*. No such reference is present. Instead, the Petition merely concludes that a selected constellation-code rate pair having the highest efficiency would have been obvious to a person of ordinary skill

in the art because selecting a constellation with optimized configurations would have been desirable to maximize performance of the system of *Eroz* and *DVB-T*. (Petition at 37-38). But desire alone is insufficient to sustain a finding of obviousness.

And it is, in fact, not obvious. There is no dispute that these limitations are not disclosed by *Eroz* and *DVB-T*. *Eroz* utilizes a single traditional uniform constellation for all code rates. *DVB-T* describes a system having hierarchical constellations. (EX1005 at 9). These hierarchical constellations include, for a given number of constellation points, two possible non-uniform constellations (i.e., an alpha value of 2 or 4 for either a 16 or 64 point constellation). (EX1005 at 9, 31-33; EX2016 at 1-2). Each hierarchical constellation requires a high priority code rate and a low priority code rate, and each of the high priority code rate and low priority code rate can take any one of five different code rate values. (EX1005 at 9, 31-33; EX2016 at 1-2).

There is no clear way how a person of ordinary skill in the art could take two different constellations, each of which has a high priority code rate and a low priority code rate, and pair the constellations with five different code rates, to result in a system having a plurality of different constellations where each constellation is only included in one of the plurality of predetermined code rate and constellation pairs as required by each challenged claim.

Put more simply, *DVB-T* does not teach constellations that are amenable to code-rate constellation pairs nor does *DVB-T* teach enough constellations to have a different constellation for each code rate – constellation pair. Quite the opposite – it teaches the use of a small number of constellations with different code rates to accommodate different broadcast scenarios. Furthermore, the use of different hierarchical constellations in *DVB-T* is not to achieve as high a data rate as possible at different SNR operating points. Instead, the constellations offer different tradeoffs between high priority and low priority bitstreams at a given SNR operating point.

And the Petition acknowledges this weakness by explaining that “the obviousness of such a system is corroborated in *De Gaudenzi*”. (Petition at 38). Yet indicated by *De Gaudenzi*’s co-author, Dr. Dr. Guillén i Fàbregas, recognizing that configuring constellation and code rate pairs that have been optimized for SNR or spectral efficiency would have been desirable is one thing, but finding the system to achieve this goal is a very different thing. (EX2002 at 2, 13). Indeed, how someone could modify the *Eroz* and *DVB-T* combination to optimize for SNR or spectral efficiency is not straightforward. (EX2002 at 2, 13).

If anything, the Petition’s conspicuous absence of any discussion or reference to either *Eroz* or *DVB-T* is tantamount to the Petitioner’s admission that the element of “each of the plurality of different non-uniform multidimensional symbol constellations is only included in each of the plurality of predetermined LDPC code

rate and multidimensional symbol constellation pairs” is not disclosed by the combination of *Eroz* and *DVB-T*. And, as explained below, all evidence shows that it would not have been obvious to modify *Eroz* and *DVB-T* to optimize each constellation for SNR and spectral efficiency.

In short, the Petition fails to provide evidence to support a conclusion of obviousness and admits that the combination of *Eroz* and *DVB-T* fails to disclose the above described limitation of the claims.

2. Petitioners Unsupported Argument Fails to Consider That There is No Clear Highest Efficiency Constellation in a Hierarchical System

The Petition asserts that configuring SNR optimized constellation and code rate pairs is desirable. (Petition at 37-38). What is unclear, however, is how a person of ordinary skill in the art could possibly achieve this objective. Instead of providing insights regarding how the objective may be achieved, the Petition simply reaffirms the desirability for configuring SNR optimized constellations. Much more is needed.

In the proposed combination of *Eroz* and *DVB-T*, the traditional equally spaced constellation would be replaced by the hierarchical constellations of *DVB-T*. (Petition at 20). These hierarchical constellations of *DVB-T* include, for a given number of constellation points, two possible non-uniform constellations. (EX1005 at 9, 21-24). These two non-uniform constellations can be selected based on the desired relative error protection between the high priority data stream and the low

priority data stream. (EX1005 at 9). One of two non-uniform constellations can be selected and both the high priority data stream and the low priority data stream are paired with any of five different code rates. (EX1005 at 30-32).

But a hierarchical constellation is a single constellation that is used to communicate two different data streams. (EX1005 at 9; EX2016 at 1). By modifying a constellation to improve the efficiency of one data stream, the efficiency of the other data stream will be reduced. Put another way, there is no clear evident way a person of ordinary skill in the art **could** optimize each constellation to perform at the highest efficiency for a given code rate. The Petition leaves many aspects of the proposed modification unexplained, such as how to even assess improving efficiency of a hierarchical constellation.

Moreover, for a hierarchical constellation, each data stream can simultaneously have a different code rate. (EX1005 at 30-32). In other words, there are *two* code rates that must be defined, the high priority code rate, and the low priority code rate. (EX1005 at 30-32). The Petition does not even recognize that multiple code rates are required for the hierarchical constellations of *DVB-T*, let alone explain how a person of ordinary skill in the art could optimize them for SNR or spectral efficiency to result in code rate and 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.” (EX1001 at Claims 1, 11, and 21).

3. The Proposed Modification Goes Against *DVB-T*'s Teaching of Providing Flexibility to Implementers to Control Constellations and Code Rates Based on Network Requirements

DVB-T is a standard for digital terrestrial television, that is, broadcast television. (EX1005 at 6; EX2001 at 45). Because broadcast television can be implemented in a wide variety of requirements and conditions, *DVB-T* provided implementers with the flexibility to select the constellations and code rates to address a given networks requirements. (EX1005 at 30-32; EX2001 at 45; EX2016 at 1-2). This flexibility was desirable because a number of variable factors could affect what was considered the best constellation to use at any given time, such as changing channel conditions (e.g., weather), desired broadcast range, desired video resolution, number of supported television channels, and so on. (EX2001 at 45).

In order to enable a network operator implementing *DVB-T* to adapt the communication network to the changing requirements, *DVB-T* allows for control of relative data rate of high priority and low priority data streams, noise robustness, and coverage area by controlling the alpha value (α), high priority code rate, and low priority code rate such that for any given data frame, the best constellation and code rate can be selected. (EX1005 at 9, 31-33; EX2001 at 45-46; EX2016 at 4-5). For

this reason, the TPS allows for the specification of α , high priority code rate, and low priority code rate without limitation (e.g., any α , high priority code rate, and low priority code rate can be used in combination to satisfy changing network requirements). (EX1005 at 9, 31-33; EX2001 at 46).

A person of ordinary skill in the art would have recognized that allowing for the dynamic selection of code rates and constellations without limitation was advantageous. (EX2001 at 46). For example, if a given television network wished to increase the coverage area of the high priority data stream at the expense of the low priority stream, they could change the alpha value to a lower value without changing the code rate. (EX2001 at 46; EX2016 at 5).

The Petition's conclusory assertion that a person of ordinary skill would find it obvious to select constellation and code-rate pairs to provide the highest efficiency fails to consider that a person of ordinary skill in the art would see the ability of *DVB-T* to choose constellations and code rates without restriction as an advantage. Indeed, *DVB-T*'s teachings would lead a person of ordinary skill in the art away from making the proposed modification.

B. Grounds 1B, 2B, 3B, 4B: The Board Should Deny Institution Because *De Gaudenzi* Does Not Cure the Deficiencies of Grounds 1A, 2A, 3A, and 4A

Implicitly acknowledging that *Eroz* and *DVB-T* fail to describe or render obvious the “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” limitation, the Petition attempts to address that deficiency by relying on *De Gaudenzi* as allegedly teaching that it would be obvious to optimize each of *DVB-T*’s constellations for capacity. (Petition at 57-58, 60-62). However, *De Gaudenzi*’s teachings related to non-hierarchical APSK constellations cannot easily be applied to *DVB-T*’s hierarchical QAM constellations. This is confirmed by *De Gaudenzi*’s coauthor, Dr. Guillén i Fàbregas, who states “it is not clear or straightforward how the optimization techniques I described in *De Gaudenzi* could be used to optimize the constellations of *DVB-T* that required both a high priority code rate and a low priority code rate.” (EX2002 at 13).

As a result, the Petition wholly fails to establish any reasonable likelihood of success that Petitioner LG will meet its burden of providing that a person of ordinary skill in the art could modify the teachings of *Eroz* and *DVB-T* with *De Gaudenzi*.

1. The Petition Fails to Explain How the Optimization Approach of *De Gaudenzi* Could Be Applied to the *Eroz-DVB-T* Combination

a. *De Gaudenzi* Provides No Guidance How to Modify a Hierarchical Constellation

De Gaudenzi’s authors focused on optimizing joint capacity for a non-hierarchical system, specifically for APSK constellations used for systems having

highly nonlinear amplifiers. (EX1014 at 1; EX2001 at 47). *De Gaudenzi* describes different APSK constellations at different code rates (e.g., Table I). (EX1014 at 11; EX2001 at 47). These code rates are for non-hierarchical systems. (EX2001 at 47). *De Gaudenzi* provides no suggestion or teaching whatsoever of how to optimize a hierarchical modulation system to improve capacity, where points represent multiple data streams and where multiple code rates can be used with a single constellation. (EX2001 at 47).

The Petition asserts that “it would have been obvious to a POSITA [to incorporate] the teachings of *De Gaudenzi* (such as Table I) [] into EDC’s system” such that in the combination “a table similar to DeGaudenzi’s Table I but with optimized 16-QAM or 64-QAM constellations and corresponding parameters (e.g., code rate, α , spectral efficiency) would have been provided.” (Petition at 57-58, 61-62). But the Petition provides no explanation as to how a person of ordinary skill in the art might possibly achieve the combination based on the teachings of *DVB-T* and *De Gaudenzi*. (EX2001 at 47-48).

First, there is no discussion in *De Gaudenzi* how to apply Table I, which lists a single code rate per APSK constellation, to a constellation that requires two different code rates (*i.e.*, a high priority code rate and a low priority code rate). (EX2001 at 48). Even if a person of ordinary skill in the art were to try to combine *De Gaudenzi* with the *Eroz* and *DVB-T* combination, the Petition has failed to

explain how they could possibly derive each constellation from two respective code rates using the teachings of *De Gaudenzi*. Indeed, the Petition fails to even recognize that each of the *DVB-T* constellations requires two code rates, rather than *De Gaudenzi*'s one code rate. (EX2001 at 48). As a result, a person of ordinary skill in the art would not find it obvious to make the proposed combination nor have a reasonable expectation of success in doing so.

This is confirmed by *De Gaudenzi*'s co-author, Dr. Guillén i Fàbregas, who states “the constellations that I and my co-authors described were directed towards non-hierarchical APSK systems. These constellations were non-hierarchical and, as a result, required only a single code rate be specified at any given time for use with the constellations. In my opinion, it is not clear or straightforward how the optimization techniques I described in *De Gaudenzi* could be used to optimize the constellations of *DVB-T* that required both a high priority code rate and a low priority code rate.” (EX2002 at 13).

Second, *De Gaudenzi* cannot be applied to the hierarchical system of *DVB-T* because the capacity for the high priority data stream and the capacity for the low priority data stream are interrelated. Put differently, in a hierarchical system, one cannot modify the constellation to improve the capacity of one data stream without reducing the capacity of the other data stream. (EX2001 at 48). A person of ordinary skill in the art would appreciate that *De Gaudenzi*'s teachings could not easily be

applied to the constellations of *DVB-T* since *De Gaudenzi* describes only non-hierarchical constellations. (EX2001 at 48).

This too is confirmed by *De Gaudenzi* author, Dr. Guillén i Fàbregas, who states “the technique I describe in *De Gaudenzi* addresses APSK constellations to improve capacity of a single data stream. It is therefore unclear to me how one even could apply the *De Gaudenzi* teachings to a hierarchical constellation such as DVB-T’s constellations.” (EX2002 at 13).

And third, the Petition proposes a person of ordinary skill in the art would select a *DVB-T* constellation and alpha value, and then optimize the selected constellation for capacity using the techniques of *De Gaudenzi*. (Petition at 57-62). However, the alpha value defines the amount of error protection and the constellation in *DVB-T*. (EX2001 at 49). Once the alpha value is selected, there is nothing left to change that does not also change the capacity and error protection provided to either the high priority stream, the low priority stream, or both. (EX2001 at 49).

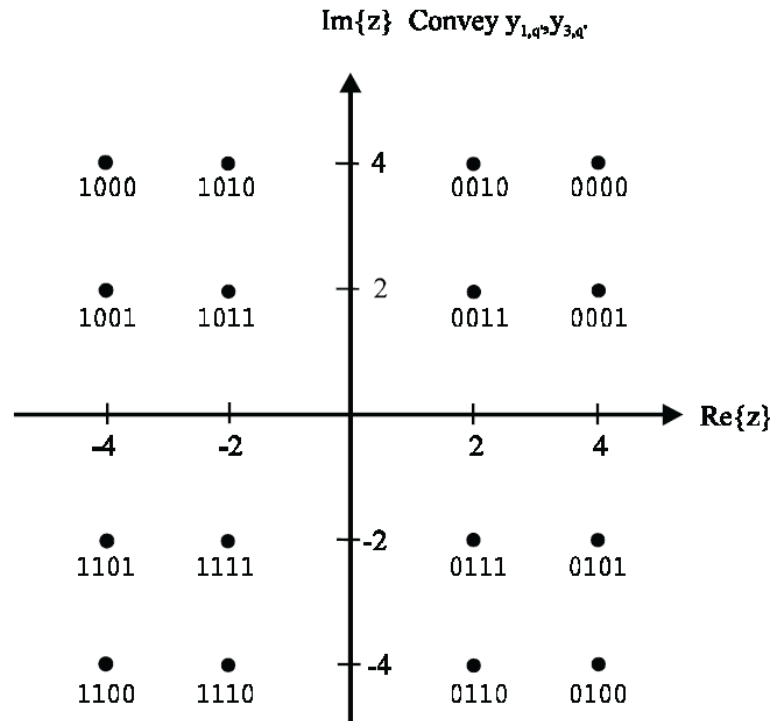
Because there is no explanation in *De Gaudenzi* of how to make the proposed combination, the Petitioner has failed to meet their burden that combination is possible, much less obvious. Instead, Petitioner bases its argument on the presumption that optimizing a constellation designed for a single channel (non-

hierarchical system) can easily be extended to two channels (hierarchical system). It cannot.

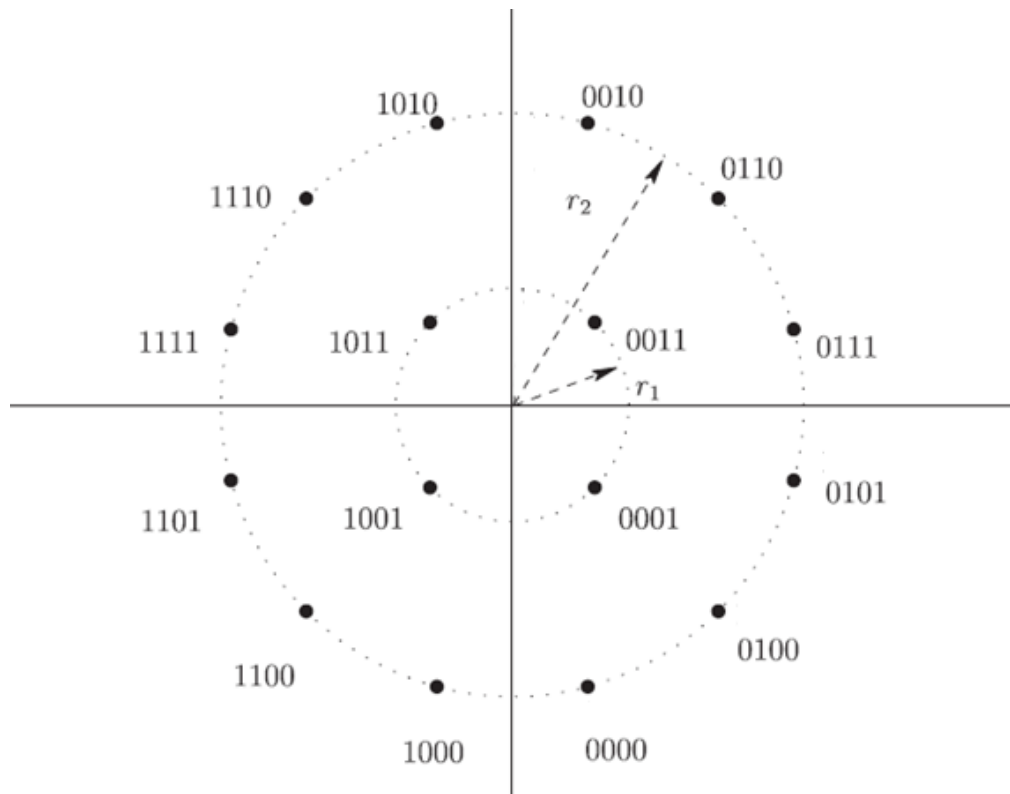
b. De Gaudenzi Gives No Guidance on How to Modify a QAM

A person of ordinary skill in the art looking to improve upon the *Eroz* and *DVB-T* combination to, as the Petition asserts, maximize parallel decode capacity of each constellation to optimize spectral efficiency or SNR, would have understood the teachings of *De Gaudenzi* to be inapplicable to the constellations of *DVB-T*. (EX2001 at 49).

As relied upon by the Petition, *DVB-T* teaches QAM constellations, which modulate (varies) the amplitude of two components of a sinusoid (the in-phase and quadrature components) that are offset in phase by 90 degrees. (EX2001 at 49). The *DVB-T* QAM-16 constellation with alpha value of 2 is reproduced below. (EX2001 at 49).



In contrast, *De Gaudenzi* teaches optimizing APSK, where points are placed in rings, the phase is required to remain uniform, and the ratio between the rings is varied. An example APSK is illustrated below. (EX2001 at 50).



The Petition asserts that it would be obvious to combine *De Gaudenzi* with *Eroz* and *DVB-T* to “configure constellation designs to maximize parallel decode capacity,” and that a person of ordinary skill in the art would “modify the constellation design software, to include code that can implement DeGaudenzi’s method.” (Petition at 57-58).

But it is not clear how to apply the teachings of uniform phase and varying ring ratio to a QAM. QAM is composed of a sinusoid having two amplitude components offset by 90 degrees and which are independently modulated. (EX2001 at 51). There is no ring ratio to optimize. (EX2001 at 51). There is no phase to

maintain as uniform. (EX2001 at 51). And the Petition is silent on how these obstacles could be overcome by a person of ordinary skill in the art. (EX2001 at 51-52).

Accordingly, a person of ordinary skill in the art would not have been able to apply the teachings of *De Gaudenzi* to maximize parallel decode capacity, nor would they have had a reasonable expectation of success in doing so. (EX2001 at 52).

C. All Grounds: The Board Should Deny Institution Because LG’s Petition Fails to Establish a Reasonable Likelihood of Success That A Person of Skill In The Art Would Want to Combine *Eroz* and *DVB-T*

The combination of *Eroz* and *DVB-T* is solely relied upon with respect to each asserted Ground. However, the Petition fails to establish any reasonable likelihood of success that Petitioner LG will meet its burden of proving that a person of ordinary skill in the art would want to modify the teachings of *Eroz* with *DVB-T*.

1. Many Unexplained Substantial Functional Changes Would be Required By the Combination, Which Would lead Person of Skill in the Art Away From the Combination

The Petition asserts that a person of ordinary skill in the art would find it predictable to combine *Eroz* and *DVB-T* because “*Eroz*’s communication system (with a transmitter and a receiver) would still perform in the same or similar manner but use the constellation and code rate pairs specified by *DVB-T*”, and the modifications “would have merely involved implementing software code for

configuring the desired code rates, modulation and constellation types.” (Petition at 22-23).

As established above, *Eroz* is a simple non-hierarchical point-to-point communication system. Given *Eroz*’s simplicity of design, *Eroz* only required transmitter and receiver components to support a single data stream. (EX2001 at 52).

DVB-T, in contrast, is a complex hierarchical one-to-many (broadcast) communication system. (EX2001 at 53). *DVB-T* requires substantially different transmitter and receiver components to support the hierarchical modulation with multiple data streams. (EX2001 at 53). Further, each stream must then be processed with separate processing components. (EX2001 at 53). Indeed, *DVB-T* transmitters require an interleaver to interleave the high priority data stream and the low priority data stream, and *DVB-T* receivers require a separator, which operates to separate a bit stream into primary bits (high priority bits) and secondary bits (low priority bits). (EX2001 at 53). No teaching or suggestion of any component comparable to the interleaver or selector is described in *Eroz*. (EX2001 at 53).

The Petition fails to explain how a person of ordinary skill in the art could make many of these additional substantial functional changes in the proposed modification of *Eroz*. A person of ordinary skill in the art looking to improve upon *Eroz* and considering *DVB-T* would understand that there are many substantial functional changes required and that any combination would require *Eroz*’s

communication system (with a transmitter and a receiver) to perform in a different and dissimilar manner were they to use *DVB-T*'s constellations. (EX2001 at 53). Not only would these changes to components of *Eroz* cause them not to perform similar functions, but these required changes would require modifications well beyond “merely [] implementing software code for configuring the desired code rates, modulation and constellation types.” (Petition at 22).

And were one to attempt to use a hierarchical constellation of DVB-T with the system of *Eroz* without making these necessary and unexplained substantial functional changes, there would be no hierarchical function nor would the combination provide improved performance, in direct contrast to *Eroz*'s stated goals. (EX2001 at 53-54).

These required substantial and unexplained (by the Petition) functional changes required of *Eroz* would lead a person of ordinary skill in the art away from the proposed combination. And a person of ordinary skill in the art would therefore **not** have wanted to combine *Eroz* and *DVB-T*. (EX2001 at 54).

VII. CONCLUSION

For any of the foregoing reasons, the Board should deny institution of the Petition.

Dated: April 20, 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 preliminary response, that the number of words in this paper is 12,958. This word count excludes the tables of contents, tables of authorities, certificate of word count, certificate of service, and table of exhibits.

Dated: April 20, 2023

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CERTIFICATE OF SERVICE

I certify that copies of Patent Owner's Preliminary Response and accompanying Constellation Exhibits 2001 through 2016 are being served by electronic mail on the following counsel of record:

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