

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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LG ELECTRONICS, INC.,  
Petitioner,

v.

CONSTELLATION DESIGNS, LLC,  
Patent Owner.

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

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**DECLARATION OF GIUSEPPE CAIRE REGARDING PATENT  
OWNER'S PRELIMINARY RESPONSE FOR *INTER PARTES REVIEW* OF  
U.S. PATENT NO. 10,693,700**

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

## **I. Introduction**

1. My name is Giuseppe Caire. I have been retained in the above-referenced *inter partes* review proceeding by Constellation Designs, LLC, to evaluate United States Patent No. 10693,700 (the “’700 patent”) against certain references that are presented by the Petitioner. As detailed in this report, it is my opinion that the Petition does not establish that of the challenged claims are anticipated or rendered obvious by the references presented by the Petitioner. If requested by the Patent Trial and Appeal Board, I am prepared to testify at trial about my opinions expressed herein.

## **II. Qualifications**

2. I have over thirty years of experience in the field of electrical engineering. For the past nine years I have held a Full Professorship and faculty position as the Chair of Communications and Information Theory at Technische Universität Berlin. In my work and research, I have researched and written about Information Theory, Communication Theory and Coding Theory, Wireless Communication Systems, Signal Processing and Statistics.

3. Prior to my appointment at the Technische Universität, Berlin I was a tenured Full Professor at the University of Southern California, Los Angeles from 2005-2016. Although I am currently at the Technische Universität Berlin, I have

retained the title of Adjunct Research Professor at the University of Southern California, Los Angeles since 2016. Prior to my tenure at the University of Southern California, Los Angeles, I spent seven years as a Professor at Eurecom Institute, and held various Assistant Professorships from 1995-1998.

4. I studied Electrical Engineering and received my Ph.D. in 1994 from the Politecnico di Torino, my Master's Degree in 1992 from Princeton University, and my Bachelor of Science Degree in 1990 from the Politecnico di Torino. In addition to my studies at undergraduate and graduate levels and academic qualifications, I have held industrial research positions such as my current role as the Director of the Huawei-TU Berlin Joint Innovation Center, which has a focus on fundamental research in wireless technology.

5. I have authored or co-authored over four hundred publications in the areas of computer networks, and telecommunications. My publication and patents are listed on my curriculum vitae, which is attached hereto as EX2012.

6. In 2021, I was awarded the Leibniz Price, which is awarded to "exceptional scientists and academics for their outstanding achievements in the field of research" and known as the most important research award in Germany. In 2022, I was elected a Member of the Berlin Brandenburg Akademie der Wissenschaften (BBAW). Further, I served as President of the Institute of Electrical and Electronics Engineers (IEEE) Information Theory Society in 2011.

7. As a result of my background in information and communication theory, I have extensive knowledge regarding the state of the technical art in this area at the time of filing of the ‘700 patent.

8. One of my papers was cited and relied upon by Petitioner. Specifically, I am co-author of EX1018 an article titled “Bit-Interleaved Coded Modulation” which was published in IEEE Transactions on Information Theory, Vol. 44, No. 3, May 1998 at pp. 927-946. This paper has been cited in other publications over thirty two hundred (3200) times (Google Scholar).

### **III. Materials Considered**

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

2. I have also reviewed the Petition, declaration of Dr. Bertrand Hochwald (EX1003) and all publications and exhibits cited in the Petition and declaration of Dr. Bertrand Hochwald including:

- U.S. Patent Publication No. 2004/0054960 to Eroz et al. (“Eroz” EX1004);

- ETSI EN 300 744 V1.2.1, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television*, July 1999 (“DVB-T” EX1005);
- D. Sommer and G.P. Fettweis, *Signal Shaping by Non-Uniform QAM for AWGN Channels and Applications Using Turbo Coding*, January 2000 (“Sommer” EX1006); and
- De Gaudenzi et al. *Turbo-coded APSK modulations design for satellite broadband communications*, Int. J. Satell. Commun. Network. 2006; 24:261-281, Published online 19 May 2006 in Wiley InterScience (“De Gaudenzi” EX1014).

10. I have also reviewed relevant parts of the publications and exhibits cited in this declaration, including the following publications:

- U. Madhow, *Fundamentals of Digital Communication*, Cambridge University Press 2008 (“Madhow” (EX2003)); and
- R.G. Gallager, *Principles of Digital Communication*, Cambridge University Press 2008 (“Gallager” (EX2004)).

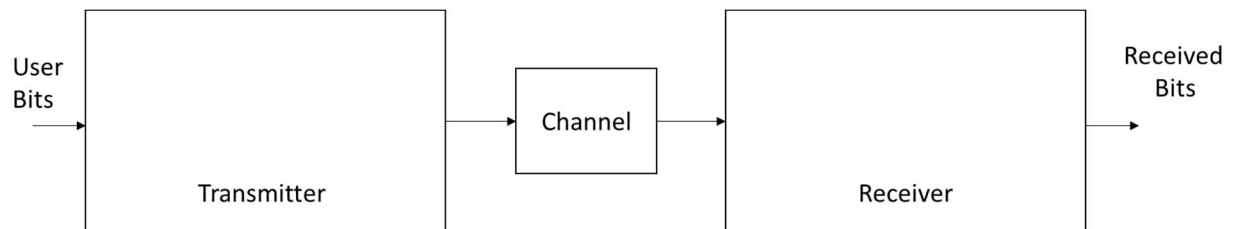
#### **IV. Using “Constellations” In Digital Communications**

11. 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 Communication System

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



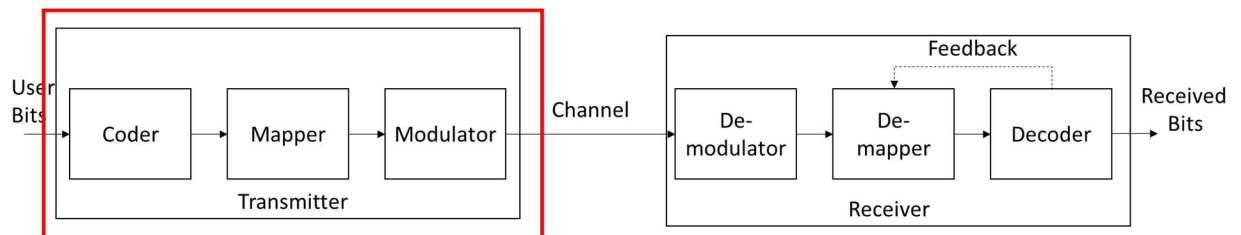
13. As illustrated in the above overview, information in the form of user bits (sequences of 0s and 1s) is input to the transmitter, which first converts those bits into an electromagnetic signal and then transmits that electromagnetic signal over the channel to the receiver. (EX2003 at 2-4; EX2004 at 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. (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. (EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

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

### 1. The Transmitter

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



16. 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. (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 to 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. (EX2003 at 2-3; EX2004 at 11, 298).

17. 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. 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.

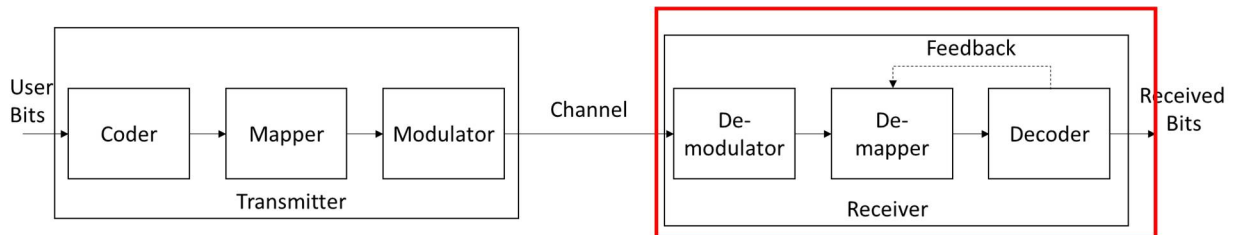
18. The resulting new bit sequence is input to the **mapper**, which maps this new sequence to constellation points, which are one or more carrier signal values (such as amplitude and/or phase) that can be used to represent a longer sequence of bits. (EX2003 at 7; EX2004 at 181-209). Such mapping and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

19. 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. (EX2003 at 2-3; EX2004 at 181-209). There are numerous different ways for a modulator to apply such information to a carrier signal. (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. (EX2003 at 45; EX2004 at 184-196).

## 2. The Receiver

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



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

22. 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. (EX2003 at 3-4, EX2004 at 11).

**B. Constellation Mapping and Demapping****1. Constellation Point Locations and Labels**

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

24. 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. As explained below, the former is a constellation point's "location," and the latter is its "label."

25. Signal characteristics that may be used as constellation point locations include amplitude, phase, and frequency. (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. (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. (EX2003 at 45; EX2004 at 184-196). In such a system, the signal's different amplitudes may serve as constellation point locations.

26. 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. 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. Where a particular constellation point falls on the spectrum of available values is called its “location.”

27. 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. 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. The sequence to which a constellation point is assigned is its “label.”

28. 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. 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. The sequence to which a constellation point is assigned is its “label.”

29. To complete this simplified example, the following depicts the location and labels for four constellation points. 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.

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

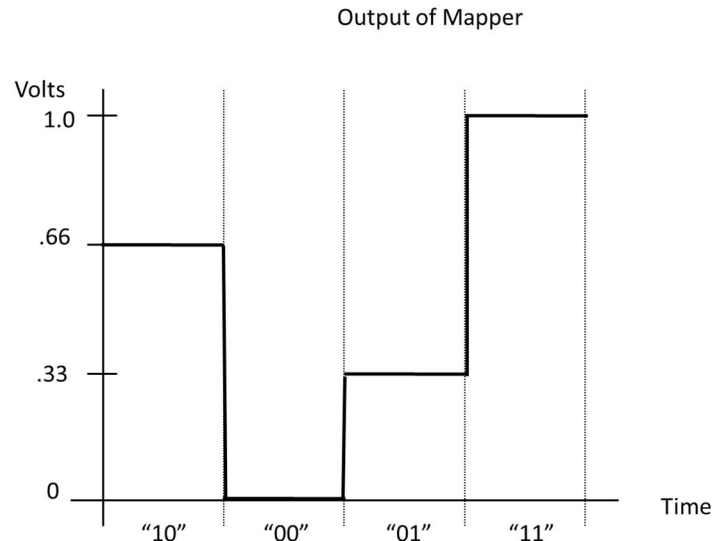
## 2. The Mapper

30. The transmitter’s mapper uses these constellation labels and locations to map a bit sequence to a corresponding sequence of constellation points. (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. 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.

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

31. 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

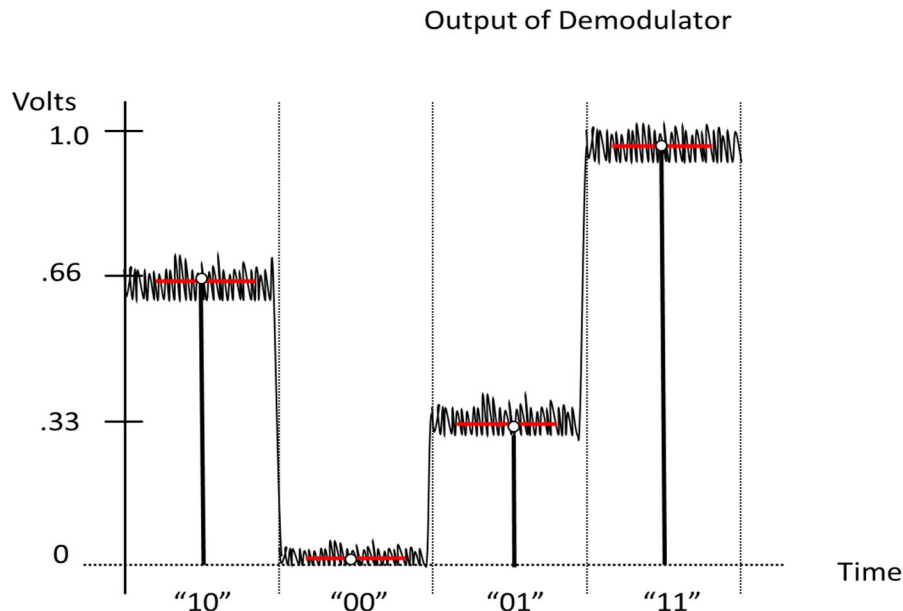
and the x-axis represents time. For reference, the transmitted bit sequence is shown for each time slot below the figure.



### 3. The Demapper

32. 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. (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. (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:



33. 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. (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. (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<sup>1</sup>. (EX2003 at 127).

34. 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

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<sup>1</sup> 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. In many implementations, the demapper performs “soft” decisions, that is, outputs probabilities on which bit sequence corresponds to the input signal.

- if the output of the demodulator is greater than .75, then the bit sequence is “11”.

35. 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. Put together, these component bits result in the sequence “10000111.”<sup>2</sup>

### **C. Hierarchical Communications**

36. 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. (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. (EX2016 at 2-3). Hierarchical systems can also provide a lower-quality fallback signal in the case of weak signals that allows for a graceful degradation instead of a complete signal loss. (EX2016 at 2-3).

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

37. 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. (EX2016 at 2-4).

38. In hierarchical modulation, different bits are provided with varying levels of reliability or error protection. (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. (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. (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. (EX2016 at 2-4).

39. Hierarchical modulation also does not increase the overall data transmission rate of a communication system. 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. (EX2016 at 3).

## **V. Prior Art Approaches**

40. 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.

41. 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.

### **A. Channel Capacity Measures**

42. Each digital communication system has a measurable “capacity,” which is the maximum amount of information that the system can reliably send over the channel. (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).

43. In general, letting  $X$  denote the channel input signal (sent by the transmitter) and  $Y$  the channel output signal (obtained at the receiver), Shannon channel coding theorem proves that the capacity  $C$  is equal to the maximum of the

mutual information  $I(X;Y)$  where the maximization is over all possible statistical distributions of the input  $X$ , subject to physical constraints imposed on the channel (e.g., average transmit power). As a consequence, in order to determine the channel capacity it is essential to define what the channel input  $X$  and the channel output  $Y$  are. In particular, when the channel input is any possible (unquantized) signal value, subject to the average power constraint, and the channel output  $Y$  is the (unquantized) signal sampled at the receiver, and the channel introduces additive Gaussian noise, we have the well-known Shannon capacity formula measured in bit/second given as  $C = B \log(1 + \text{SNR})$  where  $B$  is the channel bandwidth (in Hz) and SNR is the Signal to Noise Ratio, i.e., the ratio between the signal power and the noise power at the receiver. When the input  $X$  is constrained to be a point of a discrete constellation (i.e., a finite set of values defined by the corresponding amplitude and phase of the transmitted signal), and the output  $Y$  is defined as before, as the unquantized signal value at the receiver, the corresponding capacity is generally less than the above Shannon limit and depends on the constellation  $X$ .

44. A non-trivial design problem consists of finding constellations  $X$  approaching the above limit in a certain range of SNR, while maintaining some simplicity in the actual modulator design. This type of constellation-dependent capacity is referred to in the literature as “coded-modulation” (CM) capacity, or also “joint decoding capacity” in some works, since it assumes that the receiver

treats the received signal as a whole, without any form of simplifying (and suboptimal) preprocessing.

45. A simplified and “pragmatic” approach to system design was proposed under the name of “pragmatic coded modulation” in Zehavi, Zehavi, E., 1992. 8-PSK trellis codes for a Rayleigh channel. IEEE Transactions on Communications, 40(5), pp.873-884, and popularized by Caire et al. as Bit-Interleaved Coded Modulation in EX2015 (G. Caire, G. Taricco, and E. Biglieri, “Bit-interleaved coded modulation,” IEEE Transactions on Information Theory, vol. 44, no. 3, pp. 927–946, 1998).

46. This approach considers that, at the transmitter, a sequence of binary coded information bits (output by a binary encoder) is interleaved (i.e., the order of the sequence is scrambled according to a specific permutation pattern). The interleaved sequence is partitioned into small blocks called “labels”, and each label is mapped onto signal constellation points via a mapping referred to as “binary labeling” of the constellation points. At the receiver, a particular processing referred to as “demapper” produces soft values that represent the “likelihood” of each bit in the labels. The sequence of likelihoods is then treated as the output of a virtual channel. As such, the appropriate capacity metric for such a method is different, and was found through an explicit formula in Caire et al. (EX2015). This is known as BICM capacity, or also “parallel decoding

capacity” since it is as if the label bits were input to individual bit-wise parallel channels, and then decoded in parallel at the receiver. Generally speaking, while the joint decoding capacity is a function of only the constellation  $X$ , the parallel decoding capacity is a function of both  $X$  and the binary labeling, i.e., for the same constellation  $X$  the parallel decoding capacity is different for different binary labelings of the points.

47. In general, for a given constellation  $X$ , the joint decoding capacity is an upper bound to the parallel decoding capacity for any possible binary labeling. It should also be said that, more recently, some authors have proposed an iterative decoder/demapper scheme for which some soft likelihood values are fed back from the decoder to the demapper, and the demapper is recalculated on the basis of this feedback information. This reprocessing can be performed multiple times in an iterative fashion. It has been shown that this iterative processing of BICM (so-called BICM-ID, that stands for BICM with Iterative Demapping) can significantly reduce the gap between the BICM (parallel decoding) capacity and the CM (joint decoding) capacity. This however comes at a non-trivial increase in the decoder/demapper complexity.

#### **B. The Shannon Channel Capacity Limit**

48. 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. (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. (EX2003 at 252-255, 263-264; EX2004 at 1).

49. Shannon calculated at this capacity limit by determining the maximum possible efficiency of error correcting methods. (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. (EX2003 at 252-255, 263-264; EX2004 at 1,184-187, 253).

### **C. Prior Art Approaches Failed To Achieve the Shannon Limit**

50. 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).

## **VI. The Challenged '700 Patented Invention**

### **A. The Patent's Improved Approach to Implementing Non-Uniform Constellations**

#### **1. Optimizing Constellation Locations and Labels**

51. 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).

52. 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. (EX2008 at 20).

53. 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).

54. 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). 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). 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). 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. Non-Uniform Constellations Optimized For Particular Code Rates**

55. 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). 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). Put another way, a given non-uniform constellation will not enable the best possible performance across all code rates. (EX1001 at 5:16-21). As an example, a constellation optimized for a code rate of  $1/2$  may not have the same performance at a code rate of  $2/3$ . 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.

56. 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.

### **3. Using Multiple Optimized Constellations For a System Having Multiple Code Rate and SNR Operating Points**

57. 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). 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). 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).

## **B. The Challenged Claims**

58. 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.

59. 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.*

## VII. Petition

60. I understand 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                                 |

61. I understand that 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.

**A. *Eroz***

62. 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.

63. *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]). *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]). *Eroz*’s one-to-one system is shown in Figure 1, which is reproduced below. (EX1004 at [0030], [0033]).

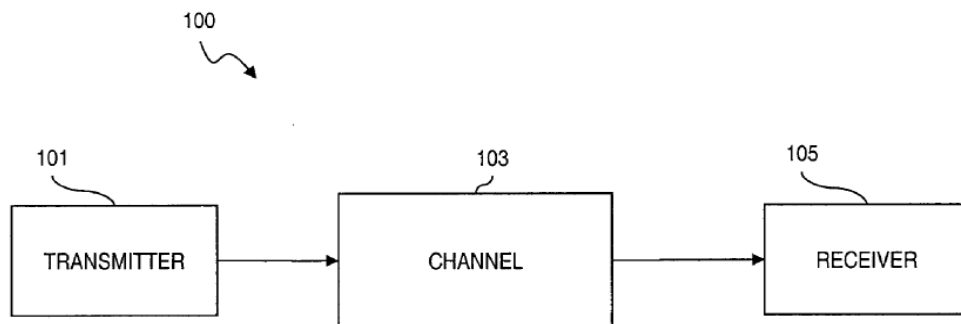


**FIG. 1**

64. *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. 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]). 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.

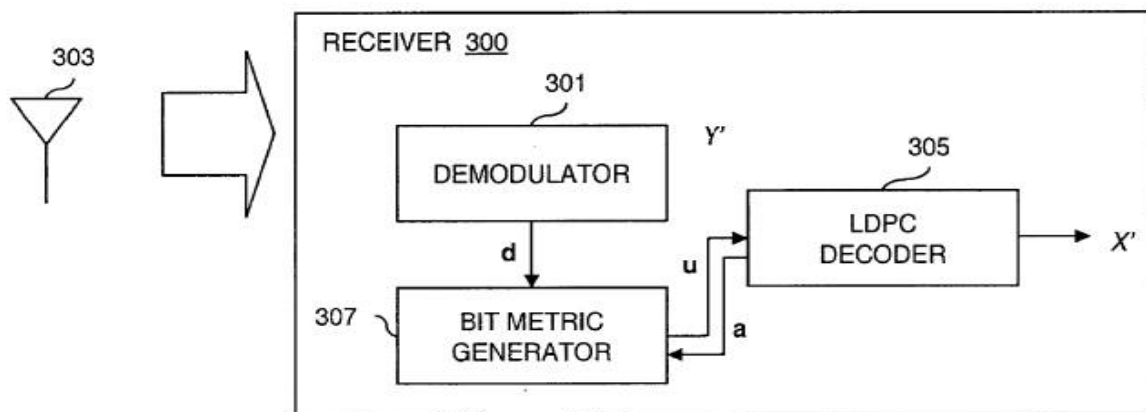


FIG. 3

65. 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]).

## B. DVB-T

66. 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; EX2016 at 1).

67. 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; EX2016 at 2-3). Further, hierarchical modulation also allows for varying levels of quality of service. (EX1005 at 9; 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. (EX2016 at 2-4).

### **1. *DVB-T* Was Designed For Hierarchical Broadcast Communications**

68. *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. This type of hierarchical communication system requires a different architecture than *Eroz*. A brief description of an example *DVB-T* transmitter, reproduced below, is instructive.

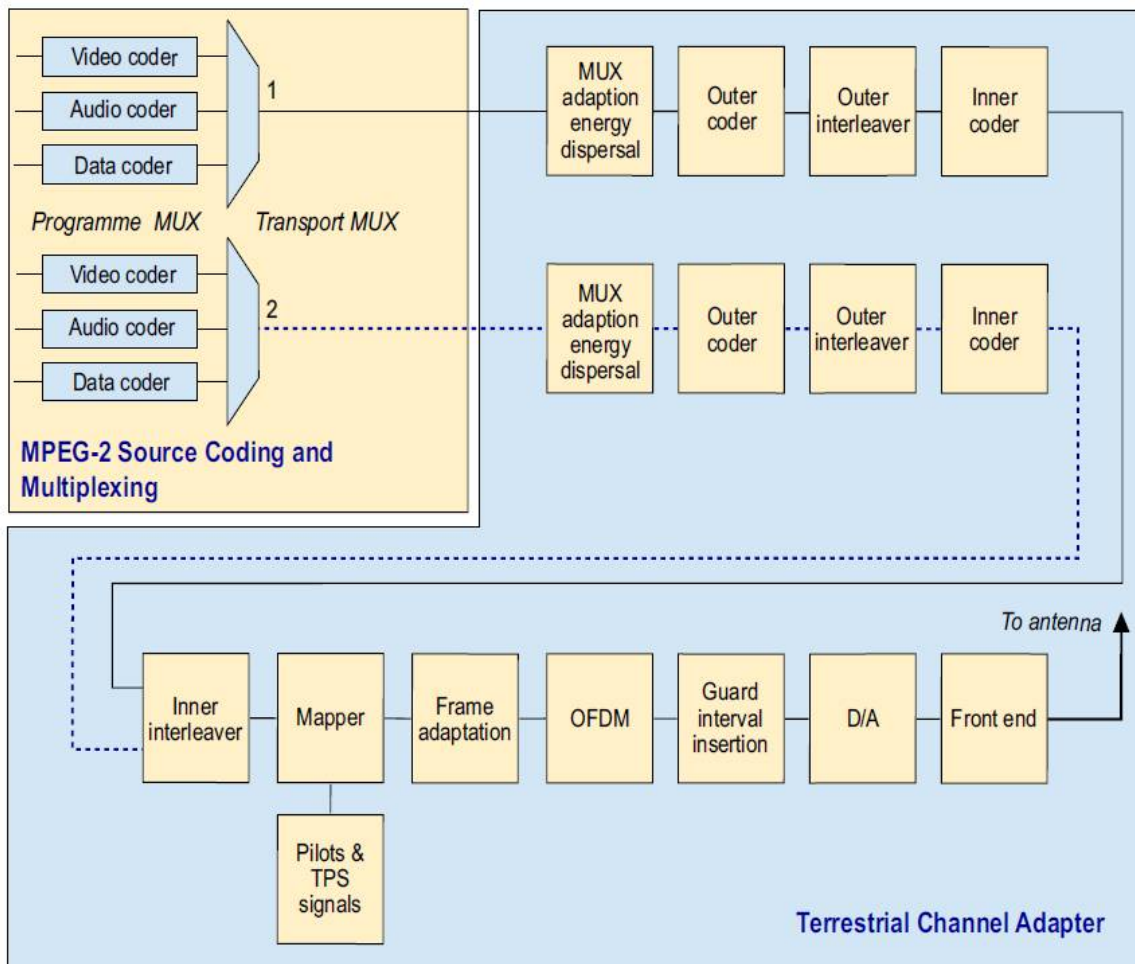


Figure 2  
Block diagram of a DVB-T system with hierarchical modulation

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

69. 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.

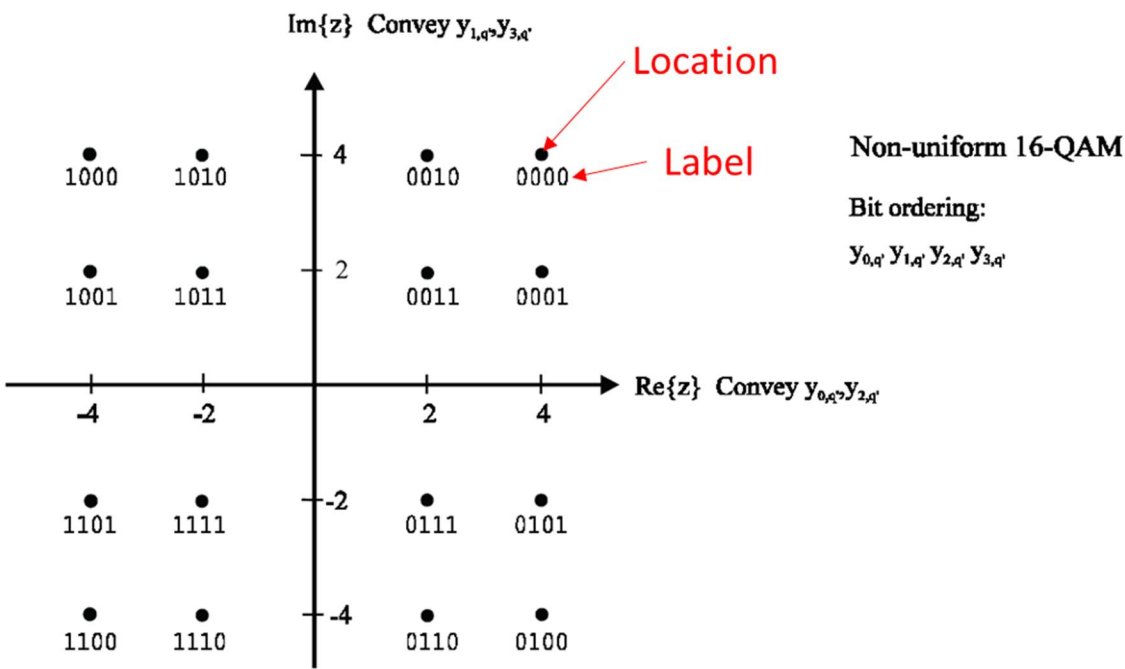
70. As shown in the Figure above, the transmitter includes two completely separate transport streams, which are combined at an inner interleaver prior to transmission. (EX1005 at 10; EX2016 at 3). The receiver similarly is required to

separate the transmission into two data streams. 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.

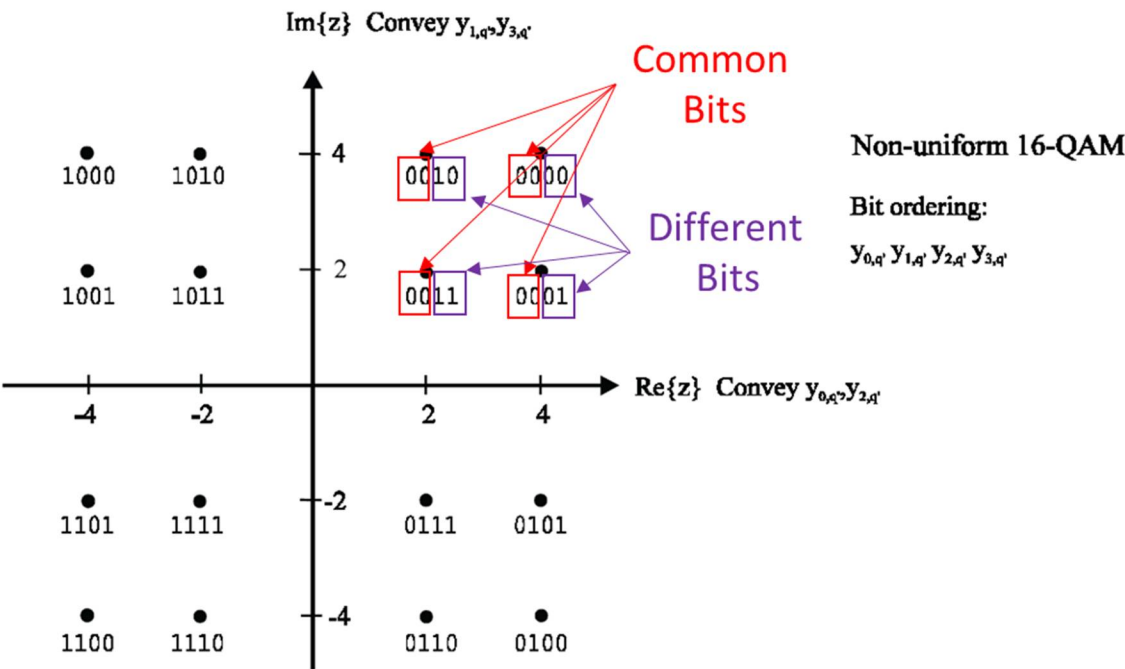
## **2. Hierarchical Modulation Constellations in *DVB-T***

71. 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; 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; 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; EX2016 at 2-4).

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

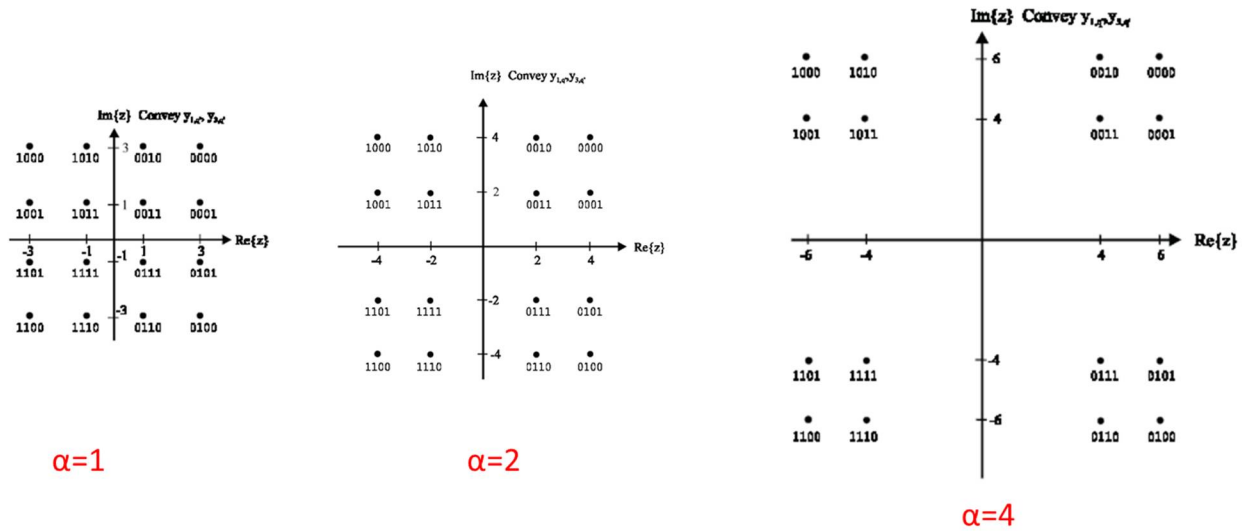


73. All labels within a quadrant share two bits in common, and two bits that are different.



74. 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; 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”. 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”.

75. *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; EX2016 at 4). Each of the three QAM-16 hierarchical constellations are defined by an alpha parameter (“ $\alpha$ ”), which can take a value of 1, 2, or 4. (EX1005 at 9, 21-24; EX2016 at 4). The QAM-16 hierarchical constellations of *DVB-T* are shown below.



76. The alpha parameter represents the spatial distance between neighboring points located in adjoining quadrants. (EX1005 at 9, 21-24, 31; 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; EX2016 at 4). A higher alpha value thus improves the high priority bits resilience to noise. (EX1005 at 9, 21-24; 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; EX2016 at 4). An alpha value of 1 indicates the constellation is a traditional uniformly spaced constellation.

77. Similar constellations are provided for QAM-64, with alpha values of 1, 2, and 4.

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

78. *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; 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; 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; 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. (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.

79. Notably, *DVB-T* allows for choosing the values of these parameters ***without limitation***. 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  $7/8$ ).

80. This flexibility in choosing the values of these parameters is intentional. 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. 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. (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. (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. (EX2016 at 2, 5).

81. 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. Each parameter can be selected to fit the needs of a network. And these

needs can change over time. 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. (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. (EX2016 at 5).

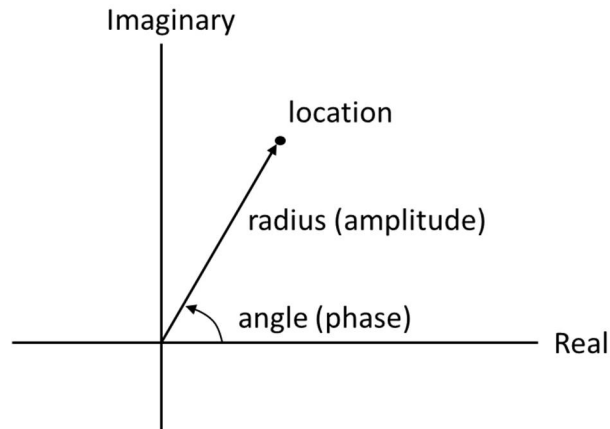
82. In view of these changing needs of a network, there is no clear predefined code rate and constellation pairings that are most efficient for all scenarios. As a result, *DVB-T* advantageously allows for the selection of constellation, alpha value, high priority code rate, and low priority code rate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

### **C. *De Gaudenzi***

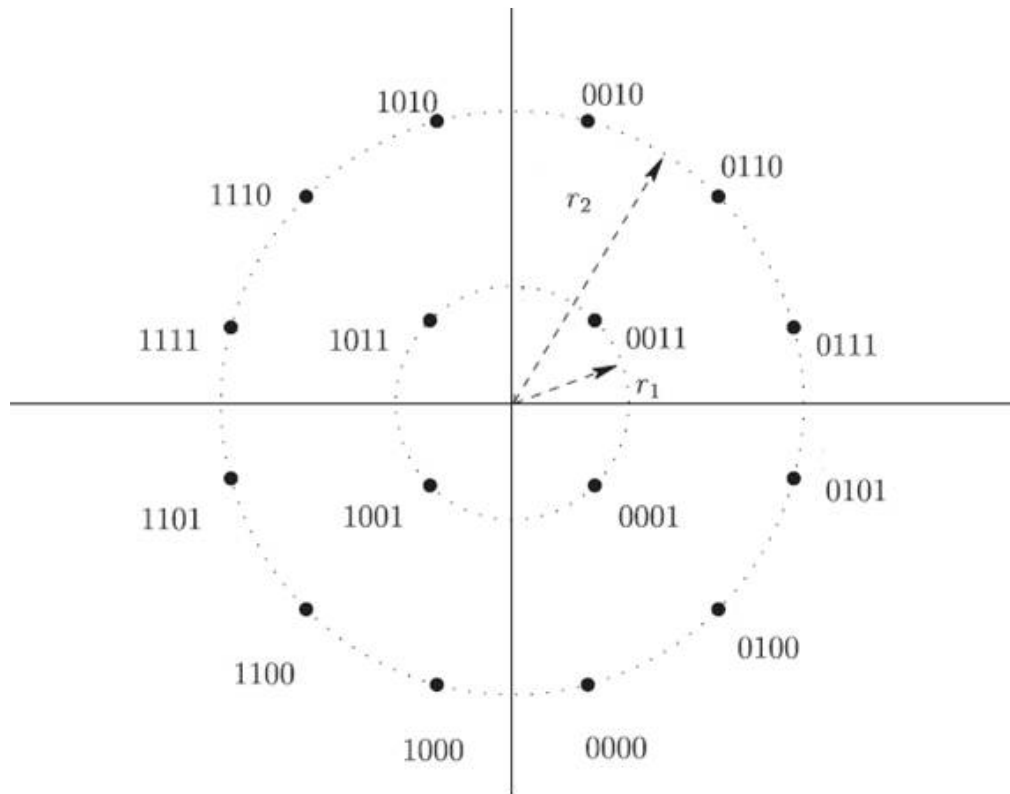
#### **1. *De Gaudenzi* Uses Only APSK Constellations**

83. In a previously discussed illustration of constellations, a constellation point's location was indicated by a single characteristic of the carrier signal, its amplitude. *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). 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).



84. 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. For example, the following figure from *De Gaudenzi* depicts two “rings” of constellation points. 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).



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).

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).

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

85. 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). 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).

86. For example, *De Gaudenzi* puts restrictions on the phase aspect of the constellation point locations. (EX1014 at 4). At each ring/amplitude, *De Gaudenzi* requires that the constellation points be uniformly spaced in phase. (EX1014 at 4-5). 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). 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).

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

87. *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. 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.

88. 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. 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.

89. *De Gaudenzi's* statement regarding the design of digital QAM constellations at page 4 of EX1014 refers generally to APSK's as related to QAM in that APSK's can be represented in the real and imaginary dimensions. 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.

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

90. Not only are *De Gaudenzi's* techniques inapplicable to rectangular QAM modulation, they are also inapplicable to hierarchical modulation.

91. As noted above, *DVB-T* is a hierarchical system in which two data streams are represented by one constellation. (EX1005 at 9, 21-24; 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. 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.

92. 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.

**VIII. Grounds 1A, 2A, 3A, 4A: Claimed “Where Each ... Different Non-Uniform Multidimensional Symbol Constellations Is Only Included In One Of The ... Pairs” Is Not Obvious In View of Eroz and DVB-T**

93. 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.”

94. *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*.

95. But 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.

96. 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.

**A. There is No Clear Highest Efficiency Constellation in a Hierarchical System**

97. 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.

98. 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).

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

99. *DVB-T* is a standard for digital terrestrial television, that is, broadcast television. (EX1005 at 6). 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; 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.

100. 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 ( $\alpha$ ), 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; EX2016 at 4-5). For this reason, the TPS allows for the specification of  $\alpha$ , high priority code rate, and low priority code rate without limitation (e.g., any  $\alpha$ , high priority code rate, and low priority code rate can be used in combination to satisfy changing network requirements). (EX1005 at 9, 31-33).

101. 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. 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. (EX2016 at 5).

**C. Grounds 1B, 2B, 3B, 4B: *De Gaudenzi* Does Not Cure the Deficiencies of Grounds 1A, 2A, 3A, and 4A**

**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***

102. *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). *De Gaudenzi* describes different APSK constellations at different code rates (e.g., Table I). (EX1014 at 11). These code rates are for non-hierarchical systems. *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.

103. 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,  $\alpha$ , 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*.

104. 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). 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.

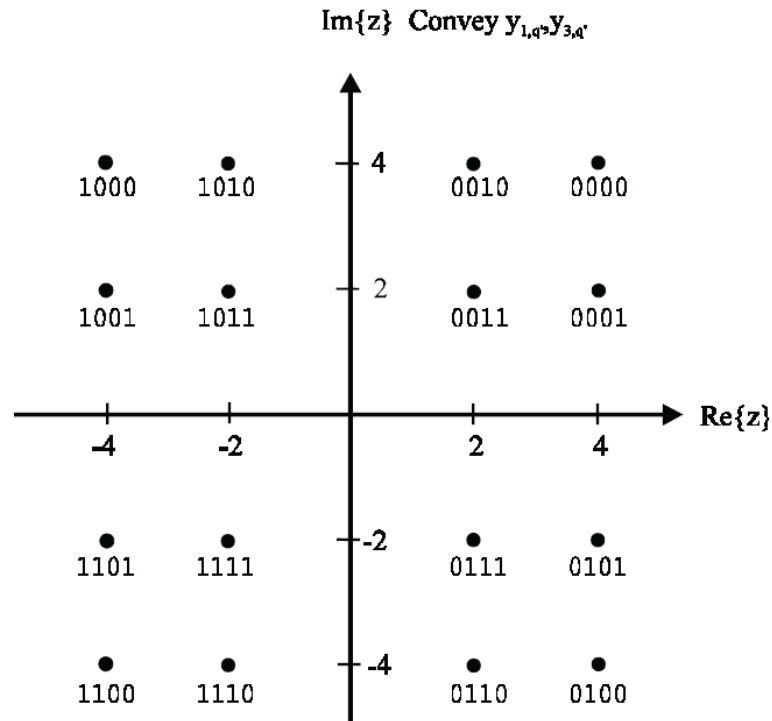
105. Second, *De Gaudenzi* cannot be applied to the hierarchical system of *DVB-T* because the capacity for the high priority data stream and the capacity for the low priority data stream are interrelated. Put differently, in a hierarchical system, one cannot modify the constellation to improve the capacity of one data stream without reducing the capacity of the other data stream. 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.

106. 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*. 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.

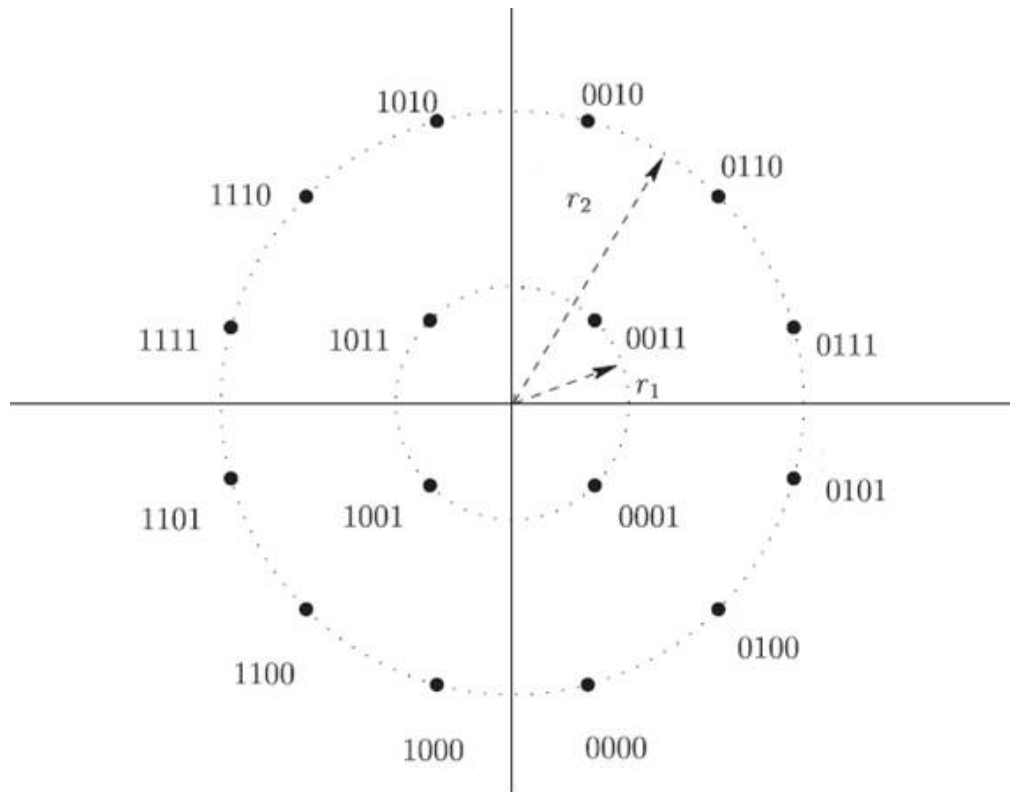
**2. *De Gaudenzi* Gives No Guidance on How to Modify a QAM**

107. 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*.

108. 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. The *DVB-T* QAM-16 constellation with alpha value of 2 is reproduced below.



109. 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.



110. 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).

111. 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. There is no ring ratio to optimize. There is no phase to maintain as uniform. And the Petition

is silent on how these obstacles could be overcome by a person of ordinary skill in the art.

112. 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.

**IX. All Grounds: A Person of Skill In The Art Would Not Want to Combine *Eroz* and *DVB-T***

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

113. 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).

114. 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.

115. *DVB-T*, in contrast, is a complex hierarchical one-to-many (broadcast) communication system. *DVB-T* requires substantially different transmitter and receiver components to support the hierarchical modulation with multiple data streams. Further, each stream must then be processed with separate processing components. 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). No teaching or suggestion of any component comparable to the interleaver or selector is described in *Eroz*.

116. 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. 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."

117. 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.

118. 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*.

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

Dated: April 15, 2023

A handwritten signature in blue ink, appearing to read "Giuseppe Caire", written over a horizontal line.

Dr. Giuseppe Caire