

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. IPR2023-00320
U.S. Patent No. 11,019,509

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

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Cases

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<i>Ariad Pharms., Inc. v. Eli Lilly & Co.</i> , 598 F.3d 1336 (Fed. Cir. 2010).....	<i>passim</i>
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<i>Firstspear, LLC v. Lineweight, LLC</i> , IPR2019-01169, Paper 15, 2019 Pat. App. LEXIS 13455	<i>passim</i>
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<i>Indivior UK Ltd. v. Reddy's Labs. S.A.</i> , 18 F. 4th 1323 (Fed. Cir. 2021)	<i>passim</i>
<i>LG Electronics, Inc v. Constellation Designs, LLC</i> , IPR2023-00229, Paper 2 (PTAB Dec. 8, 2022)	<i>passim</i>

Other Authorities

35 U.S.C. § 103	40
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TABLE OF EXHIBITS

Exhibit	Description
2001	Declaration of Dr. Giuseppe Caire
2002	RESERVED
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	RESERVED
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	RESERVED
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 '509 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 '509 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 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 '509 Patent inventors 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 the impact was wide-spread. The inventions were eventually incorporated into a new standard for satellite digital broadcasting, known as DVB-S2X, resulting in improvements that were reported as “extraordinarily large” by Mustafa Eroç – the same author of the *Eroç* reference relied upon by Petitioner in related IPR2023-00229, also challenging the ‘509 patent. (EX2005 at 353-534).

And Petitioner LG took notice, too. 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 claimed use of a constellation in which the locations and labels have been freely assigned and optimized to maximize parallel decode 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 at least because **none of the relied upon references qualify as prior art.**

The Petition argues that the ‘509 patent does not deserve its priority claim to the ‘777 patent and ‘319 provisional because those documents allegedly lack written description of the challenged claims. However written description can be found in the priority documents at least because:

- The claimed code rate ranges are not only explicitly disclosed, there are sufficient “blaze marks” in the priority applications to identify and differentiate the claimed code rate ranges that provide operating points under which non-uniform constellations provide a benefit, and further differentiate between non-uniform constellations having overlapping points and those that do not;
- There is sufficient written description in the priority applications to show inventors possessed a communication system in which each of the non-uniform constellations used in the system are capable of providing greater parallel decode capacity when operated at an operating SNR than the other non-uniform constellations used in the system at least because the priority documents explicitly disclose systems having multiple constellations, each of which being optimized for at different SNRs, thereby providing greater capacity gains at their respective optimized-for SNR.

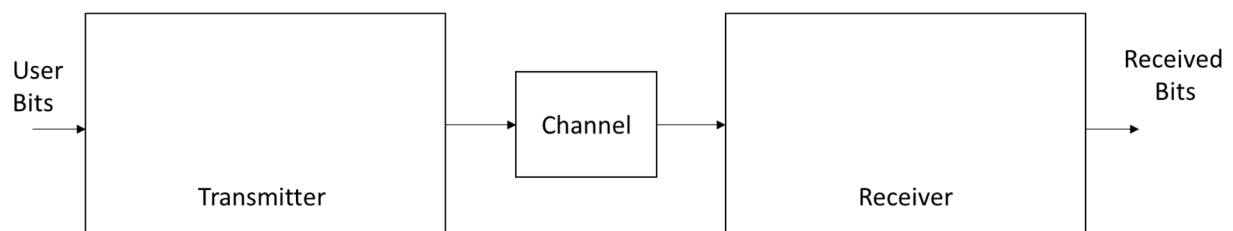
Indeed, unlike the cases which the Petition relies upon, the challenged claims claim exactly what is disclosed in the ‘777 Patent and a person of ordinary skill in the art would understand that the inventors possessed the claimed invention at the time of filing the ‘777 Patent. As a result, none of the references relied upon by each and every ground qualify as prior art, and so 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 Communication System

A digital communication system typically includes a transmitter that sends information to a receiver over a wireless or wired channel. (EX2001 at 6; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).



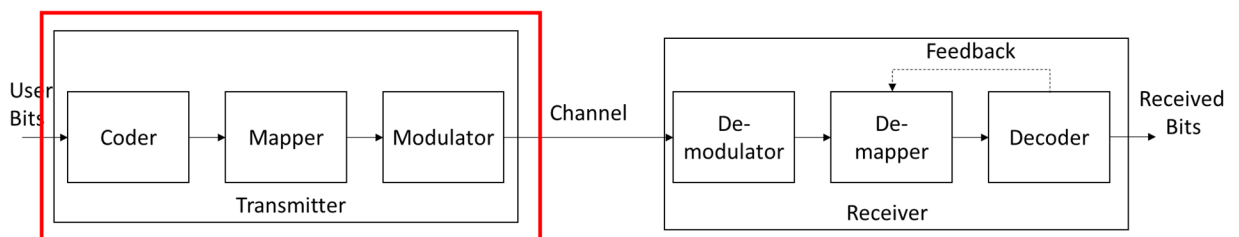
As illustrated in the above overview, information in the form of user bits (sequences of 0s and 1s) is input to the transmitter, which first converts those bits into an electromagnetic signal and then transmits that electromagnetic signal over the channel to the receiver. (EX2001 at 6; EX2003 at 2-4; EX2004 at 1-5, 95, 181-

183, 208-209). As the electromagnetic signal passes through the channel, bits and data can be lost or corrupted; in this manner, the channel introduces “noise” (signal loss) to the transmission. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209). The receiver receives the electromagnetic signal (along with any noise introduced by its passage through the channel) and converts the received signal back into bits. (EX2001 at 7; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

Each digital communication system has a measurable “capacity,” which is the maximum amount of information that the system can reliably send over the channel. (EX2001 at 7; 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 7; 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

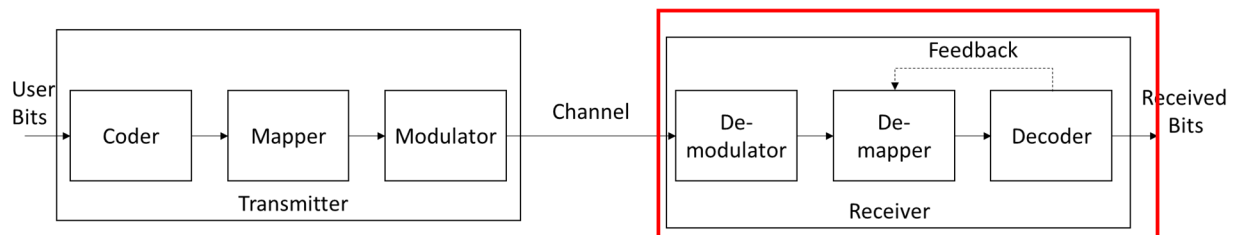
the receiver. (EX2001 at 7; EX2003 at 2-3; EX2004 at 11, 298). For example, the coder may add additional redundant bits to the input user bits that would later enable the receiver's decoder to use error-correcting codes (such as turbo codes or Low Density Parity Check (LDPC) codes) to help detect or recover user bits lost to noise during transmission. (EX2001 at 7-8; EX2003 at 2-3; EX2004 at 11, 298). The amount of expansion in the number of bits from the input user bits to the longer sequence of output bits is referred to as the code rate. (EX2001 at 8). The code rate is a ratio of the relative length of the input user bits to the length of the output bits. (EX2001 at 8). For example, a code rate of $1/2$ indicates that for every bit in the sequence of input user bits, there are 2 bits in the sequence of output bits. (EX2001 at 8). Similarly, a code rate of $3/5$ indicates that for every 3 bits in the sequence of input user bits, there are 5 bits in the sequence of output bits. (EX2001 at 8).

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 8; 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 8).

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 8; EX2003 at 2-3; EX2004 at 181-209). There are numerous different ways for a modulator to apply such information to a carrier signal. (EX2001 at 9; EX2003 at 2-3; EX2004 at 181-209). For example, in a Pulse Amplitude Modulation (PAM), the modulator can modify (modulate) the amplitude of the carrier signal so that the signal's different amplitudes will represent different bit sequences. (EX2001 at 9; 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 9; EX2003 at 2-4; EX2004 at 1-5, 11, 95, 181-183, 208-209).



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

The extracted signal values are then input to the **demapper**, which is used to help identify which bit sequence corresponds to the extracted constellation signal values. (EX2001 at 9; 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 9).

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 9; 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 10).

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 10). As explained below, the former is a constellation point’s “location,” and the latter is its “label.” (EX2001 at 10).

Signal characteristics that may be used as constellation point locations include amplitude, phase, and frequency. (EX2001 at 10; 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 10; 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 10; 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 10-11). 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 11). Where a particular constellation point falls on the spectrum of available values is called its "location." (EX2001 at 11).

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 28). 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 11). The sequence to which a constellation point is assigned is its “label.” (EX2001 at 11).

To complete this simplified example, the following depicts the location and labels for four constellation points. (EX2001 at 11). The first constellation point is located at 0.0 volts and is labeled to “00,” the second is located at .33 volts and is labeled to the “01,” and so on. (EX2001 at 11-12).

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

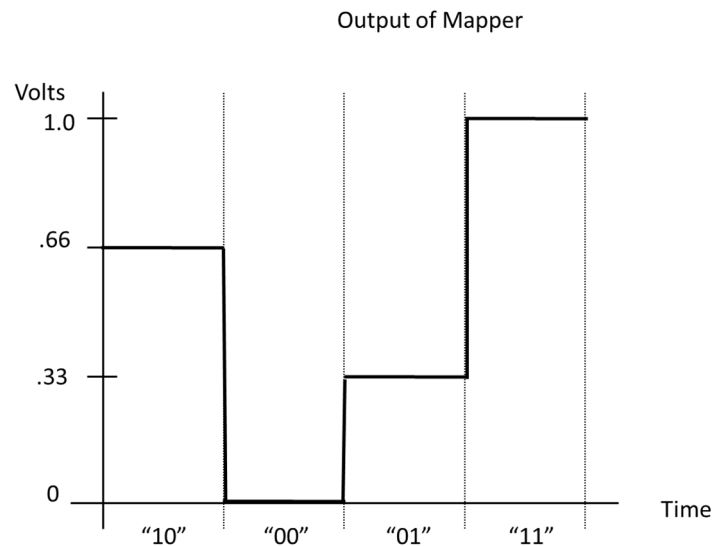
2. The Mapper

The transmitter’s mapper uses these constellation labels and locations to map a bit sequence to a corresponding sequence of constellation points. (EX2001 at 12; 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 12). 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 12).

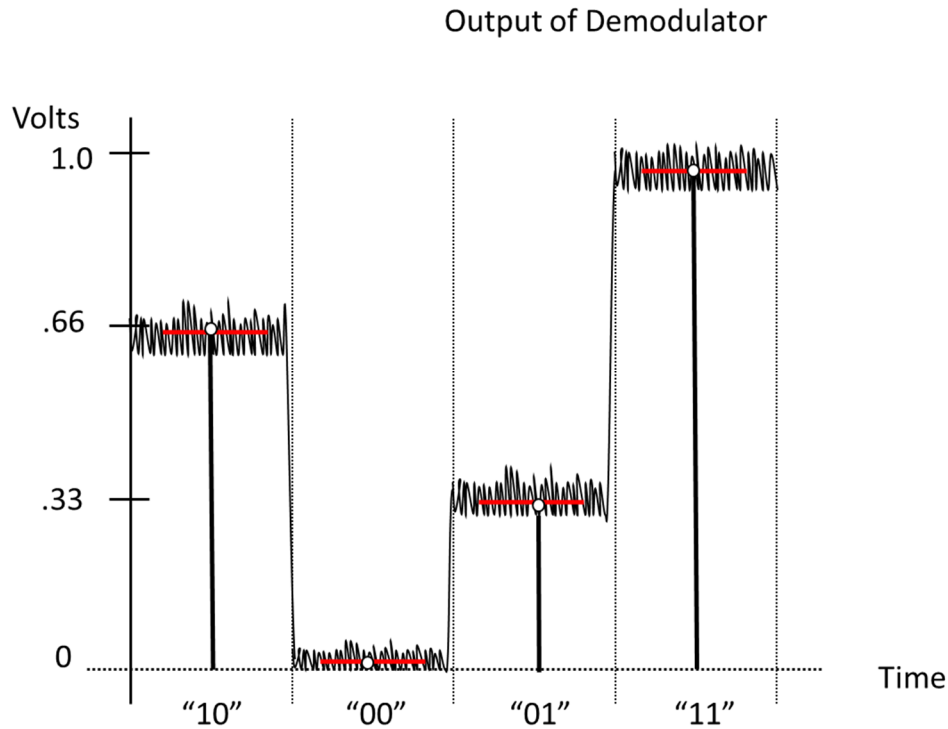
Constellation Label	Constellation Location
"00"	0
"01"	.33
"10"	.66
"11"	1.0

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 12-13). For reference, the transmitted bit sequence is shown for each time slot below the figure. (EX2001 at 13).



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 13; 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 13; 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 14; 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 14; 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 14-15; 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 15). In many implementations, the demapper performs “soft” decisions, that is, outputs probabilities on which bit sequence corresponds to the input signal. (EX2001 at 15).

- if the output of the demodulator is greater than .75, then the bit sequence is “11”. (EX2001 at 15-16).

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 16). Put together, these component bits result in the sequence “10000111.”² (EX2001 at 16).

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.

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.

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

A. The Shannon Channel Capacity Limit

Each digital communication system has a measurable “capacity,” which is the maximum amount of information that the system can reliably send over the channel. (EX2001 at 17; EX2003 at 252; EX2004 at 253-254, 311-312). As detailed in the challenged ’509 Patent, two different ways of measuring capacity are “joint capacity” and “parallel decode capacity.” (EX1001 at 6:42-7:30; 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; 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 20; EX2003 at 252-255, 263-264; EX2004 at 1).

Shannon calculated at this capacity limit by determining the maximum possible efficiency of error correcting methods. (EX2001 at 20; 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 20-21; 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 '509 Patent, no designers were able to even come close.

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

1. Constellation Point Locations That Are Equally Spaced

The '509 Patent's Background explains that the most prevalent (by far) approach at the time of the invention was to locate constellation points with equal spacing between points to maximize the distance between neighboring constellation points. (EX1001 at 1:46-50; *See also, e.g.*, EX1027 at 1:33-37; *See also, e.g.*, EX2001 at 21).

As already discussed and illustrated above, noise is introduced when constellation points are sent from the transmitter to the receiver. (EX2001 at 21; EX2003 at 2-4; EX2004 at 1-5, 95, 181-183, 208-209).

The prevailing wisdom was that if constellation points were located close together (for example, if one constellation point at 0.7 volts and another at 0.6), then there was a greater chance that noise would cause the demapper to mistake one transmit signal value for another, resulting in the wrong bit sequence being selected and output. Thus, to minimize the chances of noise resulting in the demapper erroneously selecting the wrong bits, it was well accepted that constellation points should be spaced equally apart, to maximize the distance between any two neighboring locations. (EX1001 at 1:44-52; *See also, e.g.*, EX1027 at 1:31-39; *See also, e.g.*, EX2001 at 21-22).

Accordingly, most viable systems spread constellation locations evenly over the range of values that the locations could take, putting as much distance between any two points as the range of values allowed, and resulting in equal spacing between constellation points. (EX1001 at 1:44-52, 2:6-17, 7:61-63; *See also, e.g.*, EX1027 at 1:31-39, 1:59-2:3, 7:40-42; *See also, e.g.*, EX2001 at 22). At the time of the invention, such “equally spaced” locations were well accepted as the best approach with no drawbacks to be improved upon. (EX1001 at 1:44-52, 2:6-17,

7:61-63; *See also, e.g.*, EX1027 at 1:31-39, 1:59-2:3, 7:40-42; *See also, e.g.*, EX2001 at 22).

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

IV. The Challenged '509 Patented Invention

But after others tried and failed for 60 years, the '509 Patent inventors succeeded, developing a system and approach that finally closed the gap and achieved capacity approaching the Shannon limit. They did so by going against the conventional wisdom. Instead of trying to improve error-correcting methods used to transmit constellations, they tried to improve the constellations themselves. Instead of keeping constellation points uniformly spaced, they experimented with changing both the locations and labels of the constellations.

The result was revolutionary. The '509 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 when optimizing a constellation with a fixed number of points, at certain code rates and SNRs, a lower number of unique locations may provide an improvement. As a result, the inventors disclosed constellations having overlapping locations, effectively providing optimized constellations at all code rates, even where the optimized constellation had a fewer number of unique locations.

The inventors further 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 an 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 '509 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 1:32-24). A focus of Dr. Jones's NASA work was developing communications

systems and error-correction methods used for deep space robotic probes to Mars, including the Mars Reconnaissance Orbiter, Mars Science Lander, Mars Volatile Evolution Explorer, and the Mars Perseverance Rover.

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

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

Counter-intuitively, they discovered that 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.

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

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

Thus, the '509 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 '509 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 maximize parallel decode capacity; and
- The inventors developed an approach of optimizing for different operating conditions (such as signal to noise ratio, error correcting codes) that allow for reducing the gap to the Shannon limit across a wide variety of conditions.

1. Optimizing Constellation Locations and Labels

The '509 Patent discloses that one way to freely assign constellation point locations and labels is to optimize those locations and labels. (EX1001 at 2:31-35, 2:51-53, 3:7-10, 3:15-17, 3:22-24; *See also, e.g.*, EX1027 at 2:14-20, 2:39-41, 2:59-63, 2:67-3:8; *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 23; EX2008 at 20).

In the optimization approach disclosed in the '509 Patent, the objective function to be optimized can be the system's capacity, such as its parallel decode capacity. (EX1001 at 8:61-62; *See also, e.g.*, EX2001 at 23). 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, 7:8-21; *See also, e.g.*, EX1027 at 2:56-63, 6:56-7:1; *See also, e.g.*, EX2001 at 23).

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.*, EX1027 at 2:56-63; *See also, e.g.*, EX2001 at 23). 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.*, EX1027 at 2:37-41; *See also, e.g.*, EX2001 at 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 3:4-12; *See also, e.g.*, EX1027 at 2:56-63; *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 7:60-8:7; *See also, e.g.*, EX1027 at 7:40:52; *See also, e.g.*, EX2001 at 23-24).

2. Optimized Constellations That Have Overlapping Points

The '509 Patent inventors disclose that when optimizing constellations at different SNR and code rates, if a constellation having fewer locations would provide greater capacity, then the optimization will place points on top of one another. (EX1001 at Figures 13b, 14c; *See also, e.g.*, EX2001 at 24). For example, if optimizing an 8-point PAM, for a given SNR and code rate, a PAM with 4 unique locations or a PAM with 2 unique locations may have better performance. In this instance, rather than using a 4-point PAM or a 2-point PAM, the '509 Patent Inventors describe placing points on top of one another. An example of such an approach is given in figure 13b. Figure 13b provides a table showing different constellation locations that are optimized at different code rates. (EX2001 at 24). Each column represents a different constellation. In the first column of the table of figure 13b, the PAM-8 constellation includes 8 points with a first set of four overlapping points (x_0, x_1, x_2, x_3) and a second set of four overlapping points (x_4, x_5, x_6, x_7). (EX2001 at 24). In other words, there are only two unique locations. In the second column of the table of figure 13b, the PAM-8 constellation includes 8 points with four sets of two overlapping points ($(x_0, x_1), (x_2, x_3), (x_4, x_5), (x_6, x_7)$). (EX2001 at 24).

PAM-8 constellations optimized for parallel decoding capacity at different

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

FIG. 13b

Overlapping points are also illustrated in figure 12c. The locus plot shows that the optimized constellations at target user rate (x-axis) below approximately 0.6 bits per symbol (bps) have only two unique locations (resulting in two sets of four overlapping points), and the optimized constellations between 0.6 bits per symbol (bps) and approximately 1.3 bits per symbol (bps) have only four unique locations (resulting in four sets of two overlapping points). (EX2001 at 25).

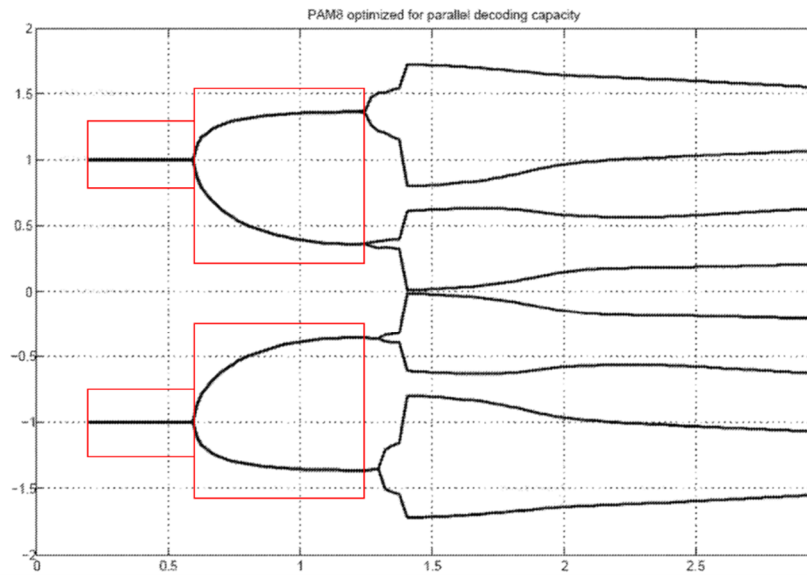


FIG. 12c

3. The '509 Patent Describes Optimizing Single-Dimension and Multi-Dimension Constellations

The '509 patent teaches that both single dimension constellations (such as PAM) and multi-dimension constellations (such as QAM) can be optimized. (EX1001 at 10:8-13; *See also, e.g.*, EX1027 at 9:50-55; *See also, e.g.*, EX2001 at 26). One approach disclosed by the '509 patent for optimizing a multidimensional QAM constellation is to directly optimize over each degree of freedom. (EX1001 at 12:38-48; *See also, e.g.*, EX1027 at 12:39-48; *See also, e.g.*, EX2001 at 26). Another disclosed approach to optimizing a multidimensional QAM constellation is to first optimize a PAM constellation, then apply that PAM constellation to both of the in-phase and quadrature components. (EX2001 at 26). The '509 Patent describes this approach as orthogonalizing the PAM constellation into a second dimension to form

the QAM constellation. (EX1001 at 3:25-34, 12:42-61; *See also, e.g.*, EX1027 at 3:9-19; 12:17-37; *See also, e.g.*, EX2001 at 26-27). This results in a constellation that has a number of points that is equal to the square of the number of PAM points, for example a PAM-8 is orthogonalized to a QAM-64 (8 x 8). (EX1001 at 12:3-6, 67:7-11, 68:1-5; *See also, e.g.*, EX1027 at 3:9-19, 12:11-37; *See also, e.g.*, EX2001 at 27). Further, the QAM-64 includes the same PAM-8 spacing among points in both dimensions, that is, in the in-phase dimension and the quadrature dimension. (EX2001 at 27).

The '509 illustrates an example of this orthogonalizing approach in Figure 21, showing that a PAM-8 constellation optimized for capacity at a user bit rate per dimension of 1.5 bits per second (bps) can be used to construct a QAM-64 constellation. As shown below in annotated Figures 13b and 21, orthogonalizing a capacity optimized PAM-8 includes replicating a full PAM-8 constellation 8 times. (EX1001 at 3:25-34; 12:42-67; *See also, e.g.*, EX1027 at 3:9-19, 12:11-37; *See also, e.g.*, EX2001 at 27).

PAM-8 constellations optimized for parallel decoding capacity at different

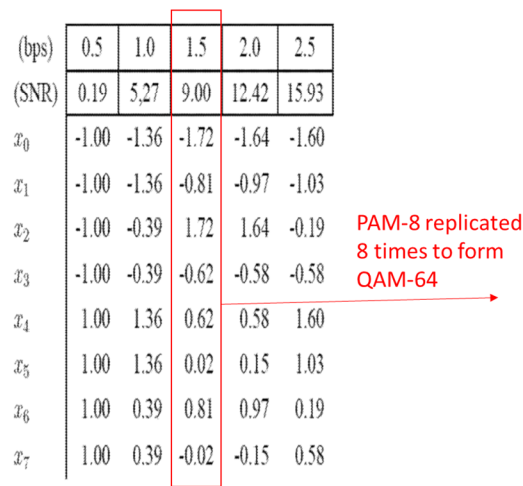


FIG. 13b

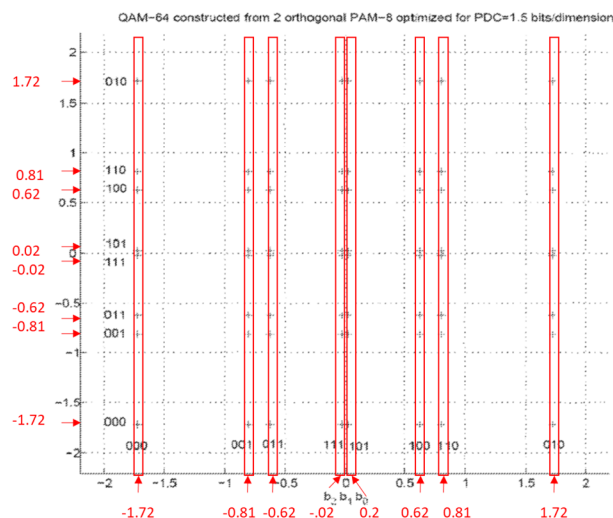


FIG. 21

The resulting combination is similarly spaced in both dimensions (i.e., the in-phase and quadrature). (EX2001 at 28). That is, the spacing of points in both the x and y-axis of Figure 21 are distributed according to the PAM-8 optimized locations. The distribution of the x-axis is highlighted in the above annotated Figure 21. (EX2001 at 28). The distribution of the y-axis is highlighted in the below annotated Figure 21. (EX2001 at 28).

PAM-8 constellations optimized for parallel decoding capacity at different

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

FIG. 13b

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

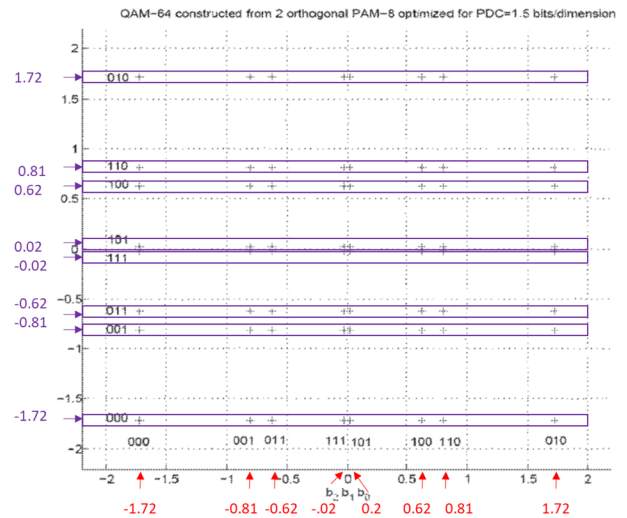


FIG. 21

This approach uses the same 8 point PAM locations, which were optimized for capacity, to produce 64 point QAM locations that have been optimized for capacity. (EX2001 at 29).

4. Non-Uniform Constellations Optimized For Particular Code Rates

The '509 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.*, EX1027 at 4:62-66; *See also, e.g.*, EX2001 at 29). For example, the '509 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 5:16-21; *See also, e.g.*, EX1027 at 4:66-5:7; *See also, e.g.*, EX2001 at 29). 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.*, EX1027 at 4:66-5:7; *See also, e.g.*, EX2001 at 29-30). As an example, a constellation optimized for a code rate of $1/2$ provides gains when with a code rate of $1/2$, but may not provide the same gains at other code rates, such as $2/3$ code rate. (EX2001 at 30). Instead, when using a code rate of $2/3$, a different constellation may be used – a constellation optimized for use at $2/3$ code rate. (EX2001 at 30).

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 30). For example, the '509 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 30). For example, Figures 11b, 13b, 15b and 17b all disclose constellations that are optimized for parallel decode capacity for use at a specific SNR and code rate. Figure 11b is illustrated below. (EX2001 at 30). The table provides the constellation locations (x_0, x_1, x_2, x_3), the corresponding SNR, and the user bit rate (denoted as bps (bits-per-symbol)). (EX2001 at 30). As acknowledged by the Petition, the code rate can be easily determined from the user bit rate. (Petition at 6). The code rate can be determined from a well-known equation relating the number of user bits per

dimension to the code rate and which is described in the '319 Application. (EX1015 at 2; *See also, e.g.,* EX2001 at 30). The equation is given by:

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

where η is the number of user bits per dimension, R is the code rate, M is the number of constellation points, and N_{dim} is the number of signal dimensions. (EX1015 at 2). Rearranging this equation one can compute the code rate (R) as a function of the user bits per dimension as follows:

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

As an example, in order to compute the equivalent code rate for a QAM-16 for the user bits per dimension (η) listed in Figure 11b, we would take the number of dimension (N_{dim}) to be 2, the number of constellation points (M) to be 16, and the user bits per dimension (η), which is listed in figure 11c, as [0.50, 0.75, 1.00, 1.25, 1.50]. (EX2001 at 31). The resulting code rates can easily be computed as [2/8, 3/8, 4/8, 5/8, 6/8]. (EX2001 at 31). Note that similar calculations can be performed for each constellation size (e.g., QAM-64 (from PAM-8), QAM-256 (from PAM-16), QAM-1024 (from PAM-32), etc.). (EX2001 at 31).

The below figure has been annotated with these code rates for a corresponding QAM-16 built by orthogonalizing the PAM-4 optimized constellations. (EX2001 at

31). Each column of the table provides a different, unique constellation. (EX2001 at 31).

PAM-4 constellations optimized for parallel decoding capacity at different

(CR_{QAM16})	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$
(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39

FIG. 11b

Similarly, the '509 Patent discloses a number of locus plots showing the optimized constellations over a broad range of code rates. (EX2001 at 32). These locus plots include Figures 10c, 12c, 14c, and 16c. In these locus plots, the y-axis represents the constellation point location and the x-axis represents the target data rate in bits per second (bps), from which the code rate can be determined. (EX2001 at 32). Thus each vertical "slice" of a locus plot represents a different optimized

constellation. (EX2001 at 32). An annotated Figure 10c and 11b are shown below illustrating that each vertical slice of the locus plot (figure 10c) is a different optimized constellation. (EX2001 at 32).

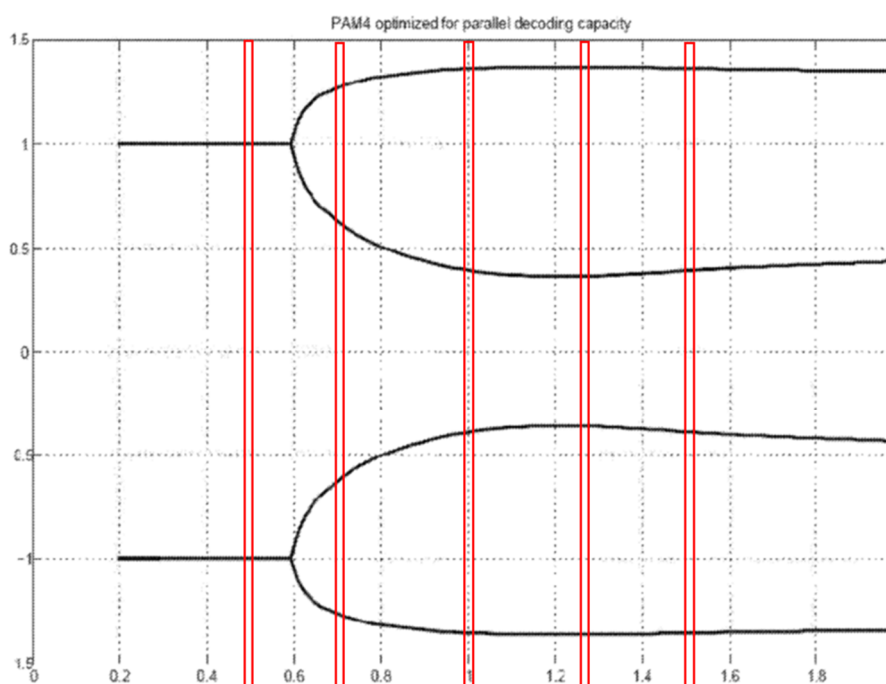


FIG. 10c

(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39

FIG. 11b

Thus, the '509 Patent discloses not only a number of discrete examples of optimized constellations in the tables of figures 11b, 13b, 15b, and 17b, but the '509

patent discloses optimized constellations over a broad range of code rates in the locus plots of figures 10c, 12c, 14c, and 16c. (EX2001 at 33).

5. 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 '509 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.*, EX1027 at 4:47-62; *See also, e.g.*, EX2001 at 34). As an example, the '509 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 11:45-12:11; *See also, e.g.*, EX1027 at 11:22-49; *See also, e.g.*, EX2001 at 34). 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 10:48-51; *See also, e.g.*, EX1027 at 9:63-65; *See also, e.g.*, EX2001 at 34).

To illustrate this concept, an annotated Figure 10c is provided below. The x-axis has been annotated to show the code rates for a QAM-16 built by orthogonalizing the PAM-4 constellations shown in Figure 10c. (EX2001 at 34). As

an example, a system utilizing multiple optimized constellations for different code rates can initialize at an operating code rate of $4/10$, at which point the communication system can utilize the constellation point locations indicated in the locus plot at the $4/10$ code rate (0.8 bps, indicated by the first vertical “slice”). (EX2001 at 34-35). In the example, if the system then changes to a code rate operating point of $6/10$, the system can utilize the constellation point locations indicated in the locus plot at the $6/10$ code rate (1.2 bps, indicated by the second vertical “slice”). (EX2001 at 35). Using this technique, the ’509 patent teaches that a system can adapt to any desired code rate (e.g., based on changing channel conditions, target user rate) and utilize the disclosed optimized constellation according to its respective code rate. (EX2001 at 35).

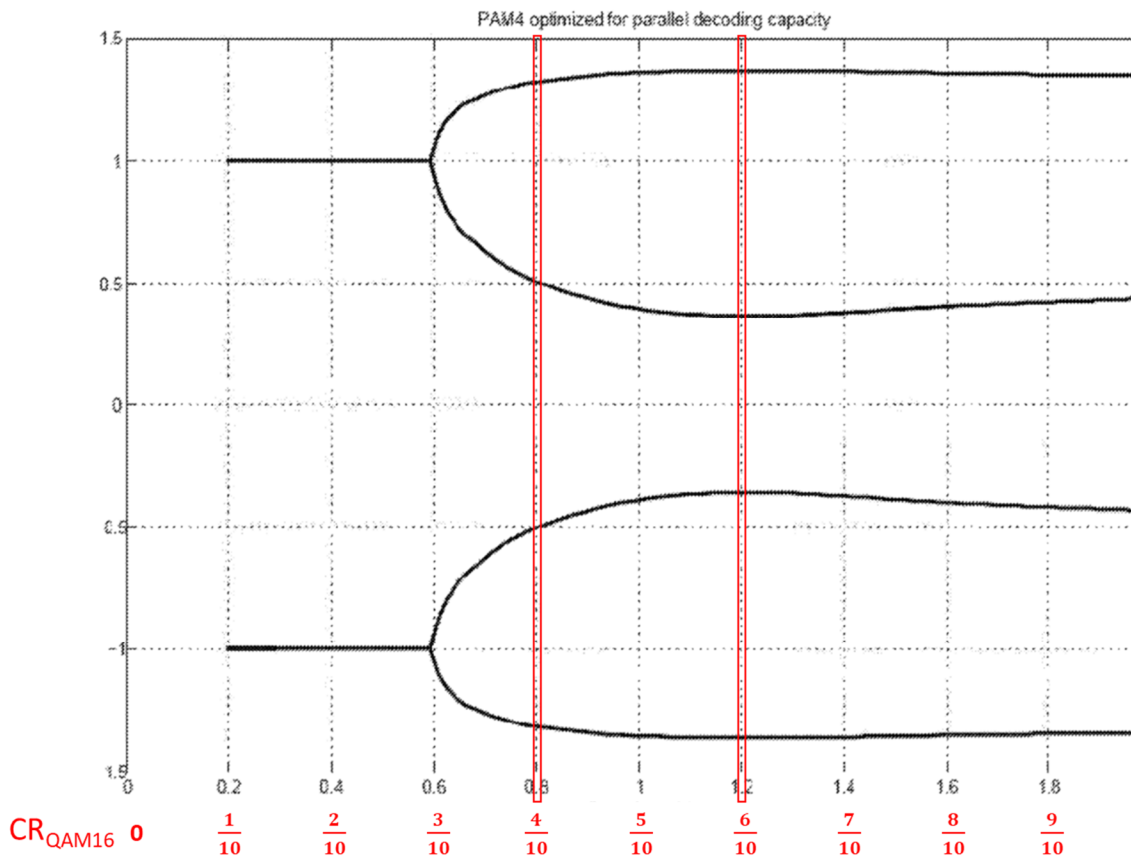
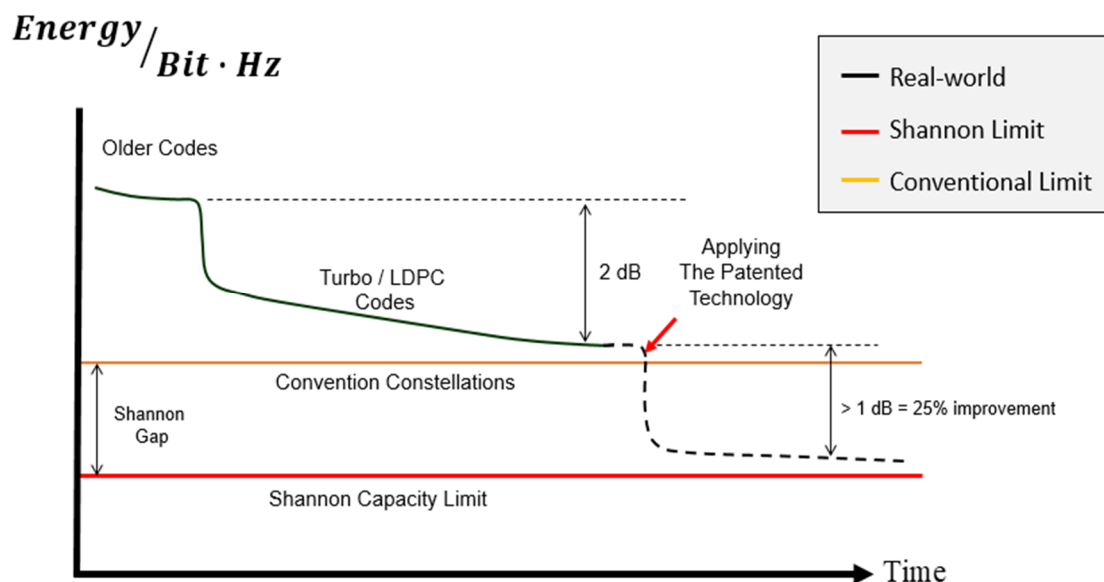


FIG. 10c

C. The Revolutionary Results

The inventor's unusual approach of freely assigning labels and locations in order to optimize capacity produced spectacular results. And when freely assigning locations and labels specifically to optimize parallel decode capacity, the results were even more spectacular—capacity increased so much that the holy grail, the Shannon capacity limit, was approached. (EX1001 at 1:55-56, 2:21-25; *See also, e.g.*, EX1027 at 1:42-43, 2:7-10).

As reported in the '509 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; 2:21-27; *See also, e.g.*, EX1027 at 1:42-43, 2:7-10). But as shown in '509 Patent Figure 8a, when the '509 Patent techniques were applied to freely assign constellation locations and labels to maximize 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; 2:21-28, 10:11-40; *See also, e.g.*, EX1015 at 1:42-43, 2:7-12; 9:57-10:18). 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 the *Eroç* reference relied upon by Petitioner in related IPR20203-00229 – 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 require an LDPC code and a constellation having constellation points at a plurality of unique locations that are unequally spaced and the locations of at least two of the constellation points are the same.

For example, each of these limitations is 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 symbol constellation that includes constellation points at a plurality of unique point locations,*** where:

the plurality of unique point locations are unequally spaced;

the constellation points each have a location and a different label; and

the locations of at least two of the constellation points are the same; 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.***

V. The Petition Hinges on Petitioner's Assertion that Challenged Claims Are Not Entitled to Priority to the '777 Patent

LG's Petition asserts the following Grounds:

Ground	References	Basis	Challenged Claims
1	'777 Patent and ATSC327	§ 103	3-7, 13-17, 24-28

Each and every ground is premised on LG's assertion that the challenged claims are not entitled to the priority date of US Provisional application No. 60/933,319 ("319 Provisional" or EX1015) nor the priority date of US Patent 7,978,777 ("777 Patent" or EX1027). But as explained below, at least the '777 Patent provides sufficient written description support for the challenged claims such that the challenged claims are entitled to at least a priority date of the '777 Patent filing date.³ As a result, the Petition lacks a reasonable likelihood of success at least because the '777 Patent, upon which all grounds rely, does not qualify as prior art.

VI. Challenged Claims Are Entitled to Priority of at Least the '777 Priority Application Because the '777 Priority Application Has Sufficient Written Description to Show the Inventors Possessed The Claimed Invention At the Time of the '777 Priority Application Filing

The '777 Patent provides sufficient written description disclosure of the claimed code rate ranges because the '777 Patent:

- (1) explicitly and specifically highlights the code rate values and associated constellation locations for the end-points of each of the claimed ranges;
- (2) provides support for each and every value within the range; and

³ Constellation Designs does not concede that the challenged claims are not entitled to the priority date of the '319 Provisional. However, given that all grounds rely upon the '777 Patent, Constellation Designs need only show that the challenged claims are entitled to priority to the '777 Patent.

(3) makes clear that using non-uniform constellations at the claimed code rate ranges are desirable and provide a benefit.

Further, the '777 Patent provides sufficient written description disclosure that each of the plurality of unequally spaced constellations is capable of providing greater capacity when operated at a symbol constellation operating SNR than the other constellations when operated at the same SNR – reflecting the disclosed techniques providing optimized non-uniform constellations that provide greater capacity at a respective operating SNR than other non-uniform constellations at that respective operating SNR.

A. Challenged Claims 3-5, 13-15, and 24-26 Are Entitled to Priority to the '777 Priority Application Because It Provides Written Description for the Claimed Code Rate Ranges

Petitioner asserts that the '777 Patent lacks written description support for the code rate ranges claimed in the '509 Patent. (Petition at 3-14). Appearing to concede that the '777 Patent discloses constellation and code rate pairs within the claimed ranges, Petitioner instead argues that applicant disclosed too much, (*e.g.*, a “forest”) and is now trying to claim a discrete “tree.” This is simply incorrect. Instead of disclosing a forest, the '777 Patent provides targeted examples of constellations across code rate ranges that directly correspond to the claimed ranges in the '509 Patent. (*See* EX1027, 10:25-11:13, Figs. 10a-17b). Accordingly, the disclosure of the '777 Patent “clearly allow[s] persons of ordinary skill in the art to recognize that

[the inventor] invented what is claimed.” *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010).

“To satisfy the written description requirement the patent disclosure must ‘reasonably convey[] to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.’” *Vanda Pharms. Inc. v. West-Ward Pharms. Int’l Ltd.*, 887 F.3d 1117, 1136 (Fed. Cir. 2018) (quoting *Ariad*, 598 F.3d at 1351). Where, for example, a patent discloses half a million chemical compounds but claims only a single compound, the specification must contain “blaze marks” directing a POSITA to the single, claimed compound. *See Purdue Pharma L.P. v. Faulding Inc.*, 230 F.3d 1320, 1326 (Fed. Cir. 2000) (citing *In re Ruschig*, 379 F.2d 990 (C.C.P.A. 1967)).

However, claiming a subset of a disclosed range of features does not compel a finding of a lack of written description and does not lead to a conclusion that the patentee disclosed a “forest” and claims only a “tree.” *See Vanda Pharms. Inc. v. West-Ward Pharms. Int’l Ltd.*, 887 F.3d 1117, 1137 (Fed. Cir. 2018); *Scriptpro, LLC v. Innovation Assocs., Inc.*, 762 F.3d 1355, 1359 (Fed. Cir. 2014) (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). Further, courts often find written description support through information taken from a subset of tables and discrete portions of the specification. *See Nalpropion Pharms., Inc. v. Actavis Labs. FL, Inc.*, 934 F.3d

1344, 1350 (Fed. Cir. 2019) (looking to a subset of tables and discrete places in the specification and stating that “[i]t is not necessary that the exact terms of a claim be used *in haec verba* in the specification, and equivalent language may be sufficient.”); *Vanda Pharms. Inc. v. West-Ward Pharms. Int’l Ltd.*, 887 F.3d 1117, 1136-37.

Here, the ’509 Patent does not claim a “tree,” the ’777 Patent does not disclose a “forest,” and the specification provides far more than blaze marks. The ’777 Patent specification provides beacons—targeted examples of constellations across code rate ranges that directly correspond to the claimed ranges in the ’509 Patent. Focusing on the challenged claims, they cover communications systems ***including*** pluralities of unequally spaced symbol constellations of two types: a first type where at least two constellation points share the same location and a second type where no two constellation points share the same location. (*See, e.g.*, EX1001, Claims 1-5). One set of challenged claims cover features of the first type, and another set of challenged claims cover features of the second type.

Importantly, the specification clearly discloses both types of unequally spaced symbol constellations and instructs a POSTA as to when to use each type of non-uniform constellation. The ’509 Patent includes design tables and locus plots for a plurality of constellations at various bit rates, which correspond to code rates. (*See* EX1027, 10:25-11:13, Figs. 10a-17b). For example, for PAM-16 constellations (which orthogonalize to QAM-256, as discussed below), Table 15b discloses a

plurality of first type constellations starting at a code rate of 5/8 and below and discloses a plurality of second type constellations at code rates ranging from 6/8 to 7/8.

PAM-16 constellations optimized for parallel decoding capacity at different

CR_{QAM256}	First Type			Second Type	
	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$
(bps)	1.5	2.0	2.5	3.0	3.5
(SNR)	9.00	12.25	15.42	18.72	22.13
x_0	-1.72	-1.98	-1.89	-1.84	-1.75
x_1	-1.72	-1.29	-1.36	-1.42	-1.42
x_2	-0.81	1.94	1.89	1.84	1.75
x_3	-0.81	-1.17	-1.14	-1.11	-1.15
x_4	1.72	-0.38	-0.35	-0.40	-0.47
x_5	1.72	-0.65	-0.70	-0.65	-0.68
x_6	-0.62	-0.38	-0.34	-0.29	-0.28
x_7	-0.62	-0.68	-0.76	-0.83	-0.90
x_8	0.62	1.09	1.13	1.11	1.15
x_9	0.62	0.76	0.76	0.84	0.90
x_{10}	0.02	1.26	1.35	1.42	1.42
x_{11}	0.02	0.76	0.70	0.65	0.68
x_{12}	0.81	0.06	0.00	0.05	0.09
x_{13}	0.81	0.29	0.34	0.29	0.28
x_{14}	-0.02	0.06	0.00	-0.05	-0.09
x_{15}	-0.02	0.29	0.35	0.40	0.47

FIG. 15b

The corresponding locus plot, Fig. 14c, discloses the full range of values between Figure 15b's 3/8 and 7/8 code rate slices. *See id.* at Fig. 15b. Thus, viewing Figs. 10a-17b, a POSITA would have immediately recognized that the specification discloses two types of unequally spaced constellations across the entirety of the disclosed ranges and when to use each type of constellation.

Further to this point, a POSITA also would have understood the relationship between the '777 Patent's disclosure of PAM constellations, QAM constellations, and the challenged claims' discussion of 16, 64, 256, and 1024 point constellations. (See EX1001, Claims 3-5, 13-15, 24-26). The '777 Patent highlights QAM constellations and explains that they are "attractive in many applications because they have low-complexity demappers." EX1027, 12:11-16 (under heading "Geometrically Shaped QAM Constellations"). The specification further explains that a QAM constellation for a given bit rate can be constructed from a PAM constellation at that bit rate by "orthogonalizing" the PAM constellation. *See id.* at 12:11-37 (constructing a QAM-64 constellation by orthogonalizing a PAM-8 constellation and noting "Due to the orthogonality of the in-phase and quadrature components the capacity characteristics [(e.g., bit rate)] of the resulting QAM-64 constellation are identical to that of the PAM-8 constellation on a per-dimension basis."). As explained above, orthogonalizing a PAM constellation into a QAM constellation would have been well within the knowledge and abilities of a POSITA. (EX2001 at 40). Therefore, the '777 patent teaches that QAM constellations are desirable and straightforward to construct using PAM constellations.

In view of that teaching, to further understand the scope of the disclosed QAM constellations, a POSITA would look to the specification's examples of PAM constellations. (EX1027, 10:25-11:13 (under heading "Capacity Optimized Pam

Constellations”)). In that section, the ‘777 patent discloses locus plots and corresponding design tables for PAM constellations across a **range** of **bit rates** and SNR values. (*Id.*; *see also id.* at Figs. 10a-17b). Further, this section explains that the disclosed **bit rates** are easily converted to **code rates** and provides examples of that conversion. (*Id.* at 10:51-62 (converting bit rates to code rates for PAM constellations and providing formulae for those conversions)). As explained above, this bit rate to code rate conversion was routine. (EX2001 at 41). Further, a POSITA would have understood that the code rates and SNRs for the corresponding QAM constellation are the same. (EX1027, 12:11-37; *See also, e.g.*, EX2001 at 41).

Petitioner’s assertion to the contrary, and purported expert testimony in support, are unsupported. *See* Petition, 12-13 (citing LGE1003, ¶[81])). Petitioner cites an IEEE paper that allegedly supports its assertion that “a POSITA would have understood that the capacities, coding rates, and SNRs for one-dimensional (PAM) and corresponding two-dimensional constellations are not the same” but fails to include that paper as an exhibit. *Id.* Worse, Petitioner’s expert makes no mention of the IEEE paper and merely parrots the language of the petition. *See* LGE1003, ¶[81]. This conclusory and unsupported testimony should be disregarded. *See* 37 CFR § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”); *Nobel Biocare Servs. AG v. Intradent USA, Inc.*, 903 F.3d 1365, 1382 (Fed. Cir. 2018) (explaining that

the Board can reject arguments based on expert testimony that lacks specificity or detail); *Firstspear, LLC v. Lineweight, LLC*, IPR2019-01169, Paper 15, 2019 Pat. App. LEXIS 13455, at *15-16 (“This testimony merely repeats the Petition's assertion and is a conclusory statement not supported sufficiently by objective evidence or analysis. For this reason, we do not credit the testimony of Dr. Palmer on this issue.”).

Thus, a POSITA would understand that the specification discloses code rate data for four types of PAM constellations: PAM-4,8,16,32. *See id.* at 10:25-11:13. Importantly, these four PAM constellations orthogonalize to the four types of claimed constellations (QAM-**16,64,256,1024** correspond to PAM-4xPAM-4, PAM-8xPam-8, PAM-16xPAM-16, PAM-32xPAM-32). (*See id.* at 12:11-37; EX1001, Claims 3-5, 13-15, 24-26 (claiming 16, 64, 256, 1024 point constellations)). So, for each type of claimed constellation, a POSITA would simply reference the relevant PAM data to understand the scope of the disclosure of code rates. For example, a POSITA would look to Figures 14a-d and 15a-b, the design tables and locus plots for PAM-16, to understand the scope of the disclosure of code rates for 256 point constellations. As discussed above, the design tables list PAM-16 constellation designs for code rates of 3/8, 4/8, 5/8, 6/8, 7/8. (*See* EX1027 at Fig. 15b). These disclose and correspond to the claimed ranges for the first and second types of the claimed 256 point constellations. (*See* EX1001 at Claims 3-5, 13-15,

24-26). Turning to the corresponding locus plots, those figures show constellation point locations across a ***continuous range*** of code rates that encompasses the code rate values from the design tables. (See EX1027 at Fig. 14c).

This disclosure of a range of code rates is squarely in line with the specification's disclosure of "Adaptive Rate Design" embodiments. That section discloses a system capable of switching to alternate constellation and code rate pairs. (EX1027 at 11:66-12:10). In other words, "[i]n a number of embodiments, the communication systems can adapt location of points in a constellation in response to channel conditions, changes in code rate and/or to change the target user data rate"—the communication systems are able to operate across a range of code rates to provide a specific constellation optimized for each code rate in that range. (EX1027 at 5:7-11). Accordingly, the '777 Patent provides support for each and every value within the range and specifically highlights the values at the end-points of the claimed ranges.

Unlike this explicit and comprehensive disclosure of the challenged limitations, Petitioner relies on cases involving far less explicit (or nonexistent) disclosures. Petitioner primarily relies on *Purdue Pharma* to challenge the priority date of the '509 patent. See Petition at 3, 10-11. In *Purdue Pharma*, the specification failed to identify the claimed pharmacokinetic parameter, $C_{max}/C[24]$. *Purdue Pharma L.P. v. Faulding Inc.*, 230 F.3d 1320, 1326-27 (Fed. Cir. 2000) ("Although

the examples provide the data from which one can piece together the $C_{max}/C[24]$ limitation, neither the text accompanying the examples, nor the data, nor anything else in the specification in any way emphasizes the $C_{max}/C[24]$ ratio.”).

This would be equivalent to the ’777 Patent failing to disclose code rates as a feature of the invention, but the ’777 Patent is replete with disclosures that the code rate is a key aspects of the invention. *See, e.g.*, EX1027, 5:4-11 (“Processes for selecting capacity optimized constellations to achieve increased coding gains based upon a specific **coding rate** in accordance with embodiments of the invention are described below. In a number of embodiments, the communication systems can adapt location of points in a constellation in response to channel conditions, changes in **code rate** and/or to change the target user data rate.”) (emphasis added).

Further, not only did the specification in *Purdue Pharma* fail to identify the $C_{max}/C[24]$ ratio as a feature of the invention, it also failed to disclose the claimed value—truly claiming a “tree” in the specification’s “forest.” *See Purdue Pharma*, 230 F.3d at 1324-26 (rejecting patentee’s argument that “the phrase ‘formulations which do not exhibit a substantially flat serum Concentration curve’ refers to the [claimed] $C_{max}/C[24]$ ratio of more than two”). Once again, as discussed above, the specification and figures of the ’777 Patent emphasize the specific code rate values that bound the claimed ranges and provide support for every value within those ranges. *Purdue Pharma* involved a far different factual scenario and is inapplicable.

Indivior UK Ltd. v. Reddy's Labs. S.A. is similarly inapplicable. There, the challenged claims included ranges of “about 40 wt % to about 60 wt %” and about “48.2 wt % to about 58.6 wt %” polymer. 18 F.4th 1323, 1325-26 (Fed. Cir. 2021). To support these ranges, the patentee cited two of several example compositions in the specification. *Id.* at 1326-29. For those two compositions, a POSITA could calculate one example composition comprising 48.2 wt % polymer and a second example comprising 58.6 wt % polymer. *Id.* However, this disclosure was not sufficient to provide written description support for the claimed ranges. *Id.* First, for the 40 wt % to about 60 wt % range, the end points of the range were not stated anywhere in the application. *Id.* Second, the examples only provided values that were “specific particular examples” of compositions. *Id.* (“Here, one must select several components, add up the individual values, determine the aggregate percentages, and then couple those aggregate percentages with other examples in the ’571 application to create an otherwise unstated range. That is not a written description of the claimed range.”).

However, as discussed above, the ’777 Patent explicitly discloses the end points of the claimed ranges and provides support for every value within those ranges. Thus, unlike the patent in *Indivior*, the ’777 patent does not merely disclose isolated examples of the end points. Further to this point, below is specific support for each code rate range limitation.

1. **Claims 3, 13, 24: The '777 Patent Provides Written Description for A QAM Constellation having Overlapping Points and the Claimed Code Rate Ranges**

a. ***The '777 Patent Provides Written Description for a QAM-64 having overlapping points and a code rate that is below 1/3***

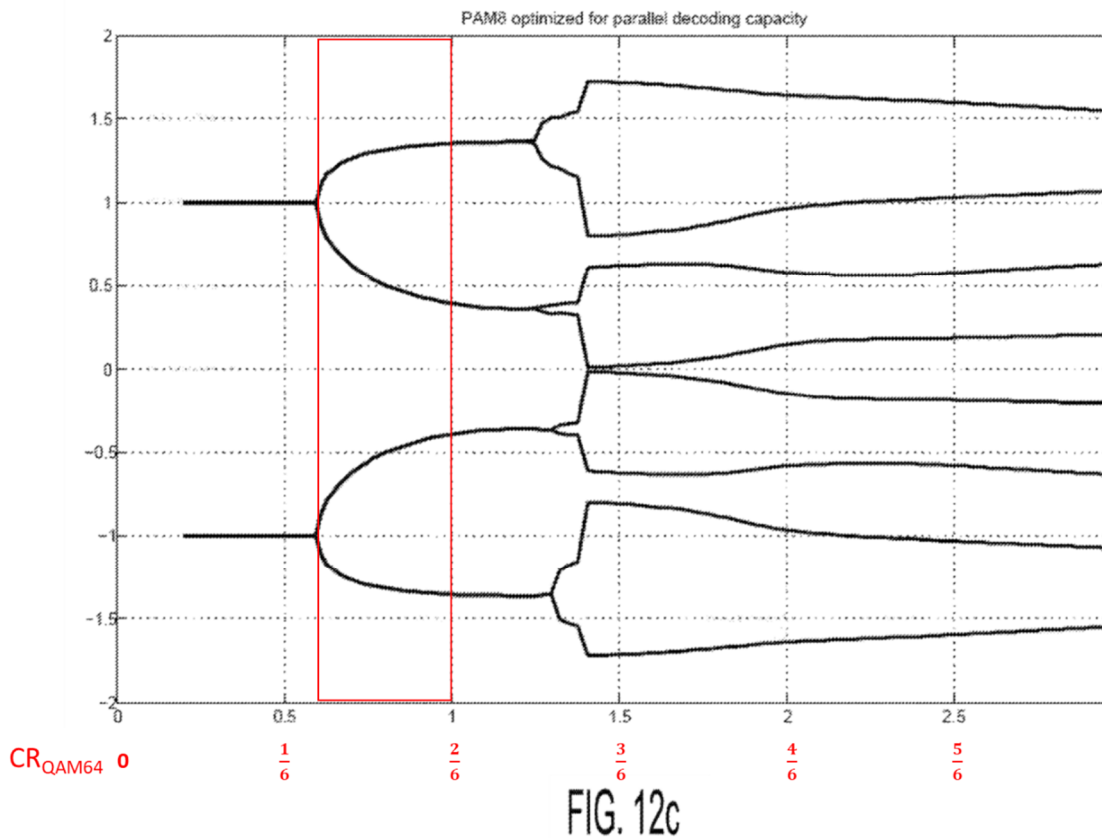
Petitioner challenges the “code rate below $1/3$ and a sixty-four-point unequally spaced symbol constellation of the first type” limitation in claims 3-4, 13-14, and 24-25 of the '509 Patent. (Petition at 4). The '777 Patent provides support for this range: it describes optimized PAM-8 constellations for code rates ranging from $1/6$ to $5/6$, and PAM-8 orthogonalizes to QAM-16. Further, in the same disclosure, the '777 Patent demonstrates that below a code rate of $2/6$ ($1/3$), but above $1/6$, the constellations are of the “first type”—that is, having at least two constellation points share the same location. Figure 13b below shows the disclosed PAM-8 constellations and has been annotated to show the code rates for a QAM-16, which is easily determined from the bit rate (bps). This figure has been further annotated to identify the explicit disclosure of the range, including the $2/6$ ($1/3$) end point with overlapping constellation points.

PAM-8 constellations optimized for parallel decoding capacity at different

(CR_{QAM64})	$\frac{1}{6}$	$\frac{2}{6}$	$\frac{3}{6}$	$\frac{4}{6}$	$\frac{5}{6}$
(bps)	0.5	1.0	1.5	2.0	2.5
(SNR)	0.19	5.27	9.00	12.42	15.93
x_0	-1.00	-1.36	-1.72	-1.64	-1.60
x_1	-1.00	-1.36	-0.81	-0.97	-1.03
x_2	-1.00	-0.39	1.72	1.64	-0.19
x_3	-1.00	-0.39	-0.62	-0.58	-0.58
x_4	1.00	1.36	0.62	0.58	1.60
x_5	1.00	1.36	0.02	0.15	1.03
x_6	1.00	0.39	0.81	0.97	0.19
x_7	1.00	0.39	-0.02	-0.15	0.58

FIG. 13b

Taken together with Figure 12c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a first type constellation for below a code rate of $1/3$ but above the $1/6$ code rate where the constellation is uniformly spaced. In addition to the disclosure in Figure 13b, Figure 12c below is a locus plot for the PAM-8 constellations. Figure 12c has been annotated to show the code rates for a QAM-64 constellation and to demonstrate the claimed range. Figure 12c thus discloses constellations for every code rate in the claimed range.



Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 12c and 13b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 13b. The claimed code rate of $1/3$ is expressly identified in the table as being associated with the only “first type” constellation, and the code rates excluded from the claimed range cover uniformly spaced constellations and “second type” constellations. *See Ex. 1027 at Fig. 13b.*

Importantly, the object of the invention was the use of **unequally** spaced constellations. *See id.* at 1:24-28 (The present invention generally relates to bandwidth and/ or power efficient digital transmission systems and more specifically to the use of unequally spaced constellations having increased capacity.). Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates below $1/3$ and a sixty-four-point unequally spaced symbol constellation of the first type.

b. The '777 Patent Provides Written Description for a QAM-256 having overlapping points and a code rate that is below $5/8$

Petitioner challenges the “code rate below $5/8$ and a two-hundred-fifty-six point unequally spaced symbol constellation of the first type” limitation in claims 3-4, 13-14, and 24-25 of the '509 Patent. (Petition at 4). The '777 Patent provides support for this range: it describes optimized PAM-16 constellations for code rates ranging from $3/8$ to $7/8$, and PAM-16 orthogonalizes to QAM-256. Further, in the same disclosure, the '777 Patent demonstrates that below a code rate of $5/8$, the constellations are of the “first type”—that is, having at least two constellation points share the same location. Figure 13b below shows the disclosed PAM-16 constellations and has been annotated to show the code rates for a QAM-256, which is easily determined from the bit rate (bps). This figure has been further annotated

to identify the explicit disclosure of the range, including the 5/8 end point with overlapping constellation points.

PAM-16 constellations optimized for parallel decoding capacity at different

		(CR _{QAM256})				
		$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$
(bps)	(SNR)	1.5	2.0	2.5	3.0	3.5
		9.00	12.25	15.42	18.72	22.13
x_0		-1.72	-1.98	-1.89	-1.84	-1.75
x_1		-1.72	-1.29	-1.36	-1.42	-1.42
x_2		-0.81	1.94	1.89	1.84	1.75
x_3		-0.81	-1.17	-1.14	-1.11	-1.15
x_4		1.72	-0.38	-0.35	-0.40	-0.47
x_5		1.72	-0.65	-0.70	-0.65	-0.68
x_6		-0.62	-0.38	-0.34	-0.29	-0.28
x_7		-0.62	-0.68	-0.76	-0.83	-0.90
x_8		0.62	1.09	1.13	1.11	1.15
x_9		0.62	0.76	0.76	0.84	0.90
x_{10}		0.02	1.26	1.35	1.42	1.42
x_{11}		0.02	0.76	0.70	0.65	0.68
x_{12}		0.81	0.06	0.00	0.05	0.09
x_{13}		0.81	0.29	0.34	0.29	0.28
x_{14}		-0.02	0.06	0.00	-0.05	-0.09
x_{15}		-0.02	0.29	0.35	0.40	0.47

FIG. 15b

Taken together with Figure 14c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of first type constellations for below a code rate of 5/8. In addition to the disclosure in Figure 15b, Figure 14c below is a locus plot for the PAM-16 constellations. Figure 14c has been annotated to show the code rates for a QAM-256 constellation and to

demonstrate the claimed range. Figure 14c thus discloses constellations for every code rate in the claimed range.

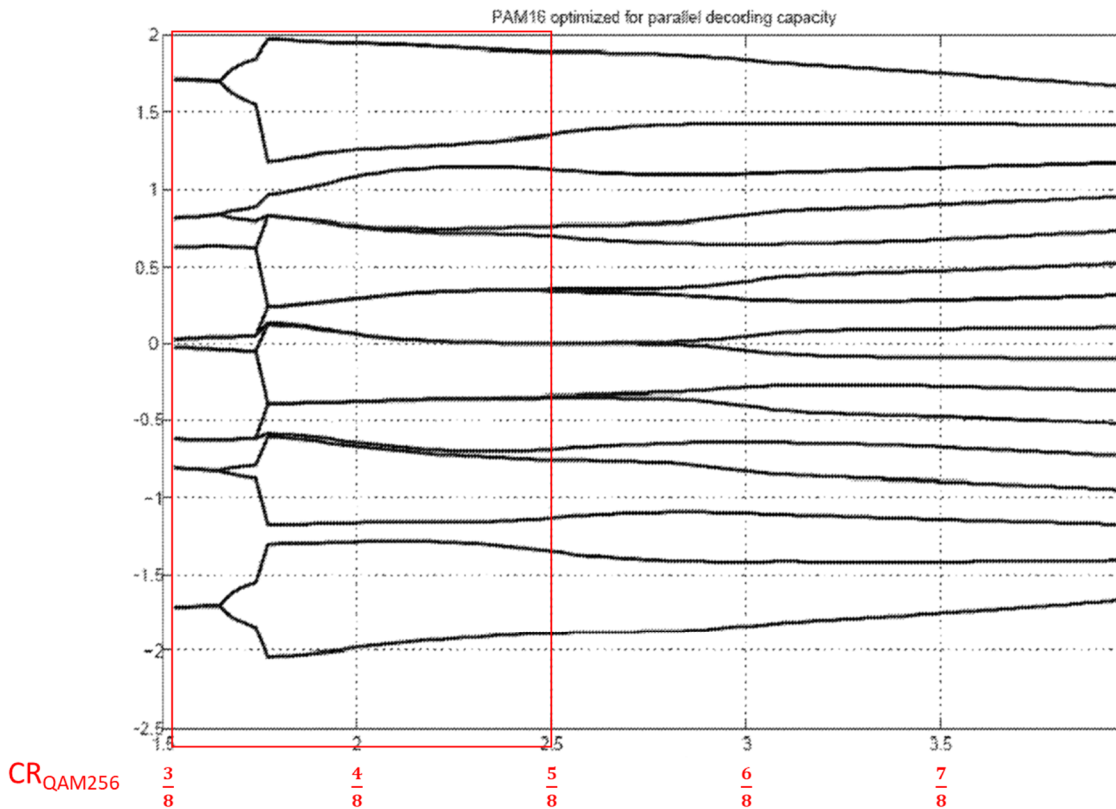


FIG. 14c

Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 14c and 15b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 15b. The claimed code rate range

starting at $5/8$ is expressly identified in the table as being associated with the “first type” constellation, and the code rates excluded from the claimed range cover “second type” constellations. *See* Ex. 1027 at Fig. 15b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates below $5/8$ and a two-hundred-fifty-six-point unequally spaced symbol constellation of the first type.

c. The '777 Patent Provides Written Description for a QAM-1024 having overlapping points and a code rate that is below $7/10$

Petitioner challenges the “code rate below $7/10$ and a one-thousand-twenty-four point unequally spaced symbol constellation of the first type” limitation in claims 3-4, 13-14, and 24-25 of the '509 Patent. (Petition at 4). The '777 Patent provides support for this range: it describes optimized PAM-32 constellations for code rates ranging from $4/10$ to $9/10$, and PAM-32 orthogonalizes to QAM-1024. Further, in the same disclosure, the '777 Patent demonstrates that below a code rate of $7/10$, the constellations are of the “first type”—that is, having at least two constellation points share the same location. Figure 17b below shows the disclosed PAM-32 constellations and has been annotated to show the code rates for a QAM-1024, which is easily determined from the bit rate (bps). This figure has been further annotated to identify the explicit disclosure of the range, including the $7/10$ end point with overlapping constellation points.

PAM-32 constellations optimized for parallel decoding capacity at different

(CR_{QAM1024})

	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
(bps)	2.0	2.5	3.0	3.5	4.0	4.5
(SNR)	12.21	15.27	18.42	21.52	24.79	28.20
x_0	-2.25	-2.16	-2.14	-2.05	-1.97	-1.85
x_1	-1.52	-1.64	-1.75	-1.74	-1.72	-1.66
x_2	2.30	2.19	-1.31	2.05	1.97	-1.35
x_3	-1.39	-1.48	-1.43	-1.49	-1.51	-1.49
x_4	1.56	1.54	2.14	-0.96	-1.03	1.85
x_5	-1.31	-1.23	1.75	-1.15	-1.17	1.66
x_6	1.67	1.65	-1.07	-0.91	-0.90	-1.21
x_7	-1.31	-1.24	-1.04	-1.28	-1.33	-1.08
x_8	-0.48	-0.43	-0.36	-0.17	-0.17	-0.42
x_9	-0.72	-0.76	-0.36	-0.34	-0.31	-0.52
x_{10}	-0.48	-0.43	-0.62	-0.17	-0.15	-0.73
x_{11}	-0.73	-0.76	-0.62	-0.34	-0.35	-0.62
x_{12}	-0.48	-0.42	-0.29	-0.71	-0.67	-0.33
x_{13}	-0.76	-0.86	-0.29	-0.52	-0.55	-0.23
x_{14}	-0.48	-0.42	-0.77	-0.72	-0.77	-0.84
x_{15}	-0.76	-0.86	-0.77	-0.52	-0.48	-0.96
x_{16}	0.87	0.98	1.07	1.49	1.51	1.21
x_{17}	0.66	0.63	1.04	1.28	1.33	1.08
x_{18}	0.87	0.98	0.77	1.74	1.72	0.84
x_{19}	0.66	0.63	0.77	1.15	1.17	0.96
x_{20}	1.07	1.13	1.31	0.72	0.77	1.35
x_{21}	0.66	0.59	1.43	0.91	0.90	1.49
x_{22}	1.05	1.10	0.62	0.71	0.67	0.73
x_{23}	0.66	0.60	0.62	0.96	1.03	0.62
x_{24}	-0.01	-0.08	0.02	0.00	0.01	0.05
x_{25}	0.17	0.25	0.02	0.17	0.15	0.14
x_{26}	-0.01	-0.08	0.29	0.00	-0.01	0.33
x_{27}	0.17	0.25	0.29	0.17	0.17	0.23
x_{28}	-0.01	-0.08	-0.02	0.52	0.48	-0.05
x_{29}	0.17	0.25	-0.02	0.34	0.35	-0.14
x_{30}	-0.01	-0.08	0.36	0.52	0.55	0.42
x_{31}	0.17	0.25	0.36	0.34	0.31	0.52

FIG. 17b

Taken together with Figure 16c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of first type constellations for below a code rate of 7/10. In addition to the disclosure in Figure 17b, Figure 16c below is a locus plot for the PAM-32 constellations. Figure 16c has been annotated to show the code rates for a QAM-1024 constellation and to demonstrate the claimed range. Figure 16c thus discloses constellations for every code rate in the claimed range.

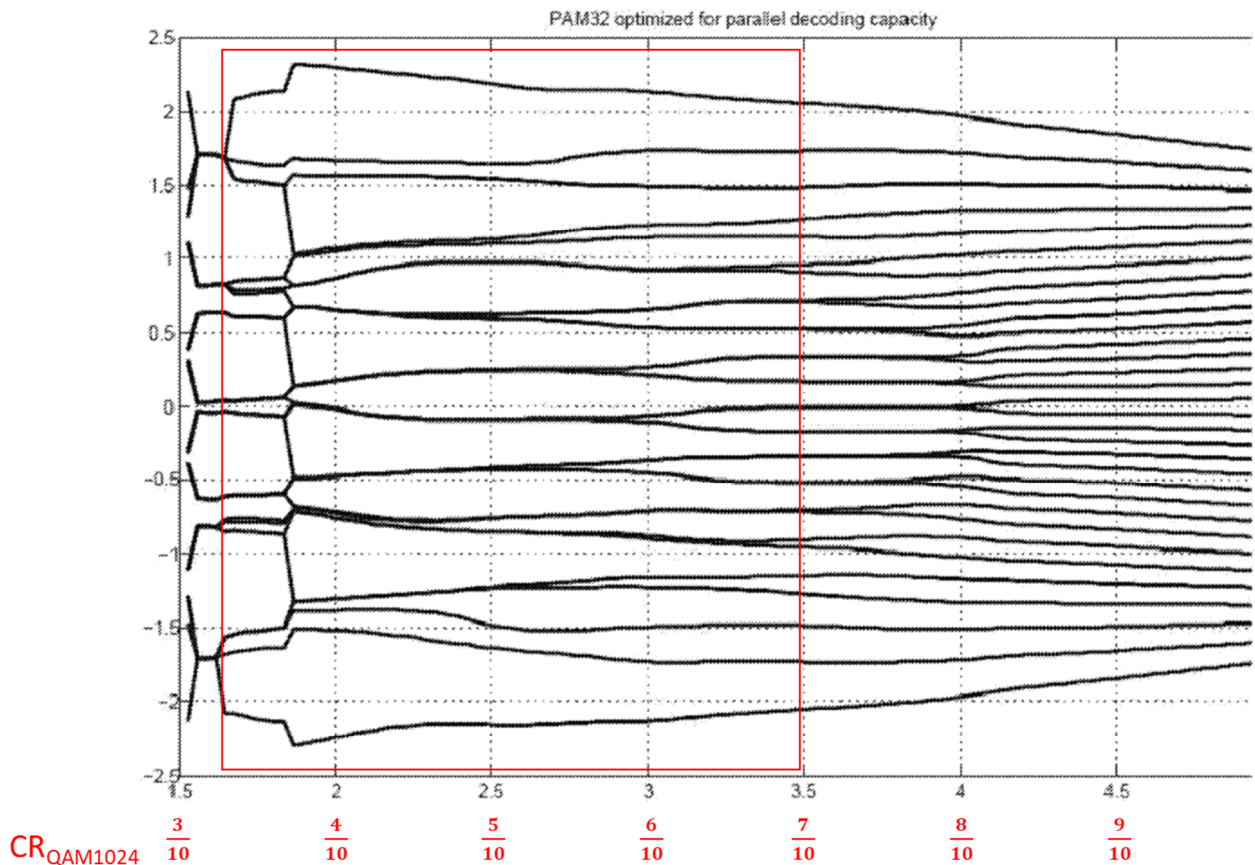


FIG. 16c

Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 16c and 17b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 17b. The claimed code rate range starting at 7/10 is expressly identified in the table as being associated with the “first

type” constellation, and the code rates excluded from the claimed range cover “second type” constellations. See Ex. 1027, Fig. 17b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates below $7/10$ and a one-thousand-twenty-four point unequally spaced symbol constellation of the first type.

2. Claims 5, 15, 26: The '777 Patent Provides Written Description for A QAM Constellation having the Claimed Code Rate Ranges

In contrast to the preceding claims, claims 5, 15, and 26 each further require a plurality of unequally spaced symbol constellations of a second type where no two constellation points within an unequally spaced symbol constellation of the second type share locations that are the same. That is, claims 5, 15, and 26 include limitations covering non-uniform constellations where no two constellation points share the same location.

a. The '777 Patent Provides Written Description For Multiple QAM-16 Constellations Having Code Rates That Are Equal To Or Greater Than $3/8$ And Less Than Or Equal To $6/8$ And That Do Not Have Overlapping Constellation Points

Petitioner challenges the “code rate that is equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type” limitation in claims 5, 15, and 26 of the '509 Patent. (Petition at 4-5). The '777 Patent provides support for this range: it describes optimized PAM-4

constellations for code rates ranging from $2/8$ to $6/8$, and PAM-4 orthogonalizes to QAM-16. Further, in the same disclosure, the '777 Patent demonstrates that for code rates that are equal to or greater than $3/8$ and less than or equal to $6/8$, the constellations are of the “second type”—that is, having at least two constellation points share the same location. Figure 11b below shows the disclosed PAM-4 constellations and has been annotated to show the code rates for a QAM-16, which is easily determined from the bit rate (bps). This figure has been further annotated to identify the explicit disclosure of the range, including the $3/8$ and $6/8$ end points that lack overlapping constellation points.

PAM-4 constellations optimized for parallel decoding capacity at different

CR_{QAM16}	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$
(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39

FIG. 11b

Taken together with Figure 10c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of second type constellations for code rates equal to or greater than $3/8$ and less than or equal to $6/8$. In addition to the disclosure in Figure 11b, Figure 10c below is a locus plot for the

PAM-4 constellations. Figure 10c has been annotated to show the code rates for a QAM-16 constellation and to demonstrate the claimed range. Figure 10c thus discloses constellations for every code rate in the claimed range.

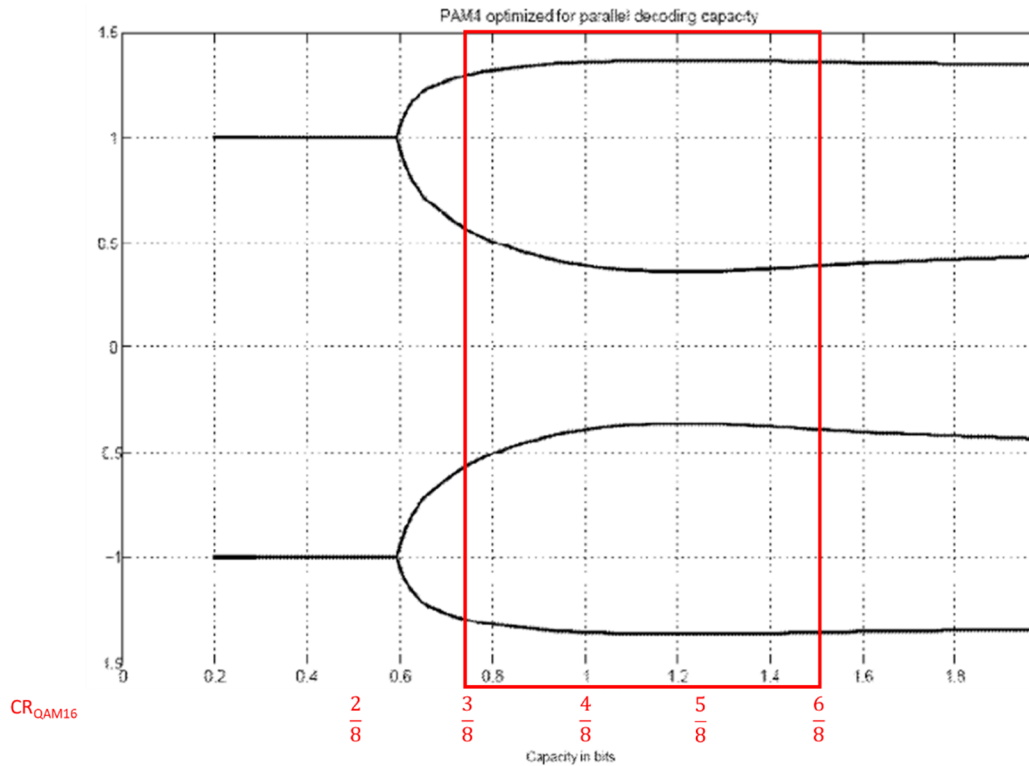


FIG. 10c

Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 10c and 11b, these figures still provide sufficient written description support for the claimed range. See *Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 11b. The claimed code rate range of equal to or greater than $3/8$ and less than or equal to $6/8$ is expressly identified in the

table as being associated with the “second type” constellation, and the code rate ($2/8$) excluded from the claimed range covers a uniform constellation. *See* Ex. 1027, Fig. 11b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates that are equal to or greater than $3/8$ and less than or equal to $6/8$ and a sixteen-point unequally spaced symbol constellation of the second type.

b. The '777 Patent Provides Written Description For Multiple QAM-64 Constellations Having Code Rates That Are Equal To Or Greater Than $3/6$ And Less Than Or Equal To $5/6$ And That Do Not Have Overlapping Constellation Points

Petitioner challenges the “code rate that is equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type” limitation in claims 5, 15, and 26 of the '509 Patent. (Petition at 4-5). The '777 Patent provides support for this range: it describes optimized PAM-8 constellations for code rates ranging from $1/6$ to $5/6$, and PAM-8 orthogonalizes to QAM-64. Further, in the same disclosure, the '777 Patent demonstrates that for code rates that are equal to or greater than $3/6$ and less than or equal to $5/8$, the constellations are of the “second type”—that is, having at least two constellation points share the same location. Figure 13b below shows the disclosed PAM-8 constellations and has been annotated to show the code rates for a QAM-64, which is easily determined from the bit rate (bps). This figure has been further annotated

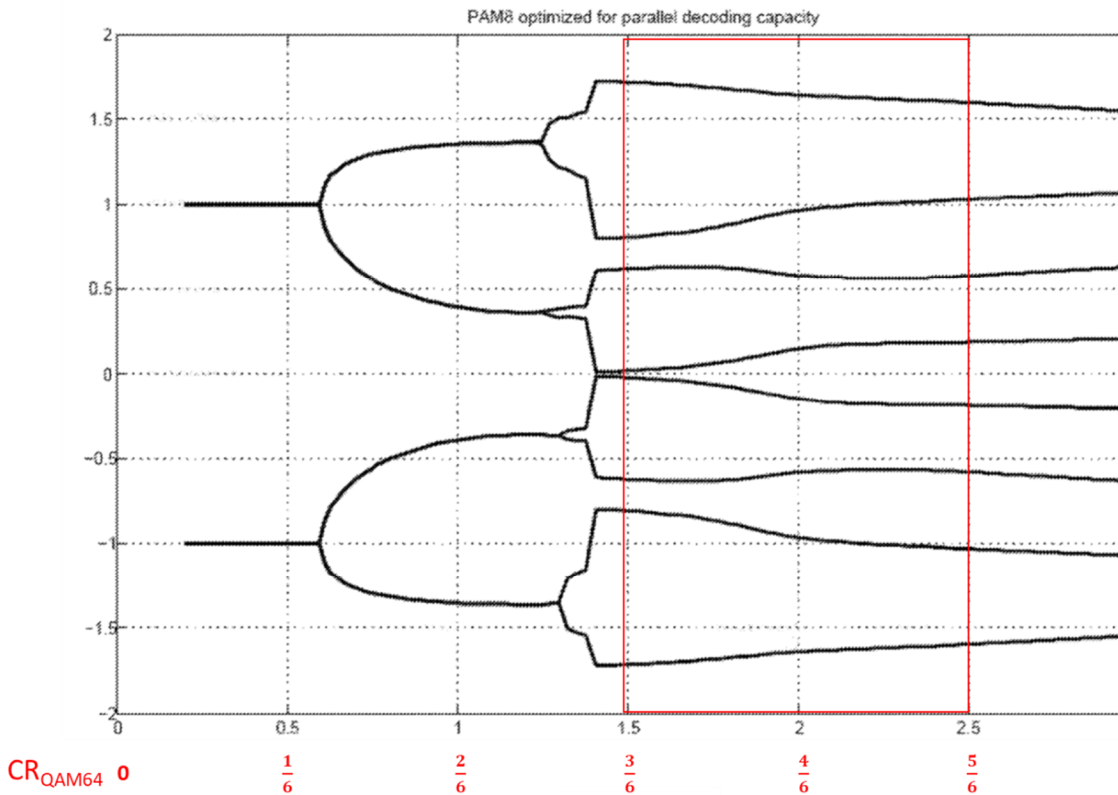
to identify the explicit disclosure of the range, including the 3/6 and 5/6 end points that lack overlapping constellation points.

PAM-8 constellations optimized for parallel decoding capacity at different

(CR_{QAM64})	$\frac{1}{6}$	$\frac{2}{6}$	$\frac{3}{6}$	$\frac{4}{6}$	$\frac{5}{6}$
(bps)	0.5	1.0	1.5	2.0	2.5
(SNR)	0.19	5.27	9.00	12.42	15.93
x_0	-1.00	-1.36	-1.72	-1.64	-1.60
x_1	-1.00	-1.36	-0.81	-0.97	-1.03
x_2	-1.00	-0.39	1.72	1.64	-0.19
x_3	-1.00	-0.39	-0.62	-0.58	-0.58
x_4	1.00	1.36	0.62	0.58	1.60
x_5	1.00	1.36	0.02	0.15	1.03
x_6	1.00	0.39	0.81	0.97	0.19
x_7	1.00	0.39	-0.02	-0.15	0.58

FIG. 13b

Taken together with Figure 12c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of second type constellations for code rates equal to or greater than 3/6 and less than or equal to 5/6. In addition to the disclosure in Figure 13b, Figure 12c below is a locus plot for the PAM-8 constellations. Figure 12c has been annotated to show the code rates for a QAM-64 constellation and to demonstrate the claimed range. Figure 12c thus discloses constellations for every code rate in the claimed range.



Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 12c and 13b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 13b. The claimed code rate range of equal to or greater than $\frac{3}{6}$ and less than or equal to $\frac{5}{6}$ is expressly identified in the table as being associated with the “second type” constellation, and the code rates excluded from the claimed range cover uniform constellations and first type

constellations. See Ex. 1027, Fig. 13b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates that are equal to or greater than $3/6$ and less than or equal to $5/6$ and a sixty-four-point unequally spaced symbol constellation of the second type.

c. The '777 Patent Provides Written Description For Multiple QAM-256 Constellations Having Code Rates That Are Equal To Or Greater Than $6/8$ And Less Than Or Equal To $7/8$ And That Do Not Have Overlapping Constellation Points

Petitioner challenges the “code rate that is equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type” limitation in claims 5, 15, and 26 of the '509 Patent. (Petition at 4-5). The '777 Patent provides support for this range: it describes optimized PAM-16 constellations for code rates ranging from $3/8$ to $7/8$, and PAM-16 orthogonalizes to QAM-256. Further, in the same disclosure, the '777 Patent demonstrates that for code rates that are equal to or greater than $6/8$ and less than or equal to $7/8$, the constellations are of the “second type”—that is, having at least two constellation points share the same location. Figure 15b below shows the disclosed PAM-16 constellations and has been annotated to show the code rates for a QAM-256, which is easily determined from the bit rate (bps). This figure has been further annotated to identify the explicit disclosure of the range, including the $6/8$ and $7/8$ end points that lack overlapping constellation points.

PAM-16 constellations optimized for parallel decoding capacity at different

(CR_{QAM256})		$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$
(bps)		1.5	2.0	2.5	3.0	3.5
(SNR)		9.00	12.25	15.42	18.72	22.13
x_0		-1.72	-1.98	-1.89	-1.84	-1.75
x_1		-1.72	-1.29	-1.36	-1.42	-1.42
x_2		-0.81	1.94	1.89	1.84	1.75
x_3		-0.81	-1.17	-1.14	-1.11	-1.15
x_4		1.72	-0.38	-0.35	-0.40	-0.47
x_5		1.72	-0.65	-0.70	-0.65	-0.68
x_6		-0.62	-0.38	-0.34	-0.29	-0.28
x_7		-0.62	-0.68	-0.76	-0.83	-0.90
x_8		0.62	1.09	1.13	1.11	1.15
x_9		0.62	0.76	0.76	0.84	0.90
x_{10}		0.02	1.26	1.35	1.42	1.42
x_{11}		0.02	0.76	0.70	0.65	0.68
x_{12}		0.81	0.06	0.00	0.05	0.09
x_{13}		0.81	0.29	0.34	0.29	0.28
x_{14}		-0.02	0.06	0.00	-0.05	-0.09
x_{15}		-0.02	0.29	0.35	0.40	0.47

FIG. 15b

Taken together with Figure 14c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of second type constellations for code rates equal to or greater than $\frac{6}{8}$ and less than or equal to $\frac{7}{8}$. In addition to the disclosure in Figure 15b, Figure 14c below is a locus plot for the PAM-16 constellations. Figure 14c has been annotated to show the code rates for a QAM-256 constellation and to demonstrate the claimed range. Figure 14c thus discloses constellations for every code rate in the claimed range.

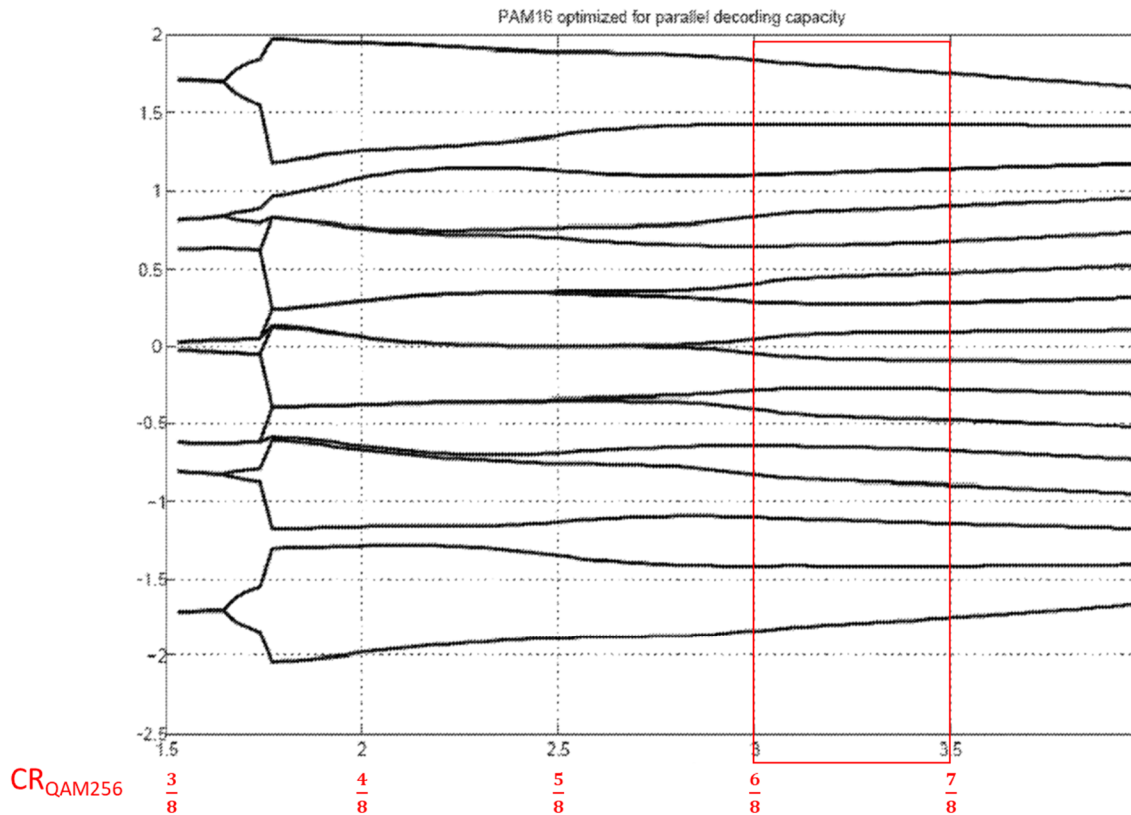


FIG. 14c

Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 14c and 15b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 15b. The claimed code rate range of equal to or greater than $\frac{6}{8}$ and less than or equal to $\frac{7}{8}$ is expressly identified in the table as being associated with the “second type” constellation, and the code rates

excluded from the claimed range cover first type constellations. See Ex. 1027, Fig. 15b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates that are equal to or greater than $6/8$ and less than or equal to $7/8$ and a two-hundred-and-fifty-six-point unequally spaced symbol constellation of the second type.

d. The '777 Patent Provides Written Description For Multiple QAM-1024 Constellations Having Code Rates That Are Equal To Or Greater Than $8/10$ And Less Than Or Equal To $9/10$ And That Do Not Have Overlapping Constellation Points

Petitioner challenges the “code rate that is equal to or greater than $8/10$ and less than or equal to $9/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type” limitation in claims 5, 15, and 26 of the '509 Patent. (Petition at 4-5). The '777 Patent provides support for this range: it describes optimized PAM-16 constellations for code rates ranging from $4/10$ to $9/10$, and PAM-16 orthogonalizes to QAM-256. Further, in the same disclosure, the '777 Patent demonstrates that for code rates that are equal to or greater than $8/10$ and less than or equal to $9/10$, the constellations are of the “second type”—that is, having at least two constellation points share the same location. Figure 17b below shows the disclosed PAM-32 constellations and has been annotated to show the code rates for a QAM-1024, which is easily determined from the bit rate (bps). This figure has

been further annotated to identify the explicit disclosure of the range, including the 8/10 and 9/10 end points that lack overlapping constellation points.

PAM-32 constellations optimized for parallel decoding capacity at different

(CR_{QAM1024})

	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
(bps)	2.0	2.5	3.0	3.5	4.0	4.5
(SNR)	12.21	15.27	18.42	21.52	24.79	28.20
x_0	-2.25	-2.16	-2.14	-2.05	-1.97	-1.85
x_1	-1.52	-1.64	-1.75	-1.74	-1.72	-1.66
x_2	2.30	2.19	-1.31	2.05	1.97	-1.35
x_3	-1.39	-1.48	-1.43	-1.49	-1.51	-1.49
x_4	1.56	1.54	2.14	-0.96	-1.03	1.85
x_5	-1.31	-1.23	1.75	-1.15	-1.17	1.66
x_6	1.67	1.65	-1.07	-0.91	-0.90	-1.21
x_7	-1.31	-1.24	-1.04	-1.28	-1.33	-1.08
x_8	-0.48	-0.43	-0.36	-0.17	-0.17	-0.42
x_9	-0.72	-0.76	-0.36	-0.34	-0.31	-0.52
x_{10}	-0.48	-0.43	-0.62	-0.17	-0.15	-0.73
x_{11}	-0.73	-0.76	-0.62	-0.34	-0.35	-0.62
x_{12}	-0.48	-0.42	-0.29	-0.71	-0.67	-0.33
x_{13}	-0.76	-0.86	-0.29	-0.52	-0.55	-0.23
x_{14}	-0.48	-0.42	-0.77	-0.72	-0.77	-0.84
x_{15}	-0.76	-0.86	-0.77	-0.52	-0.48	-0.96
x_{16}	0.87	0.98	1.07	1.49	1.51	1.21
x_{17}	0.66	0.63	1.04	1.28	1.33	1.08
x_{18}	0.87	0.98	0.77	1.74	1.72	0.84
x_{19}	0.66	0.63	0.77	1.15	1.17	0.96
x_{20}	1.07	1.13	1.31	0.72	0.77	1.35
x_{21}	0.66	0.59	1.43	0.91	0.90	1.49
x_{22}	1.05	1.10	0.62	0.71	0.67	0.73
x_{23}	0.66	0.60	0.62	0.96	1.03	0.62
x_{24}	-0.01	-0.08	0.02	0.00	0.01	0.05
x_{25}	0.17	0.25	0.02	0.17	0.15	0.14
x_{26}	-0.01	-0.08	0.29	0.00	-0.01	0.33
x_{27}	0.17	0.25	0.29	0.17	0.17	0.23
x_{28}	-0.01	-0.08	-0.02	0.52	0.48	-0.05
x_{29}	0.17	0.25	-0.02	0.34	0.35	-0.14
x_{30}	-0.01	-0.08	0.36	0.52	0.55	0.42
x_{31}	0.17	0.25	0.36	0.34	0.31	0.52

FIG. 17b

Taken together with Figure 16c (reproduced below) a POSITA would understand this table as disclosing, and the '509 patent as claiming, a plurality of second type constellations for code rates equal to or greater than 8/10 and less than or equal to

9/10. In addition to the disclosure in Figure 17b, Figure 16c below is a locus plot for the PAM-32 constellations. Figure 16c has been annotated to show the code rates for a QAM-1024 constellation and to demonstrate the claimed range. Figure 16c thus discloses constellations for every code rate in the claimed range.

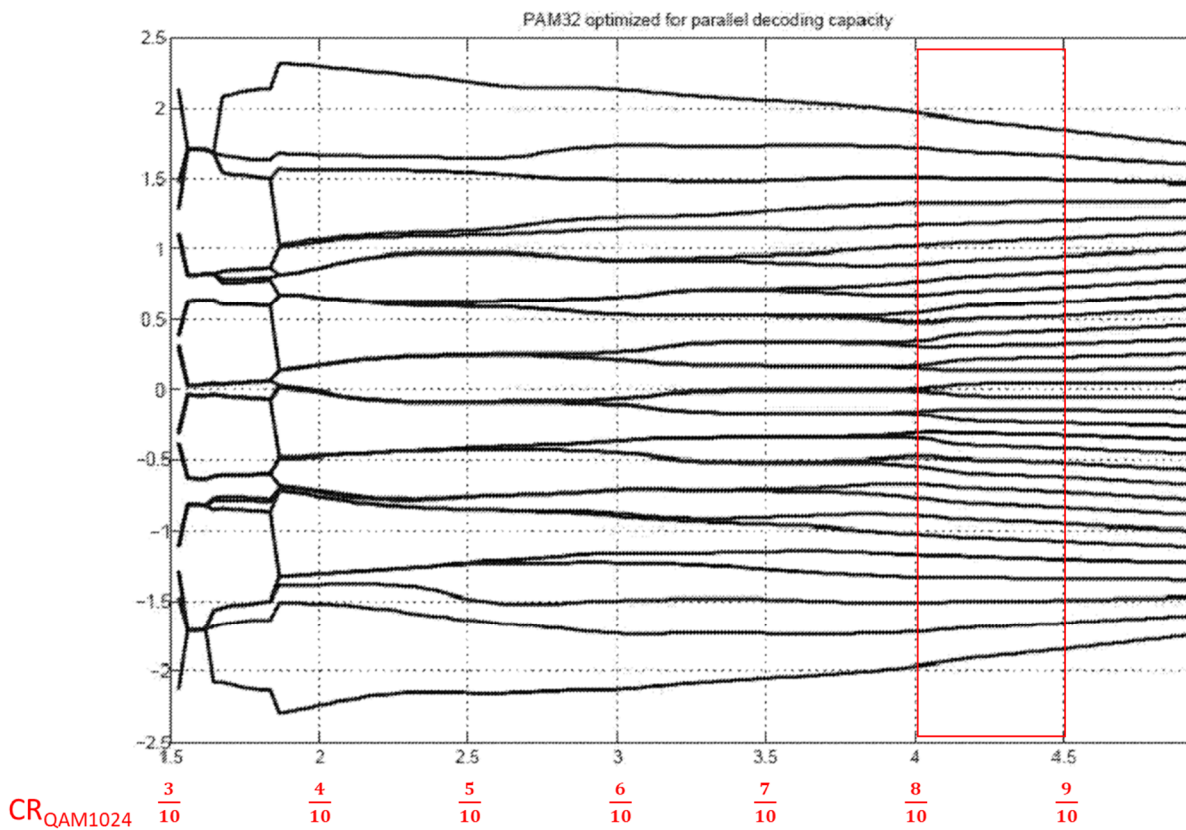


FIG. 16c

Although the claimed range is not fully coextensive with the entirety of the disclosed range in Figures 16c and 17b, these figures still provide sufficient written description support for the claimed range. *See Vanda Pharms.*, 887 F.3d at 1137; *Scriptpro*, 762 F.3d at 1359 (“It is common, and often permissible, for particular

claims to pick out a subset of the full range of described features, omitting others.”). This is particularly true in view of the Figure 17b. The claimed code rate range of equal to or greater than $8/10$ and less than or equal to $9/10$ is expressly identified in the table as being associated with the “second type” constellation, and the code rates excluded from the claimed range cover first type constellations. See Ex. 1027, Fig. 17b. Accordingly, a POSITA would have understood that the patentee was in possession of an invention covering code rates that are equal to or greater than $8/10$ and less than or equal to $9/10$ and a one-thousand-twenty-four-point unequally spaced symbol constellation of the second type.

B. Challenged Claims 6, 16, and 26 are Entitled to Priority to the '777 Priority Application Because It Provides Written Description for the Claimed Each of the Plurality of Unequally Spaced Constellations is Capable of Providing Greater Parallel Decoding Capacity When Operated At A Symbol Constellation Operating SNR Than the Other Constellations When Operated At the Same SNR

Petitioner alleges that the '777 Patent does not provide written description support for the limitations recited by claims 6, 16, and 26 relating to communication systems where each of the plurality of unequally spaced constellations is capable of providing greater parallel decoding capacity when operated at a symbol constellation operating SNR than the other constellations when operated at the same SNR. (Petition at 14-20). However, as described below, the '777 Patent provides sufficient disclosure for these limitations such that the disclosure of the '777 Patent “clearly

allow[s] persons of ordinary skill in the art to recognize that [the inventor] invented what is claimed.” *Ariad*, 598 F.3d at 1351 (Fed. Cir. 2010).

Specifically, the ’777 Patent describes determining optimized constellations for each operating SNR:

As is discussed further below, direct optimization of the constellation points of a communication system utilizing a capacity approaching channel code, can yield different constellations ***depending on the SNR for which they are optimized***. Therefore, the ***same constellation is unlikely to achieve the same coding gains applied across all code rates; that is, the same constellation will not enable the best possible performance across all rates***. In many instances, a constellation at one code rate can achieve gains that cannot be achieved at another code rate.”

EX1027 at 4:62-5:11 (emphasis added).

Optimizing a constellation for a specified capacity often involves an iterative process, because ***the optimal constellation depends upon the SNR*** at which the communication system operates.

Id. at 7:26-29 (emphasis added).

The optimization process typically finds the constellation that gives the ***largest PD capacity or joint capacity at a given SNR***. The optimization process itself often involves an iterative numerical process that among other things considers several constellations and ***selects the constellation that gives the highest capacity at a given SNR***.

Id. at 8:47-56. Therefore, for each operating SNR, an unequally spaced constellation performs best at that operating SNR compared to the other unequally spaced constellations that may be used but may not provide the same gains as those other constellations at different operating SNR. (See *id.* at 4:62-5:11, 6:15-22, 7:26-29,

8:47-56). Accordingly, the constellation optimized at a given SNR performs better than the other constellations optimized at different SNRs for that given SNR. Conversely, all other constellations, which are optimized for different operating SNR, perform worse at the given SNR.

In addition to the disclosure of the written description, the specification includes a number of tables identifying a plurality of different non-uniform multidimensional symbol constellations that are capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR. For example, Figs. 11b, 13b, 15b and 17b all disclose constellations that are capable of providing the greatest parallel decoding capacity at a specific SNR. Figures 11b and 13b are shown below.

PAM-4 constellations optimized for parallel decoding capacity at different

(bps)	0.50	0.75	1.00	1.25	1.50
(SNR)	0.19	3.11	5.26	7.22	9.25
x_0	-1.00	-1.30	-1.36	-1.37	-1.36
x_1	-1.00	-0.56	-0.39	-0.33	-0.39
x_2	1.00	1.30	1.36	0.33	1.36
x_3	1.00	0.56	0.39	1.37	0.39

FIG. 11b

PAM-8 constellations optimized for parallel decoding capacity at different

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

FIG. 13b

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

column of figure 13b (*i.e.*, the constellation optimized for an operating SNR of 5.27 dB).

Accordingly, the '777 Patent discloses a plurality of different non-uniform multidimensional symbol constellations that are capable of providing a greater parallel decoding capacity at a specific SNR than the other symbol constellations in the plurality of multidimensional symbol constellations at the same SNR. The combination of the written description and figures “clearly allow[s] persons of ordinary skill in the art to recognize that [the inventor] invented what is claimed.” *Ariad*, 598 F.3d at 1351 (Fed. Cir. 2010).

VII. Petition Should be Denied Because All Grounds Rely on References that Are Not Prior Art

Because, as shown above, the challenged claims are entitled to the priority date of at least the '777 priority application, all cited references for all grounds do not qualify as prior art under any § 102 sub-section. Accordingly, all grounds must fail, and the Petition should be denied.

VIII. CONCLUSION

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

Dated: April 21, 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 13,598. This word count excludes the tables of contents, tables of authorities, certificate of word count, certificate of service, and table of exhibits.

Dated: April 21, 2023

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CERTIFICATE OF SERVICE

I certify that copies of Patent Owner's Preliminary Response and accompanying Constellation Exhibits 2001 through 2015 are being served by electronic mail on the following counsel of record:

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