

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INFINERA CORPORATION,
Petitioner,

v.

ALEXANDER SOTO AND WALTER SOTO,
Patent Owner.

U.S. Patent 10,771,181 B2
Issue Date: Sept. 8, 2020

Title: SYSTEM AND METHOD FOR PERFORMING HIGH-SPEED
COMMUNICATIONS OVER FIBER OPTICAL NETWORKS

Inter Partes Review No.: IPR2023-00838

**PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT 10,771,181
UNDER 35 U.S.C. §§311-319 and 37 C.F.R. §§42.1-.80, 42.100-.107**

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PETITIONER’S EXHIBIT LIST

<i>Exhibit #</i>	<i>Description</i>
1001	U.S. Patent 10,771,181 (“’181 Patent”)
1002	Prosecution History of the ’181 Patent
1003	Declaration of Dr. Paul Min
1004	Prosecution History of the ’795 Patent
1005	U.S. Patent Application Publication No. 2004/0208601 A1 to Tan et al. (“Tan”)
1006	U.S. Patent Application Publication No. 2002/0167693 A1 to Vrazel et al. (“Vrazel”)
1007	U.S. Patent Application Publication No. 2003/0020986 A1 to Pang et al. (“Pang”)
1008	U.S. Patent 9,887,795 to Soto et al. (“’795 Patent”)
1009	U.S. Provisional Application 60/480,488 (“’488 Provisional”)
1010	Casimer DeCusatis, <i>Optical Data Communication: Fundamentals and Future Directions</i> , Optical Engineering 37(12), December 1, 1998
1011	Reynaud Lavoie, <i>The Evolution of the Pluggable Module</i> , Broadcast Engineering Magazine (2012)
1012	SFF Committee, INF-8053 Specification for Gigabit Interface Converter (GBIC), Rev. 5.5 (2000)
1013	SFF Committee, INF-8074i Specification for SFP (Small Form Factor Pluggable) Transceiver, Rev. 1.0 (2001)
1014	Jan Conradi, <i>Bandwidth-Efficient Modulation Formats for Digital Fiber Transmission Systems</i> , Optical Fiber Telecommunications IV.B Chapter 16, edited by Ivan Kaminow (Elsevier 2002)
1015	P Vijay Kumar et al., <i>Error-Control Coding Techniques and Applications</i> , Optical Fiber Telecommunications IV.B Chapter 17, edited by Ivan Kaminow (Elsevier 2002)
1016	U.S. Patent 10,263,723 to Soto et al. (“the ’723 Patent”)
1017	Moe Z. Win, et al., <i>Equalization Techniques for Mitigating Transmission Impairments</i> , Optical Fiber Telecommunications IV.B Chapter 18, edited by Ivan Kaminow (Elsevier 2002)
1018	U.S. Patent 2,552,629
1019	U.S. Patent 6,552,605

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1020	U.S. Patent 5,561,687
1021	U.S. Patent 7,580,380
1022	U.S. Patent 4,908,827
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1024	NextGen’s Infringement Contentions Against Petitioner for the ’181 Patent in <i>NextGen Innovations, LLC v. Infinera Corporation</i> , No. 2:22-cv-00306-JRG-RSP (E.D. Tex.)
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1027	Prosecution History of the ’723 Patent
1028	U.S. Patent 7,206,366 (“Fujimori”)
1029	U.S. Patent 7,020,729 B2
1030	SFF Committee, INF-8474i Specification for Xenpak 10 Gigabit Ethernet Transceiver, Rev. 3.0 (2002)
1031	Jack H. Winters & Richard D. Gitlin, <i>Electrical Signal Processing Techniques in Long-Haul Fiber-Optic Systems</i> , IEEE Trans. Comm. Vol. 38, No. 9, Sep. 1990
1032	Jack H. Winters et al., “Reducing the Effects of Transmission Impairments in Digital Fiber Optic Systems,” IEEE Comm. Magazine, June 1993
1033	XAUI: An Overview, Version 1.0, March 2002
1034	10 Gigabit Ethernet Technology Overview White Paper, Revision 2, Draft A, April 2002, published by 10 Gigabit Ethernet Alliance
1035	U.S. Patent 5,880,869

I. INTRODUCTION

Infinera Corporation (“Petitioner”) hereby petitions for *inter partes* review of U.S. Patent No. 10,771,181 (“’181 Patent”) (EX-1001). Petitioner respectfully submits that Claims 1-3, 5, 6, 8, 10-17, 22 and 23 (“Challenged Claims”) of the ’181 Patent are unpatentable under 35 U.S.C. §103 in view of the prior art discussed herein. This Petition demonstrates by a preponderance of the evidence that there is a reasonable likelihood that Petitioner will prevail with respect to at least one of these claims. Accordingly, it is respectfully requested that the Board institute *inter partes* review of the ’181 Patent pursuant to 37 C.F.R. §42.108.

II. OVERVIEW

The Challenged Claims are unpatentable as obvious over the prior art. The claims are directed to processing optical and electrical signals using conventional modulation and signal processing techniques, including known m-ary modulation and signal processing techniques and components in a pluggable optical transceiver.

Although the Challenged Claims were allowed and distinguished over the prior art during prosecution based on the claimed optical transceiver being “pluggable,” as set forth in this Petition, pluggable optical transceivers designed according to industry-standardized pluggable form factors were already well known in the art at the time of the alleged invention. By simply adding the term “pluggable” to the claims, the ’181 Patent failed to advance or make any patentable improvement

to the existing state of the art, and merely described implementing conventional m-ary modulation and signal processing techniques on a conventional pluggable optical transceiver.

III. GROUNDS FOR STANDING

Petitioner certifies that the '181 Patent is available for *inter partes* review and Petitioner is not barred or estopped from requesting this review. 37 C.F.R. §42.104(a). This Petition is filed under 37 C.F.R. §42.106(a).

IV. REASONS FOR THE REQUESTED RELIEF

As explained in this Petition and the Declaration of Petitioner's Expert, Dr. Paul Min (EX-1003), the systems and methods described and claimed in the '181 Patent were obvious over the prior art to a person of ordinary skill in the art ("POSA") at the time of the invention.

A. Summary of the '181 Patent

The '181 Patent is directed to a system and method for performing high-speed communications over fiber optical networks using admittedly known m-ary modulation and signal processing techniques and components in a pluggable optical transceiver. EX-1001 1:1-4, 1:36-38, 9:7-11:20, 10:20-31. The '181 Patent describes signal processing techniques, including m-ary modulation/demodulation, channel equalization, multiplexing/demultiplexing, encoding/decoding and error correction (EX-1001 6:12-17)—all of which were well known in the art before the alleged

priority date. The '181 Patent admits that m-ary modulation techniques, including Quadrature Amplitude Modulation (QAM), Pulse Amplitude Modulation (PAM), and Quadrature Phase Shift Keying (QPSK) were “known in the art.” EX-1001 10:20-31. The '181 Patent also admits that small form factor pluggable standards, including, e.g, “SFP and SFP+” were known and “[c]ommon” industry standards for pluggable optical transceivers. EX-1001 11:24-26, 34-37 (identifying “form factor[s] of standard optical modules such as . . . XFP or SFP and SFP+” as “[c]ommon optical module standards”).¹

The '181 Patent issued with 23 claims. Claim 1 is representative:

[1pre] A pluggable optical transceiver module comprising of:

[1a] an electrical system interface for receiving a first electrical data signal
and for transmitting a second electrical data signal;

[1b] an m-ary modulator for increasing the number of bits per symbol in the
first electrical data signal to produce a first m-ary modulation signal;

¹ The '181 Patent claims priority to U.S. Provisional Application No. 60/480,488, filed June 21, 2003 (EX-1009, “'488 Provisional”). EX-1001 (60). The '488 Provisional describes the industry’s adoption of “XFP” Multi-Source Agreements to “standardize” and specify all physical and electrical requirements for optical transceivers. EX-1009 1-2.

- [1c] a digital to analog converter for converting the first m-ary modulation signal to a first electrical m-ary analog modulation signal;
- [1d] a driver for amplifying the first electrical m-ary analog modulation signal to an amplified first electrical m-ary analog modulation signal to drive an optical transmitter;
- [1e] the optical transmitter for emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary analog modulation signal from the driver;
- [1f] an optical detector for receiving a second optical signal on a second wavelength to produce an electrical analog signal;
- [1g] an amplifier for amplifying the electrical analog signal to an amplified electrical analog signal;
- [1h] a clock data recovery unit for recovering clock and data information to produce a second m-ary modulation signal from the amplified electrical analog signal;
- [1i] an equalizer for performing equalization on the second m-ary modulation signal to remove noise; and
- [1i] an m-ary demodulator for decreasing the number of bits per symbol in the equalized second m-ary modulation signal to produce the second electrical data signal.

EX-1001 15:2-33.

B. Prosecution History

The '181 Patent issued from U.S. Patent Application No. 16/297,610, filed March 9, 2019. EX-1001 (21), (22). In the sole rejection, the Examiner rejected the claims of the '181 Patent application for nonstatutory double patenting over U.S. Patent 10,263,723 (EX-1016, "'723 Patent"). EX-1002 77, 124. Patent Owner ("PO") filed a terminal disclaimer to overcome that rejection. EX-1002 53, 64-72. The '181 Patent is a continuation of the '723 Patent. EX-1001 (63); EX-1002 48, 52.

The '723 Patent issued from U.S. Patent Application No. 15/884,351, filed January 30, 2018. EX-1001 (63). The Examiner issued allowance without any rejections. *See generally* EX-1027. Both the '181 Patent and the '723 Patent are continuations of U.S. Patent 9,887,795 (EX-1008, "'795 Patent"). EX-1001 (63); EX-1016 (63).

Unlike the '181 Patent and the '723 Patent, the '795 Patent was subject to multiple rejections. EX-1004 126, 174, 177. The Examiner rejected claims as anticipated by U.S. Patent No. 6,603,822 ("Brede"). EX-1004 174-177. In response, PO amended the claims to include the "pluggable" limitation. EX-1004 148. The Examiner, however, maintained the rejection. EX-1004 121. PO argued that Brede disclosed a "Host Digital Terminal" (HDT) and because its mounting process required "eight screws to [a] metal frame of a shelf of a rack," it did not function as

a “pluggable” unit. EX-1004 69-71. PO argued that Brede disclosed “a collection of rack mounted units that collectively as a whole do not function to plug into an aperture or gap.” EX-1004 71.

The Examiner rejected claims, which recited “form factors” and “a pluggable form factor standard,” as obvious over Brede and U.S. Patent Publ. No. 2007/0031153 A1 (“Aronson”) and then again, as obvious over Brede and U.S. Patent 7,729,617 B2 (“Sheth”). EX-1004 126-127, 177-178. The Examiner stated that “standardized pluggable form factors are well known in the art.” EX-1004 126. In response, PO argued that the Examiner failed to establish a motivation to combine the references. EX-1004 72-73.

The Examiner subsequently allowed the claims and the patent issued without any further comments. EX-1004 60.

C. Claim Construction

The claims should be given “their ordinary and customary meaning” as understood by a person of ordinary skill at the time of the claimed invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312, 1327 (Fed. Cir. 2005). Petitioner proposes that each claim term in the Challenged Claims be given its plain and ordinary meaning in this proceeding, and that no specific construction of any claim term is required because the prior art relied on in this Petition meets each of the claim terms under any reasonable construction. EX-1003 ¶36.

D. Priority of the Challenged Claims

The '181 Patent claims priority to U.S. Provisional Application No. 60/477,845, filed June 10, 2003. EX-1001 (60). For purposes of this Petition, Petitioner relies on prior art as of the earliest claimed priority date—June 10, 2003.

E. Person of Ordinary Skill in the Art

A POSA pertinent to the '181 Patent would have had at least a Bachelor's degree in Computer Science, Computer Engineering, Electrical Engineering or a similar degree and at least two years of professional experience with optical communications, networking, and signal processing. More experience can supplement less education and vice versa. EX-1003 ¶38. The level of skill in the art is further demonstrated by the references cited herein, including the asserted art and the background references discussed in §IV.F below. While this Petition, and supporting declaration, may occasionally use the present tense, the analysis is from the perspective of a POSA as of the time of the purported invention. EX-1003 ¶38.

F. State of the Art

This section describes the state of the art, including the general knowledge, skill, common sense, and creativity possessed by a POSA as of June 2003. It explains the conventional purposes, methods, and components in the art, informing the motivations and reasonable expectations of success. EX-1003 ¶39.

1. Pluggable Optical Transceivers and Pluggable Form Factors

By June 2003, pluggable optical transceiver modules were well known. EX-1003 ¶40. The justification for packaging optical transceivers into “pluggable” modules was that packaging transceiver modules into pluggable form factors meant that the physical layer in an optical communication network was placed on the pluggable transceiver itself. EX-1003 ¶40; EX-1010 3095; EX-1011 1-2. These pluggable modules would “plug” into a host system, e.g., a switch or router, via an electrical interface. EX-1003 ¶40. A key advantage of pluggable transceivers was that system manufacturers could design and manufacture host systems that could support a variety of physical layers. EX-1010 3095; EX-1011 1-2; EX-1003 ¶40. The Gigabit Interface Converter (GBIC) Multi-Source Agreement (MSA) was first published as an industry-wide form factor standard in 1995. EX-1012 xii; EX-1003 ¶40. Other pluggable form factor standards were also published, including the Small Form Factor Pluggable (SFP), adopted in 2001. EX-1013 1; EX-1003 ¶40.

2. M-ary Modulation

By June 2003, use of m-ary modulation techniques, including Quadrature Amplitude Modulation (QAM), Pulse Amplitude Modulation (PAM), and Quadrature Phase Shift Keying (QPSK) modulation was well known. EX-1003 ¶41. M-ary modulation techniques, such as QAM, PAM, and QPSK were “known in the art” to increase the number of bits per symbol transmitted. EX-1001 10:20-31; EX-

1014 876; EX-1003 ¶41. For example, a four-level signal would mean two bits were transmitted per symbol period. EX-1003 ¶41. An example of one such multilevel modulation format was PAM, with a four-level signal called “PAM-4.” EX-1003 ¶41.

3. Coding and Error Correction

By June 2003, error correction coding in optical communication was well known. EX-1003 ¶42. Error correction coding, also known as forward error correction (FEC), is a technique for encoding transmitted data according to an error correcting code. *Id.* Encoding the data according to a code adds redundancy to an error correction coding scheme by adding redundancy to a message, and this redundancy allows a receiver to detect and correct errors in the message. *Id.* By June 2003, numerous error correction codes were well known in communications including, e.g., Low Density Parity Check (LDPC) codes, Reed-Solomon codes, Turbo codes, and convolutional codes. *Id.*; EX-1015 952-961; EX-1018.

4. Equalization

By June 2003, use of equalization as an electrical signal processing technique in a receiver for removing distortion incurred by a signal transmitted through a channel was well known. EX-1003 ¶43; EX-1031 1439. Indeed, equalization as a receiver signal processing technique had been known in the art since at least 1990. *Id.* (paper dated September 1990).

Equalization generally refers to the use of a filter to create a flat amplitude and phase response (versus frequency) of the combined channel and filter. In optical communications, equalization frequently refers to using such filters in a receiver to compensate for impairments such as intersymbol interference. EX-1003 ¶44; EX-1031 1439. Known equalization methods can be classified by both the filter architecture and the algorithm that is used to adjust and set the filter tap weights. EX-1003 ¶44; EX-1031 1441. Equalization techniques can be implemented to aid in compensating and reducing the effects of these transmission impairments, and “the improvement from implementing [equalization] is large and the implementation is relatively simple.” EX-1017 965; EX-1003 ¶45.

By June 2003, equalization techniques such as decision feedback equalization and blind equalization were widely used. EX-1017 991, 965; EX-1003 ¶46. In decision feedback equalization, a known data sequence is transmitted during a training period and used to statistically model the signal distortion, *i.e.*, tap weights are set using a known training sequence. EX-1017 991; EX-1003 ¶46. These weights can be used to cancel and/or compensate the distortions of the transmitted signal. EX-1017 991; EX-1003 ¶46. In blind equalization, a training sequence is not used; instead, the received signal itself is used for equalization without knowing the state of the transmission channel. EX-1017 991; EX-1003 ¶46. Decision-

Directed (DD) equalization is a primitive Blind Equalization method to set filter weights and cancel Inter-Symbol-Interference in the data channel. EX-1003 ¶46.

V. IDENTIFICATION OF CHALLENGES

A. Challenged Claims

Claims 1-3, 5, 6, 8, 10-17, 22 and 23 of the '181 Patent are challenged in this Petition.

B. Statutory Grounds for Challenges

The Challenges are set forth in detail below and summarized as follows:

Ground	Claim(s)	Basis	Reference
1	1-3, 5, 6, 8, 10, 12-17, 22, and 23	§103	Pang in view of Vrazel
2	11	§103	Pang in view of Vrazel and Fujimori

C. Prior Art Basis

U.S. Patent Application Publication No. 2003/0020986 A1 (“Pang”) titled “Method and Apparatus for Pluggable Fiber Optic Modules” was filed Apr. 8, 2002, published Jan. 30, 2003, qualifying as §102(e) prior art. Pang was not cited or applied by the Examiner during prosecution.

U.S. Patent Application Publication No. 2002/0167693 A1 (“Vrazel”) titled “Increasing Data Throughput in Optical Fiber Transmission Systems” was filed Dec. 21, 2001, published Nov. 14, 2002, qualifying as §102(e) prior art. Vrazel was not cited or applied by the Examiner during prosecution.

U.S. Patent 7,206,366 B2 (“Fujimori”) titled “System and Method for Programmably Adjusting Gain and Frequency Response in a 10-Gigabit Ethernet/Fibre Channel System” was filed Jan. 7, 2003, issued Apr. 17, 2007, qualifying as §102(e) prior art. Fujimori was not cited or applied by the Examiner during prosecution.

VI. IDENTIFICATION OF HOW THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1: Claims 1-3, 5, 6, 8, 10, 12-17, 22, and 23 Are Obvious Over Pang and Vrazel

1. Pang (EX-1007)

a. Analogous Art

Pang is analogous art to the claimed invention. Pang is in the same field of endeavor as the '181 Patent because it is directed to pluggable fiber optic modules for “transducing communication by light . . . with communication by electrical signals,” including fiber optic transceivers having both transmit and receive functionality. EX-1007 Abstract, [0003], [0004]; EX-1001 1:36-38, 9:7-8, FIG. 3; EX-1003 ¶52. Pang is reasonably pertinent to the problem addressed by the '181 Patent’s claimed invention because Pang’s solution provides for “high transmission” communications over fiber optic networks. EX-1007 [0005]; EX-1001 Title, 1:1-3; 6:12-13; EX-1003 ¶52.

b. Overview of Pang

Pang discloses a pluggable fiber optic module 100 including transmit printed circuit board (PCB) 106, receive PCB 108, light transmitter 110, light receiver 111, and an edge connection to plug into and out from a host PCB. EX-1007 Abstract, [0066], [0156]; FIG. 1. The transmit PCB and receive PCB each include electrical components. EX-1007 [0159], [0160]. Transmit PCB 106 includes electrical components 112 (transmitter integrated circuit (laser driver)) and receive PCB 111 includes electrical components 116 (receiver integrated circuit (transimpedance amplifier and post amplifier)). EX-1007 [0067]. The optical transmitter and the optical receiver are configured to convert or transduce light into an electrical signal (or convert an electrical signal into light) to communicate over optical fibers using light of various wavelengths. *Id.*

In one embodiment, Pang describes fiber optic module 1700 is an “MTRJ-SFP pluggable fiber optic module” (small form factor pluggable) having an edge connection 1730 to “allow for hot pluggability . . . into a powered up host printed circuit board.” EX-1007 [150], [0156], FIG. 17A.

2. Vrazel (EX-1006)

a. Analogous Art

Vrazel is analogous art to the claimed invention. Vrazel is in the same field of endeavor as the '181 Patent because it “relates to optical fiber communication

systems and . . . increasing the throughput of data transmission over an optical fiber communication system through the use of multilevel modulation.” EX-1006 [0002]; EX-1001 1:1-3, 1:36-38; EX-1003 ¶55. Vrazel is reasonably pertinent to the problem addressed by the ’181 Patent’s claimed invention because Vrazel’s solution is aimed at “increasing the throughput of data transmission over an optical fiber communication system.” EX-1006 [0002]; EX-1001 Title, 1:1-3, 6:12-13; EX-1003 ¶55.

b. Overview of Vrazel

Vrazel discloses signal processing methods and techniques for “increasing the throughput of data transmission over an optical fiber communication system through the use of multilevel modulation.” EX-1006 [0002]. Vrazel describes “signal processing methods that enhance the transmission of a multilevel optical signal over existing fiber optics communications systems.” EX-1006 [0012]. Vrazel describes fiber optic transmitter and receiver systems utilizing known m-ary modulation techniques including, e.g., “ 2^n -ary amplitude shift keying (2^n -ASK), 2^n -ary frequency shift keying (2^n -FSK), 2^n -ary phase shift keying (2^n -PSK), as well as combinations of these techniques such as quadrature amplitude modulation (QAM).” EX-1006 [0010]. These modulation techniques “add little or no complexity to the optical components of the channel transmitter and receiver.” EX-1006 [0011].

Figure 5 depicts multilevel optical transmitter 500 comprising error protection coding (EPC) module 510, n-channel encoder 502, Digital to Analog Converter 504, pre-compensation circuitry 506, and optical source 508. EX-1006 [0050], FIGs. 5, 6. Figure 18 shows multilevel optical detector (receiver) 1802 comprising distortion post-compensation circuits 1804, Analog to Digital Converter 1806, a transimpedance amplifier, n-channel decoder 1808, and error protection decoding (EPD) module 1816. EX-1006 [0113], [0114], FIG. 18.

3. Motivation to Combine Pang and Vrazel

A POSA would be motivated to combine Pang's teaching of a pluggable small form factor optical transceiver with Vrazel's teaching of known modulation techniques for use with optical transceivers with a reasonable expectation of success because Vrazel's techniques enhance the transmission of optical signals over existing fiber optics communications systems and add little or no complexity to the optical components. EX-1003 ¶58; EX-1006 [0011], [0012].

Pang explains that the trend "towards greater usage of fiber optic communication requiring improved connectivity and smaller optical fiber connectors to more densely pack them on a system printed circuit board." EX-1007 [0006]. This made it "desirable to minimize the size of system printed circuit boards (PCBs)" and "reduce the footprint of the fiber optic module which will attach to such system PCBs." EX-1007 [0006]; EX-1003 ¶59. Pang discloses pluggable fiber optic

transceiver modules with transmit and receive PCBs arranged “within the [same] fiber optic module to reduce the footprint of the fiber optic module.” EX-1007 [0006], [0065]. Pang discloses a pluggable fiber optic module 1700 having a transmit PCB 1708, receive PCB 1710, transmitter 110, receiver 111, and interface PCB 1704. EX-1007 [0150]. Transmit and receive PCBs 1708 and 1710 are electrically connected to interface PCB 1704, which connects to a host system via edge connection 1730. EX-1007 [0155]; EX-1003 ¶59. Edge connection 1730 allows for “hot pluggability” of the module 1700 into a powered up host system. EX-1007 [0155]; EX-1003 ¶59. Pang explains that “the invention may be extended to a plurality of channels in parallel which can be all transmit channels, all receive channels or both receive and transmit channels into multiple fiber optic cables.” EX-1007 [0191]; EX-1003 ¶59.

A POSA would have been aware that “extending to a plurality of channels in parallel” was a way of increasing the number of channels carrying information and, in turn, increasing the data throughput of the system. EX-1003 ¶60; EX-1007 [0191]; EX-1006 [0004]. Pang relates primarily to the physical arrangement of components in a pluggable optical transceiver, and does not provide a detailed description of the operation of the electrical components and techniques used in its transceiver. EX-1003 ¶60. In contrast, Vrazel provides a detailed description of the operation of

electrical components and techniques suitable for use with Pang's pluggable transceiver. EX-1003 ¶60.

Vrazel discloses increasing data rates by using spectrally efficient modulation techniques that increase channel data rates. EX-1006 [0010]. Vrazel discloses that its solution may be used in combination with conventional techniques, such as Wavelength Division Multiplexing (WDM) techniques, to achieve even greater increases in data transmission rates, and that the use of such modulation techniques can achieve these increases without replacing existing optical fiber. EX-1006 [0010]. These modulation techniques allow for greater amounts of data to be encoded and then transmitted at the same time over an optical fiber. EX-1006 [0010], [0011]. These techniques add little or no complexity to the optical components of the transmitter and receiver, i.e., Vrazel's techniques provide an increase in data rate while using the same lasers and photodetectors. EX-1006 [0011]. To do this, these techniques use interface circuits that have increased signal processing capability both for encoding (i.e., transmitting) and decoding (i.e., receiving) signals that use modulation. EX-1006 [0011]; EX-1003 ¶61.

A POSA would be motivated to combine Pang's teaching of a pluggable optical transceiver with Vrazel's teaching of modulation techniques for optical transmission for several reasons. EX-1003 ¶62. First, a POSA would recognize that applying Vrazel's modulation techniques to Pang's pluggable transceiver would

increase the data rate in optical links while maintaining existing fiber installations. EX-1003 ¶62. Second, a POSA understood that market pressures made such data rate increases necessary and desirable. EX-1003 ¶62. In this regard, a POSA was aware of the increased demand for faster optical communication. EX-1003 ¶62; EX-1007 [0006] (“the trend is towards greater usage of fiber optic communication requiring improved connectivity.”).

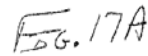
Third, a POSA understood that Vrazel’s modulation techniques, which are performed in electronic circuits, complement Pang’s smaller form factor transceiver and add little or no complexity to the optical components. EX-1003 ¶63. For example, Pang discloses pluggable optical transceiver modules having smaller form factors, thus reducing the footprint of the module and its manufacturing costs without affecting the optical link. EX-1007 [0005], [0006]; EX-1003 ¶63. Vrazel’s teachings complement Pang’s teachings by increasing the data rate for each optical link without increasing the overall size or footprint of the module. *Id.* Vrazel’s teachings, including error correction coding, multilevel modulation, and equalization, all relate to functionality in the electronics of an optical transceiver. EX-1006 [0050], [0052] (electronic functional blocks of the transmitter can be integrated into one circuit), [0113] (electronic functional blocks of the receiver can be integrated into one circuit); EX-1003 ¶63.

Vrazel's modulation techniques "add little or no complexity to the optical components of the channel transmitter and receiver, further reducing the cost of a system upgrade." EX-1006 [0011]. Vrazel explains that an increase in data rate can be provided using the same optics as those used in conventional optical links. EX-1006 [0011]; EX-1003 ¶64. Thus, a POSA would be motivated to combine Pang's pluggable optical transceiver teachings with Vrazel's teachings of additional signal processing because doing so would enable pluggable transceivers at higher data rates without modifying the optical components that are the core of Pang's pluggable transceiver. *Id.*

Further, a POSA would have a reasonable expectation of success in combining Pang's pluggable optical transceiver teachings with Vrazel's teachings of additional signal processing because it would be a routine modification for a POSA. EX-1003 ¶65. For example, Vrazel, in Figures 5 and 6, discloses a transmitter that includes an error protection coding module, an encoder, a Digital to Analog Converter, and pre-compensation circuitry. EX-1006 [0049], [0050], [0054]. These transmit electronics "can be integrated into one circuit or multichip module." EX-1006 [0054]. Vrazel also discloses a receiver in Figure 18 that includes a transimpedance amplifier, distortion post-compensation circuits, an Analog to Digital Converter, a decoder, and an error protection decoding module.

EX-1006 [0112]-[0114]. All of these receive electronics “can be integrated in one circuit or multi-chip module.” EX-1006 [0113]; EX-1003 ¶65.

Pang discloses using transmit and receive electronics, as shown in Pang’s Figure 17A (below). Pang discloses transmit PCB 1708 and receive PCB 1710 that connect to interface PCB 1704. EX-1007 [0155]. Transmit PCB 1708 includes one or more solder pads 1762 for connecting to the interface PCB, and these solder pads 1762 may be electrically coupled to one or more integrated circuits 1764 and the transmitter 110. EX-1007 [0160]. Receive PCB 1710 includes one or more solder pads 1752 for connecting to the interface PCB and may be electrically coupled to one or more integrated circuits 1754 and receiver 111. EX-1007 [0159]. Pang discloses a laser driver as a transmitter integrated circuit, and a transimpedance amplifier (TIA) and post amplifier receiver integrated circuits. EX-1007 [0067]; EX-1003 ¶66.



A POSA understood that Pang's transmit and receive PCBs 1708 and 1710 include signal processing circuitry, including transmit circuitry for driving a laser (i.e., a laser driver) and receive circuitry for amplifying a received signal (i.e., a TIA and post amplifier). EX-1003 ¶¶67. A POSA further understood that adding Vrazel's teaching of transmit and receive electronics to Pang's teaching would simply be adding additional signal processing that Pang contemplates for integrated circuits 1754 and 1764, and adding little or no complexity to the optical components. *Id.* These combined teachings would have been a routine modification well within the skill of a POSA because it involves merely combining known optical communications components and signal processing techniques according to known methods to yield predictable results. *Id.*

4. Detailed Application to the Challenged Claims

a. Claim 1

[1pre] A pluggable optical transceiver module comprising of:

To the extent the preamble is limiting, Pang discloses this limitation. EX-1003 ¶¶68-70.

Pang is directed to a “[m]ethod and apparatus for **pluggable** fiber optic modules” and discloses “[p]luggable fiber optic modules having a receive printed circuit board and a transmit printed circuit board” and an “interface printed circuit board to plug into and out from an edge connector of a host printed circuit board.” EX-1007 Title, Abstract. A transmitter optoelectronic device is coupled to the transmit PCB and a receiver optoelectronic device is coupled to the receive PCB. EX-1007 Abstract. Pang discloses a fiber optic module 100 (*a pluggable optical transceiver*) that includes transmit PCB 106, receive PCB 108, light transmitter 110, light receiver 111, and an edge connection to plug into and out from a host system. EX-1007 Abstract, [0066], [0156]; FIG. 1.

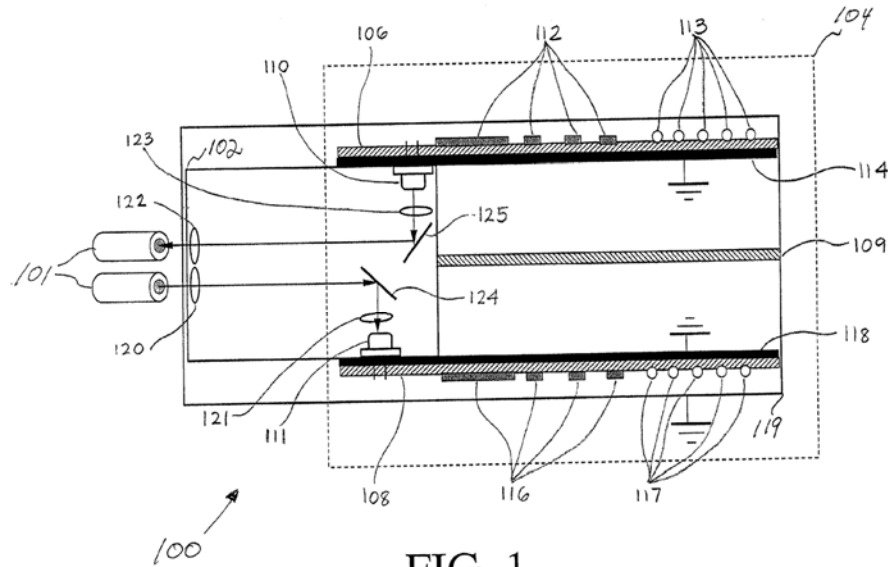
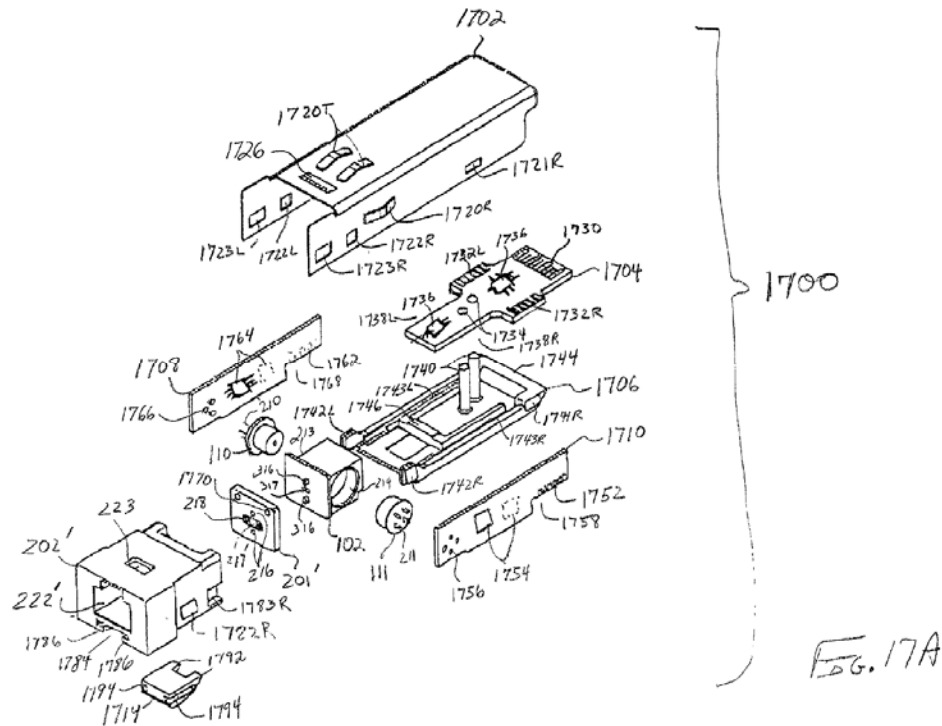


FIG. 1

Pang discloses that “**pluggable** optical module 1700” is an “MTRJ-SFP **pluggable** fiber optic module,” which includes optical block 102, transmit PCB 1708, receive PCB 1710, and interface PCB 1704. EX-1007 [0150], FIGs. 17A-17D. Pang explains that interface PCB 1704 has an edge connection 1730 that “allows the fiber optic module 1700 to be plugged into and out of an edge connector of a host printed circuit board” and “for hot pluggability . . . into a powered up host printed circuit board.” EX-1007 [0155], [0156], FIG. 17A.



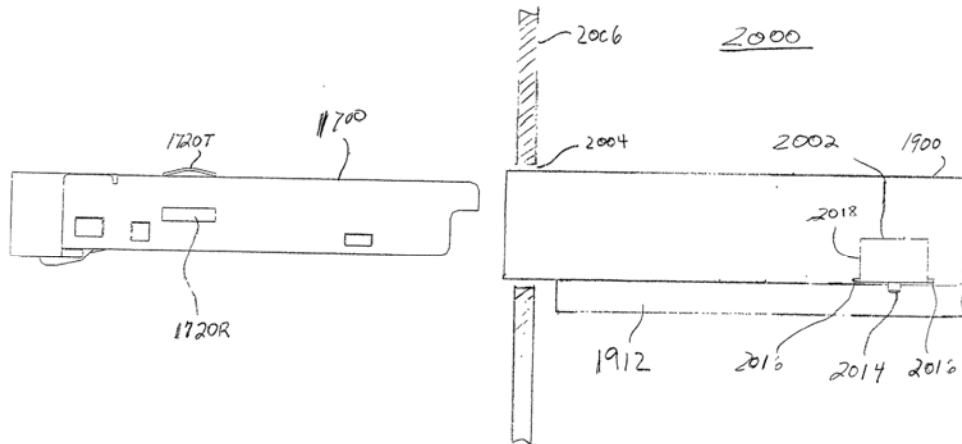
Based on Pang's disclosure, a POSA understood that pluggable optical module 1700 is a *pluggable optical transceiver module* because it includes an edge connection or hot pluggable electrical connector that allows for pluggability into a host system. EX-1003 ¶¶68-71.

[1a] an electrical system interface for receiving a first electrical data signal and for transmitting a second electrical data signal;

Pang, alone or in view of Vrazel, discloses this limitation. EX-1003 ¶¶72-75.

Pang discloses an edge connection 1730 that “may allow for hot pluggability of the fiber optic module 1700 into a powered up host printed circuit board.” EX-1007 [0155], FIG. 17A. Pang discloses that fiber optic module 1700 couples to a

host system 2000 such that edge connection 1730 of module 1700 couples to an edge connector 2002 of a host system 2000. EX-1007 [0180], [0182], FIG. 20.

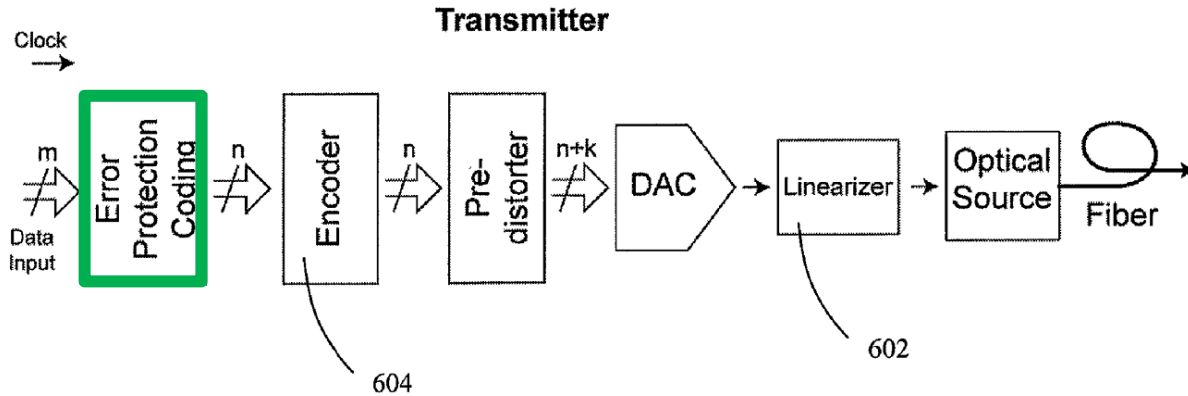


Fiber optic module 1700 is inserted into host system 2000 such that an electrical connection is formed between the fiber optic module and the host system via edge connection 1730 and edge connector 2002. EX-1007 [0185], [0188]-[0190]. This connection interface is used to provide “connections for signal or data lines.” EX-1007 [0190]. A POSA understood that the interface where fiber optic module 1700 connects to host system 2000 via edge connection 1730 and edge connector 2002 is *an electrical system interface for receiving a first electrical data signal and transmitting a second electrical data signal* because it is where the electrical connection is formed between the fiber optic module and the host system. EX-1003 ¶74. Based on Pang’s disclosure, a POSA would find it obvious to include, for example, a XAUI interface because, as the ’181 Patent admits, it was a

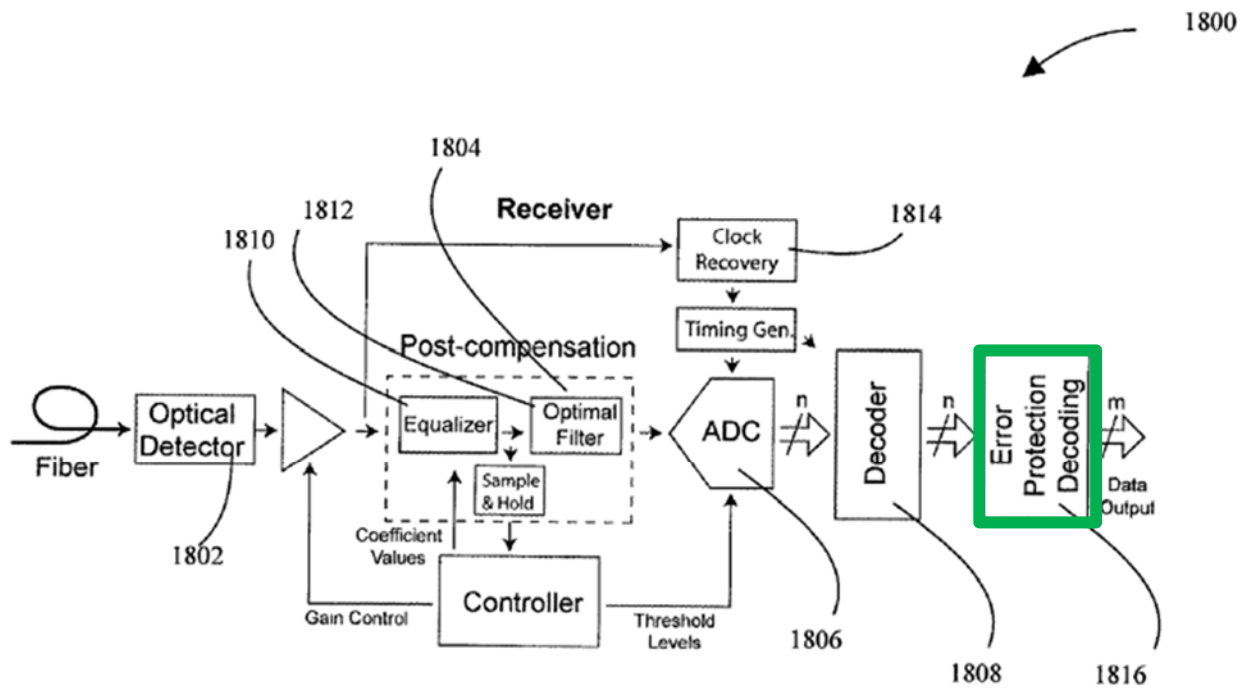
“conventional interface[]” and well known in the art for use with optical transceivers for high speed communications. EX-1001 9:22-26; EX-1028 6:43-7:2, FIGs. 1, 3; EX-1029 1:13-16, 3:49-5:1, FIG. 1; EX-1030 16, 27; EX-1003 ¶74.

To the extent PO argues that Pang does not expressly disclose the signal processing details, Vrazel discloses those details. EX-1003 ¶75. Vrazel discloses, in Figures 6 and 18, m bits of electrical data that are input and output. First, in Figure 6 (below),² Vrazel discloses a transmitter receiving an m -bit input word that is received by an error protection coding (EPC) module (green). EX-1006 [0050]. Vrazel explains that, “four digital channels can be input to the EPC module” (using $m=4$ as an example). EX-1006 [0052].

² The citations to Vrazel are a description of Vrazel’s Figure 5. Vrazel explains that Figure 6 is an “alternative exemplary transmitter” that differs from Figure 5 only in that pre-compensation is performed in the digital domain as opposed to the analog domain. EX-1006 [0018]-[0019], [0054]; EX-1003 ¶75.



Similarly, for the receiver in Figure 18 (below), Vrazel discloses that error protection decoding (EPD) module 1816 outputs m-bits of electrical data. EX-1006 [0113]. Vrazel explains that the receiver outputs “four digital data streams.” *Id.*



A POSA understood that Vrazel’s m-bit input is *an electrical system interface for receiving a first electrical data signal* because it is where the electrical data signal

inputs the transceiver on the transmit side and is received by the EPC module as “Data Input.” EX-1003 ¶¶76-77; EX-1006 [0050], FIG. 6. Likewise, a POSA understood that the m-bit output is *an electrical interface for transmitting a second electrical data signal* because it is where the electrical signal outputs the transceiver on the receive side and transmitted (output from the EPD module) as “Data Output.” EX-1003 ¶77; EX-1006 [0113], FIG. 18. A POSA would be motivated to modify Pang’s teachings with the signal processing techniques taught by Vrazel for the reasons discussed in §VI.A.3. EX-1003 ¶77.

[1b] an m-ary modulator for increasing the number of bits per symbol in the first electrical data signal to produce a first m-ary modulation signal;

Vrazel discloses this limitation in at least two ways. EX-1003 ¶¶78-83. First, Vrazel discloses an encoder 502 (red) (*an m-ary modulator*) shown in Figure 5. EX-1006 [0018], [0019], [0054].

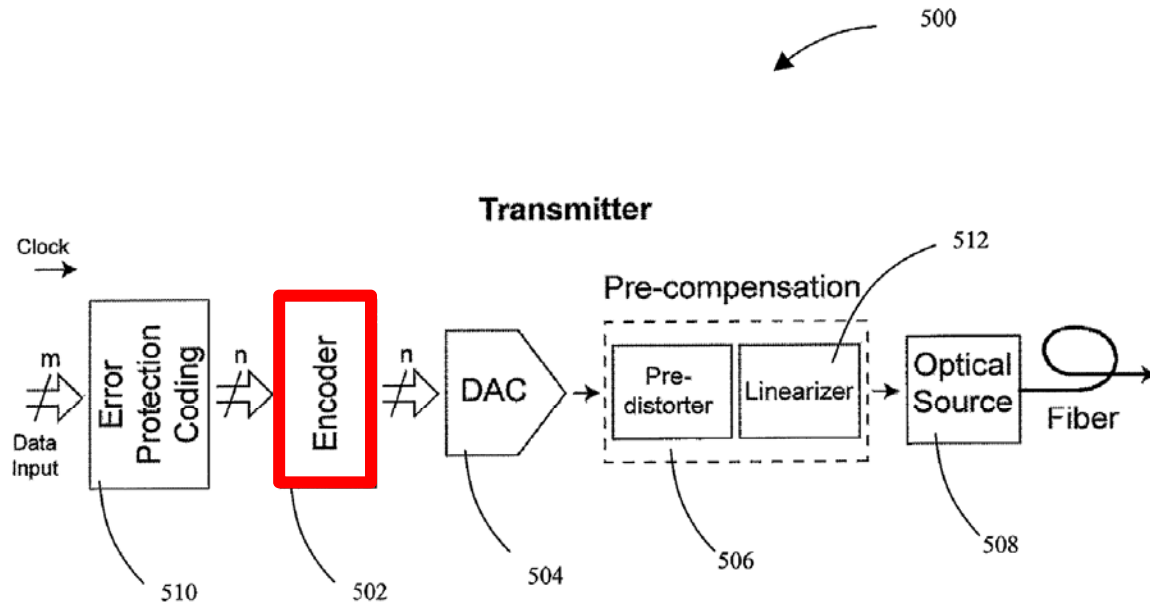


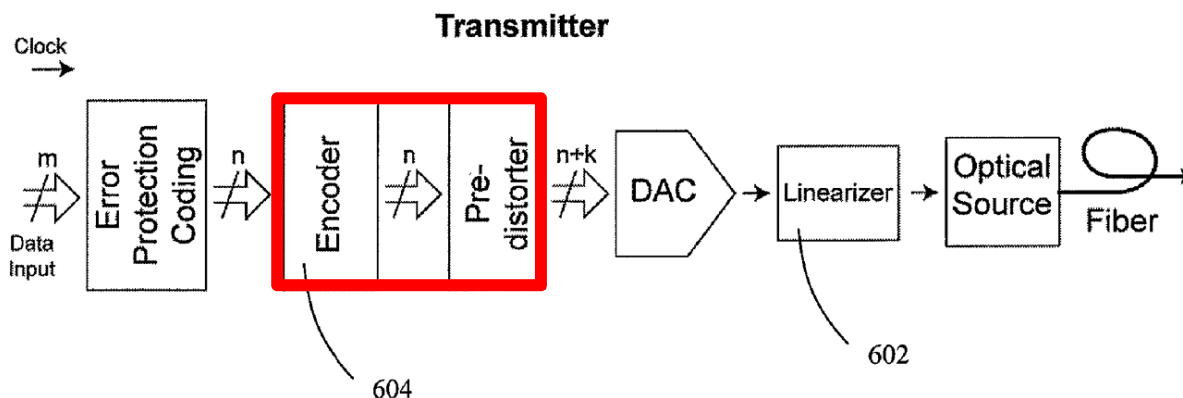
Fig. 5

Encoder 502 receives an encoded data signal from EPC module 510 and converts it to an n-channel “Q-Gray code” encoded signal, which increases the number of bits per symbol. EX-1006 [0051], [0053], [0010] (encoding “greater amounts of data into the transmitted spectrum of a channel”). That encoded signal is input to DAC 504, which “generates a 2^n -level electrical signal that can be used to modulate the optical source 508.” EX-1006 [0051]. Vrazel describes, for example, encoder 502 encoding data channels into a four-bit output that is then input to the DAC and “converted to one of 16 possible amplitude levels for a four times increase in data throughput.” EX-1006 [0051], [0053], [0043] (“allow[ing] for more

than one bit to be transmitted per clock cycle” and “combining four bits (i.e., 16 possible amplitude levels) into each single transmitted pulse, or symbol”).

A POSA understood that encoder 502 is an *m*-ary modulator because it takes an input encoded data signal (*first electrical data signal*) on the transmit side and converts it to a Q-Gray code encoded signal (*first m-ary modulation signal*) having multiple bits per symbol (*increasing the number of bits per symbol*), which is then input to the DAC to generate a 2^n -level electrical signal that is used to modulate the optical source. EX-1003 ¶¶78-80.

Second, Vrazel discloses encoder 604 and a digital pre-distortion circuit (red) (collectively, an *m*-ary modulator), as shown in Figure 6 (below):



Vrazel explains that Figure 6 is an alternate embodiment of Figure 5, which discloses encoder 502. EX-1006 [0018], [0019], [0054]. Like encoder 502, the

encoder of Figure 6³ receives encoded data from EPC module 510 and converts it to an n -channel “Q-Gray code” encoded signal, increasing the number of bits per symbol. EX-1006 [0051], [0053], [0010]. The output of encoder 604 is an n -bit encoded signal that is passed to a pre-distorter that operates in the digital domain. EX-1006 [0054]. The pre-distorter adds k bits to the input encoded signal and outputs an $n+k$ -bit Q-Gray code encoded signal. EX-1006 [0051], FIG. 6. The $n+k$ -bit Q-Gray coded encoded signal is then input to the DAC, which generates a 2^n -level electrical signal that can be used to modulate the optical source. EX-1006 [0051], [0053], [0054].

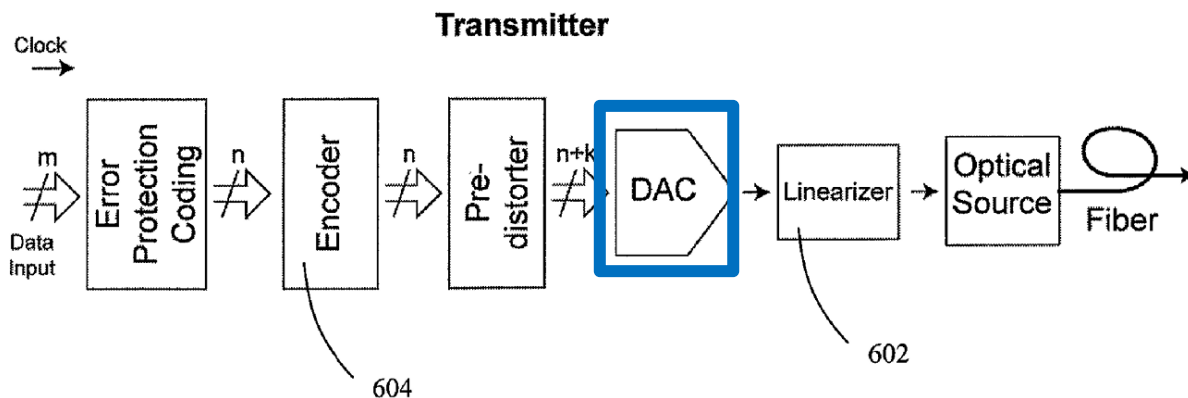
A POSA understood that the encoder and pre-distorter in Vrazel’s Figure 6, collectively, is an *m*-ary modulator because it takes an input n -bit encoded data signal (*first electrical data signal*) and converts it to an $n+k$ -bit Q-Gray code encoded signal (*first m-ary modulation signal*) having an additional k bits per symbol (*increasing the number of bits per symbol*) that is then input to the DAC to generate a 2^n -level electrical signal that can be used to modulate the optical source. EX-1003 ¶¶81-83.

³ There is a typo in paragraph [0056] of Vrazel, i.e., it refers to encoder 603 instead of 604.

[1c] a digital to analog converter for converting the first m -ary modulation signal to a first electrical m -ary analog modulation signal;

Vrazel discloses this limitation. EX-1003 ¶¶84-86.

Vrazel discloses a *digital to analog converter* (DAC) that, in Figure 5 receives n bits, and in Figure 6 (below, in blue) receives an $n+k$ bits, of input data signal in the digital domain (*the first m -ary modulation signal*) and outputs an analog electrical signal (*a first electrical m -ary analog modulation signal*) “that can be used to modulate the optical source.” EX-1006 [0051].



Because, as discussed above for [1b], the $n+k$ bits the DAC receives is an m -ary modulation signal (*first m -ary modulation signal*) and outputs an analog electrical signal (*first electrical m -ary analog modulation signal*) that can be used to modulate the optical source, a POSA understood that the DAC *converts the first m -ary modulation signal to a first electrical m -ary analog modulation signal*. EX-1003 ¶86; EX-1006 [0051], [0053], [0054], FIG. 6.

[1d] a driver for amplifying the first electrical m-ary analog modulation signal to an amplified first electrical m-ary analog modulation signal to drive an optical transmitter;

Pang, alone or in view of Vrazel, discloses this limitation. EX-1003 ¶¶87-94.

Pang discloses that fiber optic module 100 includes an electrical element 104. EX-1007 [0066], FIG. 1. Electrical element 104 includes a light transmitter 110 and a transmit PCB 106. EX-1007 [0066]. Transmitter 110 is a packaged emitter that converts an electrical signal into light, such as a semiconductor laser or LED. EX-1007 [0066]. Transmit PCB 106 includes electrical components 112, such as a “transmitter integrated circuit (**laser driver**),” pins, and a ground plane, and that these electrical components 112 control the operation of transmitter 110. EX-1007 [0067]. Similarly, Pang discloses that fiber optic module 1700 includes transmit PCB 1708 and transmitter 110. EX-1007 [0150], FIG. 17. Transmit PCB 1708 includes one or more integrated circuits 1764 and is electrically coupled to transmitter 110. EX-1007 [0160].

Based on Pang’s disclosure, a POSA understood that integrated circuits 1764 include a laser driver IC (*a driver*) because Pang expressly refers to a “laser driver IC” in describing the transmitter electrical components in Figure 1. EX-1003 ¶90. A POSA further understood that Pang’s laser driver IC is a *driver for amplifying the first electrical m-ary analog modulation signal to an amplified first electrical m-ary analog modulation signal to drive an optical transmitter* because amplifying

received signals to drive an optical transmitter, such as a semiconductor laser in these systems was the conventional use and purpose of laser driver circuits and well known in the art at the time. EX-1003 ¶89; EX-1035 1:41-50, FIG. 5.

To the extent PO argues that Pang does not expressly disclose [1d], Vrazel discloses it. EX-1003 ¶90. Vrazel discloses, in Figure 8, DAC 800 (*driver for amplifying the first electrical m-ary analog modulation signal*), “which can best be used to directly drive a laser diode.” EX-1006 [0021], [0056]. Vrazel explains that DAC 800 is a multilevel laser driver circuit that is similar to the “conventional laser driver circuit” in Figure 7 and exhibits very similar speed properties as a “conventional driver.” EX-1006 [0020], [0021], [0056].

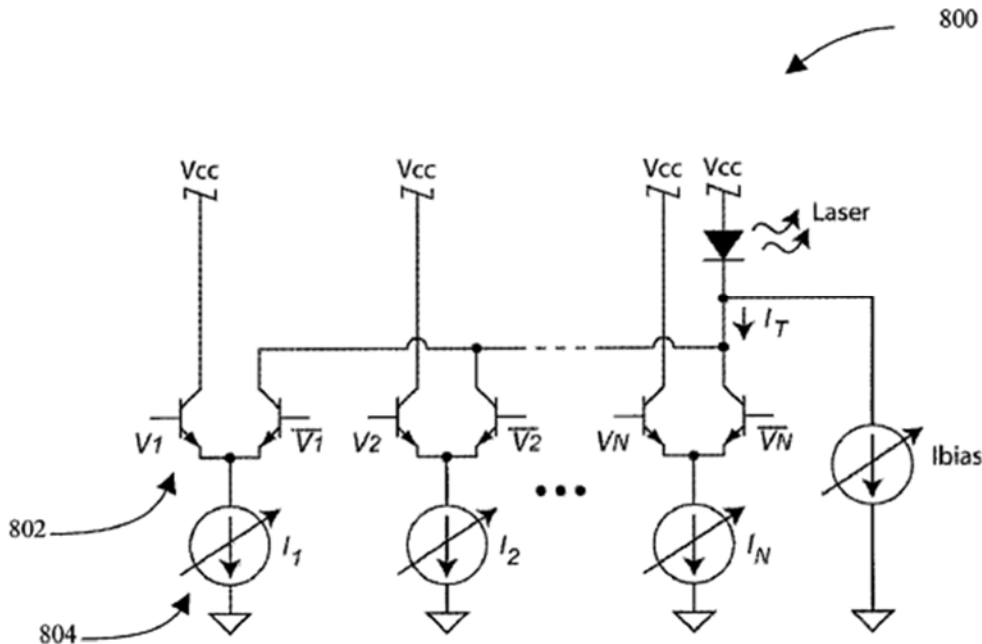


Fig. 8

Vrazel's disclosure is consistent with Pang's disclosure that transmit PCB 106 includes electrical components 112, such as a “transmitter integrated circuit (**laser driver**)” and that these electrical components control the operation of the transmitter 110. EX-1007 [0067], FIG. 1.

As discussed above for [1c], Vrazel's DAC outputs an analog electrical signal (*first electrical m-ary analog modulation signal*) that can be used to modulate the optical source. EX-1006 [0051], [0053], [0054], FIG. 6.

Based on Vrazel's disclosure, a POSA understood that DAC 800 is *a driver for amplifying the first electrical m-ary analog modulation signal* because it is

similar to a conventional laser driver circuit and used to directly drive a laser diode. EX-1003 ¶¶91-93. A POSA understood that DAC 800 was used for *amplifying the first electrical m-ary analog modulation signal* (output from the DAC) to an *amplified first electrical m-ary analog modulation signal to drive an optical transmitter* (input to the optical transmitter) because that was the conventional use and purpose of laser driver circuits and well known in the art at the time. EX-1003 ¶93; EX-1035 1:41-50, FIG. 5.

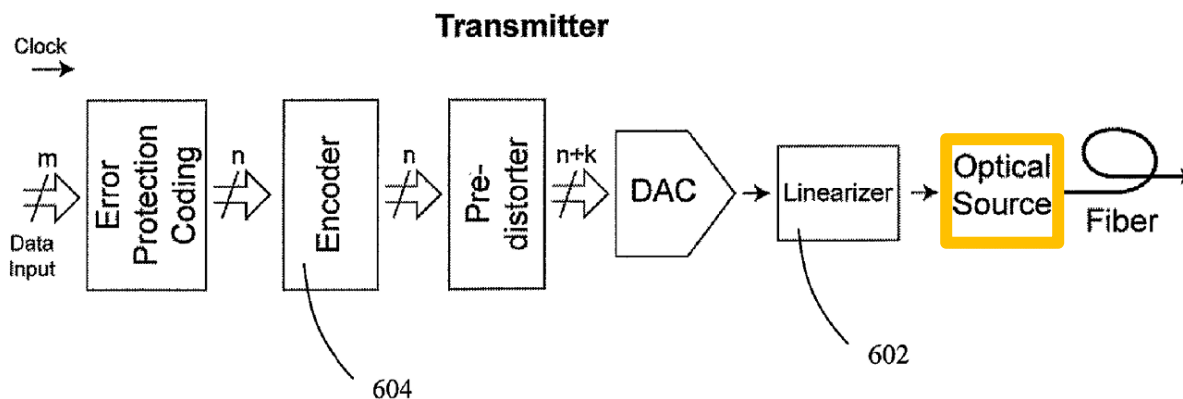
A POSA would be motivated to modify Pang's teachings with the signal processing techniques, including the driver taught by Vrazel for the reasons discussed in §VI.A.3. EX-1003 ¶94.

[1e] the optical transmitter for emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary analog modulation signal from the driver;

Pang, alone or in view of Vrazel, discloses this limitation. EX-1003 ¶¶95-97. Pang discloses a light transmitter 110 (*the optical transmitter*) that “is a packaged emitter that converts an electrical signal into emitting light or photons, such as a semiconductor laser or LED.” EX-1007 [0066] [0089], FIG. 1. Pang explains that this transmitter is “communicating with optical fibers using light of various wavelengths.” EX-1007 [0066]. Thus, a POSA understood that Pang's light transmitter 110 is an *optical transmitter for emitting a first optical signal on a first*

wavelength because it converts electrical signals into emitting light and communicates with optical fibers using light of various wavelengths. EX-1003 ¶95.

Pang's disclosure is consistent with Vrazel's teaching, in Figure 6 (below), that the optical source (yellow) receives via linearizer 602 the electrical signal from the DAC, including DAC 800 laser driver (*the amplified first electrical m-ary analog modulation signal from the driver*), and then generates an optical signal for transmission using a modulated laser. EX-1006 [0051], [0056], FIGs. 6, 8.



To the extent PO argues that Pang does not expressly disclose this limitation, based on Vrazel's disclosure, a POSA understood that the optical signal is *responsive to and representative of the amplified first electrical m-ary analog modulation signal from the driver* because, as discussed above for [1d], it is generated from the amplified electrical m-ary analog modulation signal received from the DAC, which includes the laser driver. EX-1003 ¶97. A POSA would be

motivated to modify Pang's teachings with Vrazel's teachings for the reasons discussed in §VI.A.3. *Id.*

[1f] an optical detector for receiving a second optical signal on a second wavelength to produce an electrical analog signal;

Pang, alone or in view of Vrazel, discloses this limitation. EX-1003 ¶¶98-100. Pang discloses that fiber optic modules 100 and 1700 include light receiver 111 (*an optical detector*). EX-1007 [0066], [0151], FIG. 1. Pang explains that this receiver is a packaged photodetector that detects or receives light and converts it into an electrical signal, “such as a photodiode” and can communicate with optical fibers using light of “various wavelengths.” EX-1007 [0066], [0089]. Thus, a POSA understood that Pang's light receiver 111 is *an optical detector for receiving a second optical signal on a second wavelength* because it detects or receives light and converts it into an electrical signal and communicates with optical fibers using light of various wavelengths. EX-1003 ¶99.

To the extent that PO argues that Pang does not disclose the signal processing details of the optical detector, Vrazel discloses that photodetector 1802 detects an incoming optical signal, and explains that it “converts a 2ⁿ-level optical signal into a 2ⁿ-level electrical signal.” EX-1006 [0113], [0114], FIG. 18. A POSA understood that the 2ⁿ-level electrical signal produced by Vrazel's photodetector is *an electrical analog signal* because it is input to post-compensation circuitry 1804 prior to Analog

to Digital Converter (ADC) 1806, and Vrazel discloses that the output of compensator 1804 is input to the ADC, which subsequently converts the 2^n -level signal into n digital streams. EX-1003 ¶100; EX-1006 [0113], FIG. 18. A POSA would be motivated to modify Pang's teachings with the signal processing techniques, including the optical detector taught by Vrazel for the reasons discussed in §VI.A.3. EX-1003 ¶100.

[1g] an amplifier for amplifying the electrical analog signal to an amplified electrical analog signal;

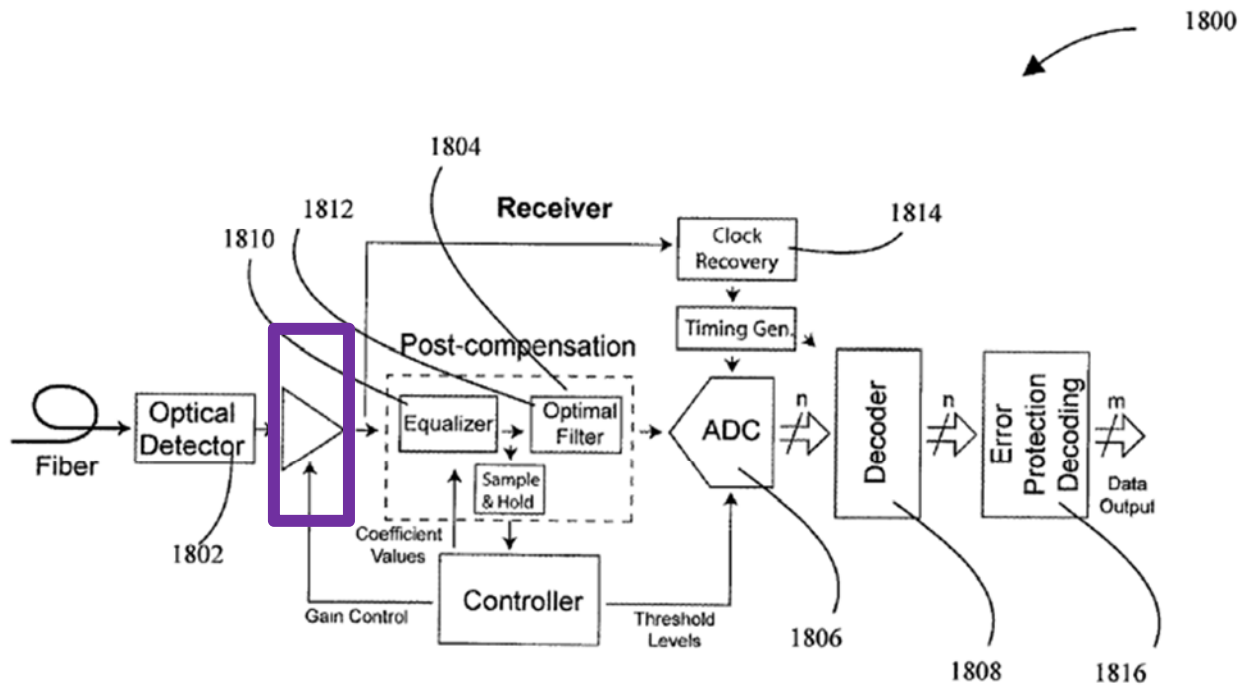
Pang, alone or in view of Vrazel, discloses this limitation. EX-1003 ¶¶101-105.

Pang discloses that fiber optic module 100 includes receive PCB 108, which includes “electrical components 116” such as a “receiver integrated circuit (**transimpedance amplifier and post amplifier**).” EX-1007 [0066], [0067], FIG. 1. Similarly, Pang discloses that fiber optic module 1700 includes receive PCB 1710 and receiver 111. EX-1007 [0150], FIG. 20. Pang explains that receive PCB 1710 includes “one or more integrated circuits (ICs) 1754” and is electrically coupled to receiver 111 via one or more solder pads. EX-1007 [0159].

Based on Pang's disclosure, a POSA understood that integrated circuits 1754 include transimpedance and post amplifiers (*an amplifier for amplifying the electrical analog signal*) because Pang expressly refers to “transimpedance and post

amplifiers” in describing the receiver electrical components in Figure 1. EX-1003 ¶¶102-103. Thus, a POSA understood that Pang’s transimpedance and post amplifiers are *for amplifying the electrical analog signal to an amplified electrical analog signal* because amplifying received signals was the conventional use and purpose of transimpedance and post amplifiers and well known in the art. EX-1003 ¶103; EX-1019 1:19-26.

To the extent that PO argues that Pang does not disclose the details of the transimpedance amplifier’s operation, Vrazel discloses that its optical detector 1802 is followed by an analog transimpedance amplifier (TIA) and its preferred embodiment is “a conventional PIN detector in conjunction with an analog TIA.” EX-1006 [0114], FIG. 18; EX-1003 ¶104. Vrazel explains that “the TIA is assumed to have gain control, which will be used to produce a signal output of fixed amplitude.” EX-1006 [0114]. This is illustrated in Figure 18, below, with the TIA (purple):



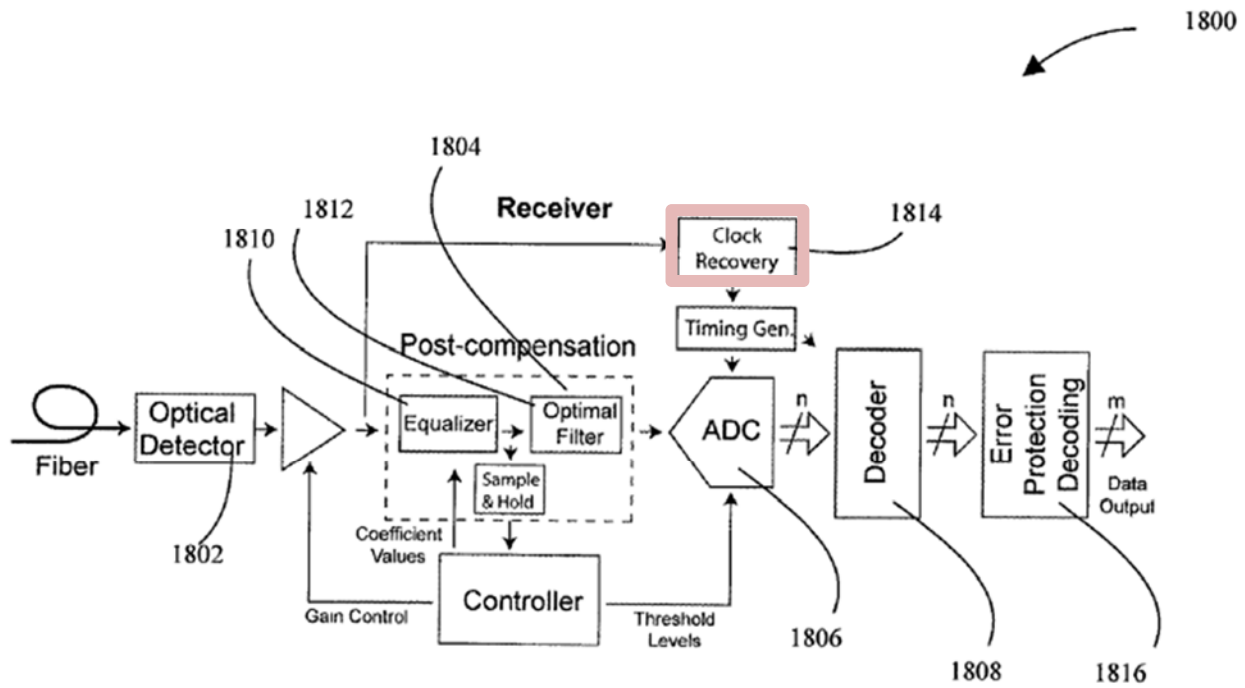
A POSA would find it obvious to use Vrazel's TIA *for amplifying the electrical analog signal to an amplified electrical analog signal* because it was well known that TIAs receive input current signals (*electrical signals*) and output a voltage signal that is proportional to the current signal (*an amplified electrical signal*). EX-1003 ¶105; EX-1019 1:15-26 (explaining that TIAs are an integral components of fiber optic communication systems that are used to convert an input current signal into an output voltage signal). A POSA would be motivated to modify Pang's teachings with Vrazel's signal processing techniques, including the TIA taught by Vrazel for the reasons discussed in §VI.A.3. EX-1003 ¶105.

[1h] a clock data recovery unit for recovering clock and data information to produce a second m-ary modulation signal from the amplified electrical analog signal;

Vrazel discloses this limitation. EX-1003 ¶¶106-110.

Vrazel, in Figure 18 (below), discloses clock recovery circuit 1814 (pink) (*clock data recovery unit*). EX-1006 [0113].⁴ Post-compensation circuits 1804 receive a 2^n -level electrical signal (*i.e.*, an analog electrical signal received from the TIA) that outputs to ADC 1806, which converts the 2^n -level signal into n digital data streams. EX-1006 [0113]. These post-compensation circuits include equalizer circuit 1810 and optimal filtering circuit 1812. EX-1006 [0113], FIG. 18.

⁴ Vrazel's disclosure is consistent with Pang's teaching regarding including "clock/data recovery (CDR)" circuitry to its transceiver module. EX-1007 [0101] (disclosing that the motherboard "may also be used to mount components or circuits for increased electrical functionality such as clock/data recovery (CDR) function").



Vrazel's optimal filtering circuit 2100, in Figure 21 (below), is used for post-compensation, and in the operation of the clock recovery circuit. EX-1006 [0122], FIG. 21. It receives a signal from equalizer circuit 1810 and then splits the signal into multiple integrate and dump filters (IDFs). EX-1006 [0122], [0123].

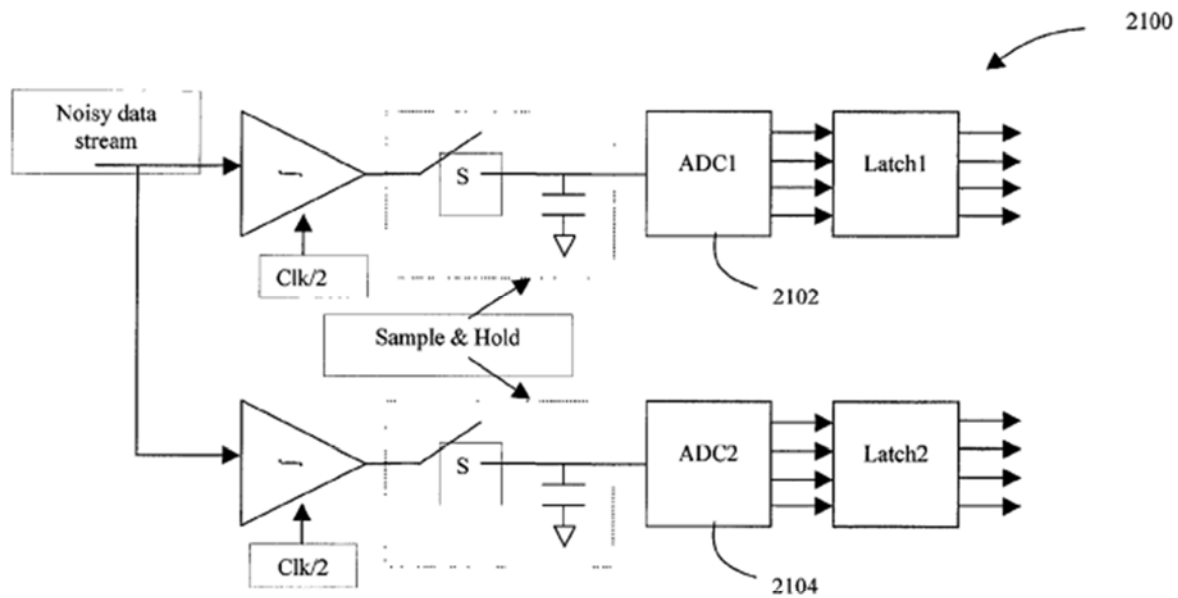


Fig. 21

In each IDF, clock information is extracted from the received signal “using a **clock recovery circuit** followed by a divide-by-two frequency divider,” and held to the end of a given symbol period for thresholding by the ADCs. EX-1006 [0123], FIG. 21. Because the clock information is extracted from the received signal using the clock recovery circuit and held for thresholding by the ADCs, a POSA understood that Vrazel’s clock recovery circuit 1814 is *a clock data recovery unit for recovering clock and data information*. EX-1003 ¶109.

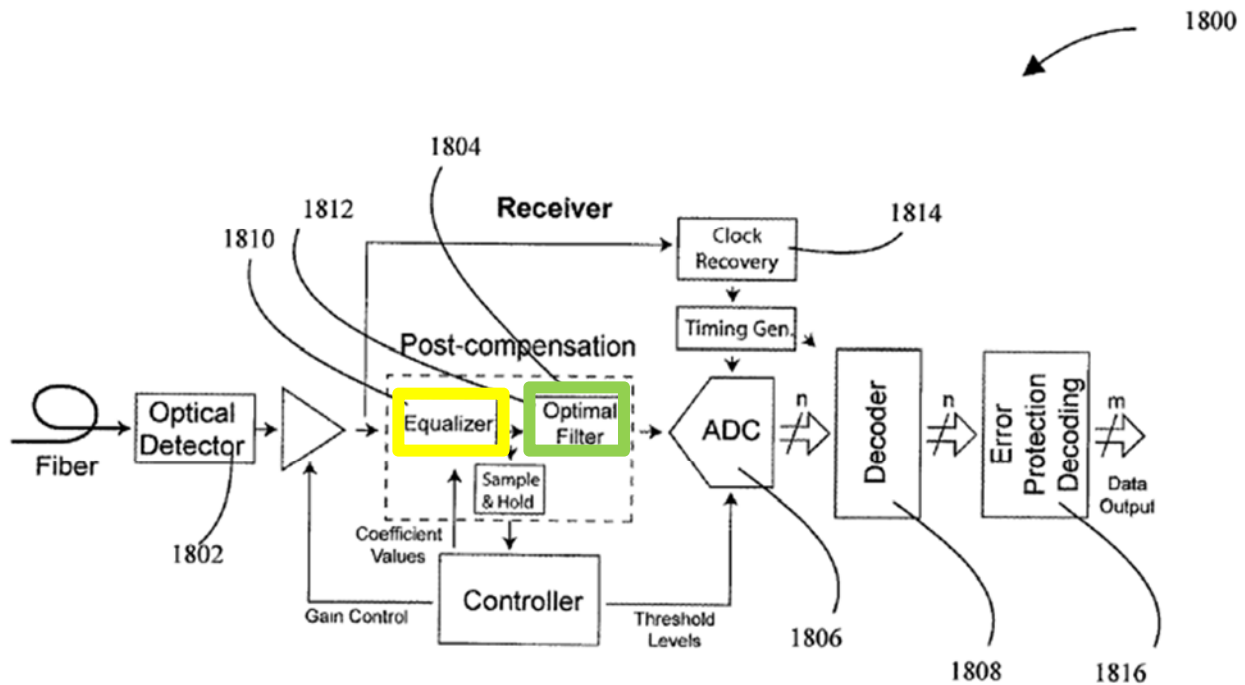
A POSA further understood that Vrazel discloses recovering clock and data information *to produce a second m-ary modulation signal from the amplified*

electrical analog signal because in connection with the clock recovery circuit and post-compensation circuitry outputs, the ADC converts the analog electrical signal output from the TIA into n digital data streams (*produces a second m -ary modulation signal from the amplified electrical analog signal*). EX-1003 ¶110; EX-1006 [0113], [0123]. Vrazel teaches recovering clock and data information from the received amplified electrical analog signal (output of the TIA) to produce a second m -ary modulation signal, namely the n -channel data streams output by the ADCs. EX-1003 ¶110.

[1i] an equalizer for performing equalization on the second m -ary modulation signal to remove noise; and

Vrazel discloses this limitation in at least three ways. EX-1003 ¶¶111-116.

First, as discussed above for [1h], Vrazel discloses post-compensation circuitry 1804 that includes adaptive equalization circuitry 1810 (yellow) and optimal filtering detection circuitry 1812 (green). EX-1006 [0113], FIG. 18.



As part of this circuitry, Vrazel describes optimal filtering detection circuit 2100 that performs “parallel noise filtering and detection implementation using integrate and dump filters.” EX-1006 [0122]. A POSA understood that optimal filtering circuit 2100 is *an equalizer for performing equalization on the second m-ary modulation signal to remove noise* because it performs parallel noise filtering (*removing noise*), which allows for parallel processing of the received data (*the second m-ary modulation signal*) and for serial to parallel data conversion without requiring an additional demultiplexer circuit in the receiver. EX-1003 ¶113; EX-1006 [0122], FIG. 18.

Second, in Figure 20 (below), Vrazel describes adaptive equalization circuitry that includes adaptive transversal filter 2000 that adjusts the amplitude of a received

symbol (*performing equalization on the second m-ary modulation signal*) based on equalizer tap gains that are calculated in microcontroller 2002 to remove the effect of intersymbol interference. EX-1006 [0117]. This circuit includes programmable transversal filter (PTF) 2016 that frequency equalizes the signal, followed by a low pass filter (optimal filter 2100) to remove noise. EX-1006 [0121]. Thus, a POSA understood that this adaptive transversal filter is *an equalizer for performing equalization on the second m-ary modulation signal to remove noise* because it adjusts the amplitude of the received symbol based on equalizer tap gains to remove intersymbol interference and, via the PTF, frequency equalizes the signal to remove noise. EX-1003 ¶114; EX-1006 [0117], [0121].

A POSA understood that adjusting the amplitude of a received symbol based on equalizer tap gains is a technique for noise removal well-known in the art. EX-1003 ¶115; EX- 1020 1:14-20 (employing equalizer taps for minimizing noise and intersymbol interference in signals conveyed over high-speed data service loop).

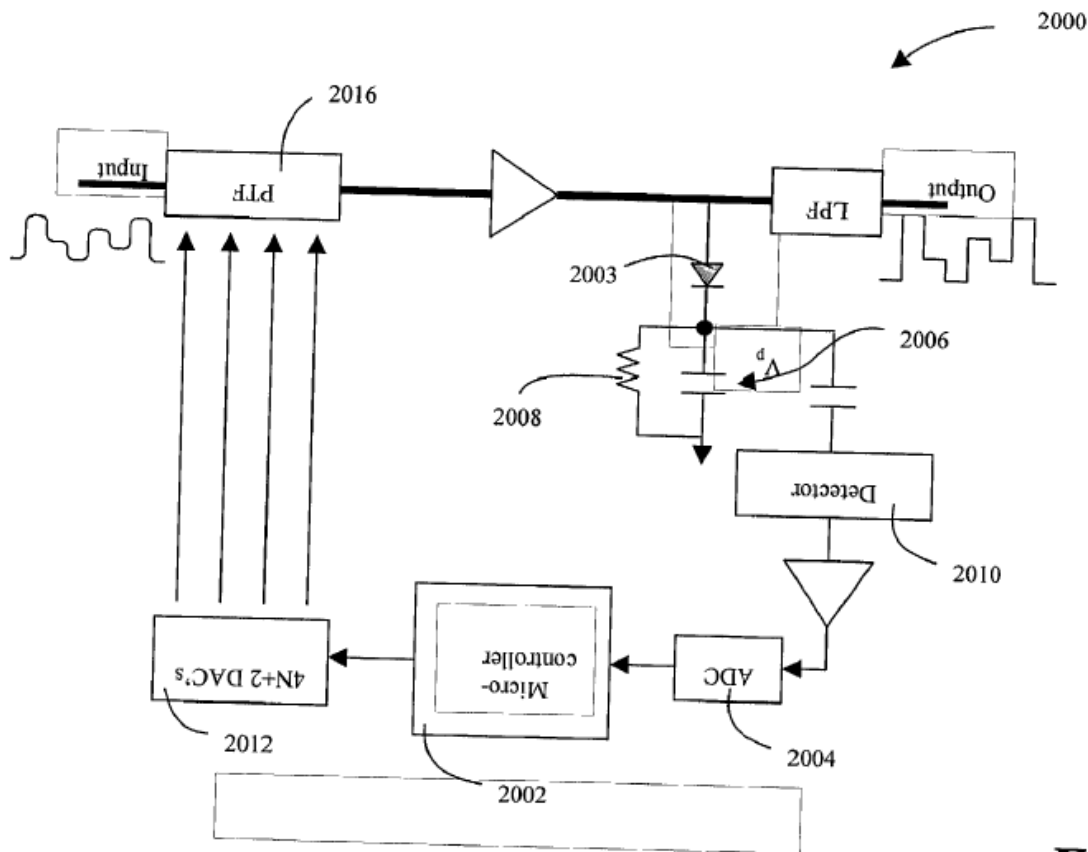


Fig. 20

Third, Vrazel discloses that its ADC receives input signals distorted by the optical link. EX-1006 [0128]. Vrazel describes sampling the received signal at random points in time based on a history of received inputs, and via Digital Signal Processor (DSP) 2502, using that history to adjust the ADC thresholds. EX-1006 [0130], [0134], [0135]. Vrazel explains that using this sampling approach to adjust detection thresholds compensates for “time varying distortion/noise of the received signal.” EX-1006 [0135]. A POSA understood that using the DSP in conjunction with the post-compensation circuitry (*an equalizer*) to adjust the detection thresholds

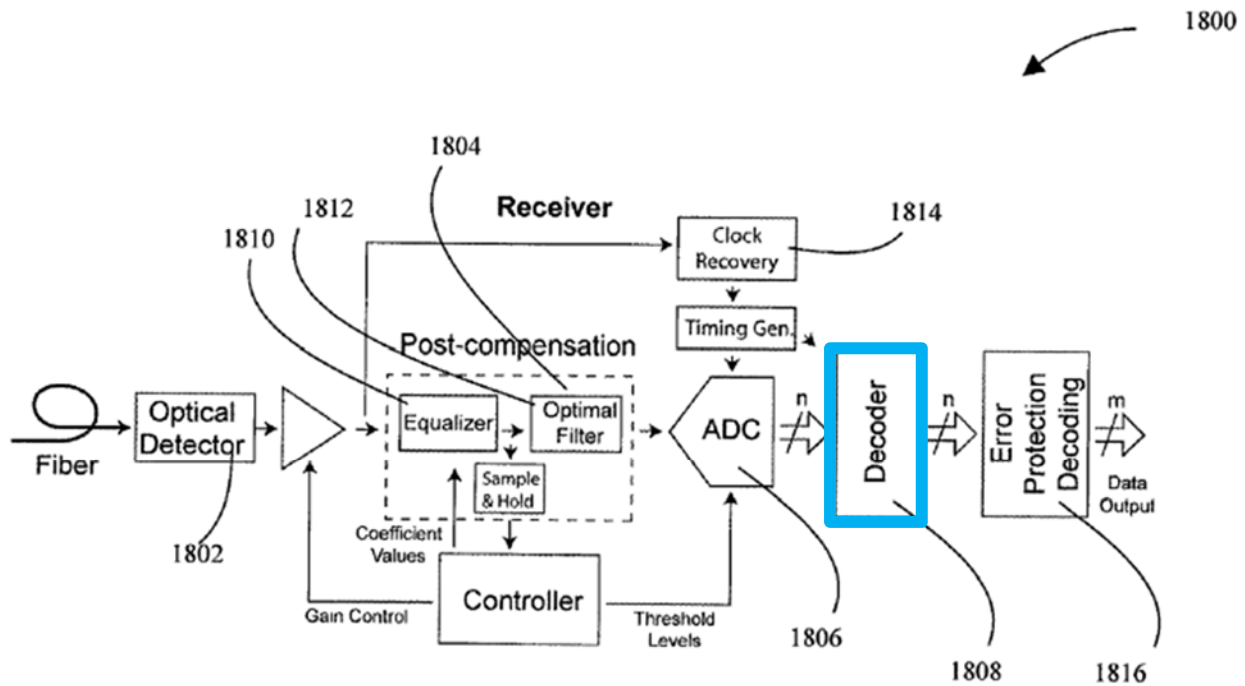
to compensate for distortion/noise of the received signal is performing equalization to remove noise from the signal output by the post-compensation circuitry (*for performing equalization on the second m-ary modulation signal to remove noise*).

EX-1003 ¶116.

[1j] an m-ary demodulator for decreasing the number of bits per symbol in the equalized second m-ary modulation signal to produce the second electrical data signal.

Vrazel discloses this limitation. EX-1003 ¶¶117-119.

Vrazel, in Figure 18 (below), discloses that Analog to Digital Converter 1806 outputs n digital data streams, and these n data streams are then input into decoder 1808 (blue) (*an m-ary demodulator*). EX-1006 [0113], FIG. 18. This decoder “converts a coded n-bit word each clock cycle into [a] corresponding n-bit word” that was initially input to the transmitter encoder shown in Figures 5 and 6, as discussed above for [1c]. EX-1006 [0113]. The output of this decoder is error-protected data that is then input to error protection decoding module 1816. EX-1006 [0113]. For example, a 16-level amplitude-modulated signal detected by optical detector 1802 can be ultimately converted to four digital data streams, thereby reducing the number of bits per symbol. EX-1006 [113].



A POSA understood that decoder 1808 is an *m*-ary demodulator for decreasing the number of bits per symbol because it receives the coded *n*-bit *m*-ary modulation signal output from the ADC (*the equalized second m-ary modulation signal*) on the receive side and converts it to an *n*-bit signal corresponding to the *n*-bit signal initially input to the transmitter encoder in [1b] having fewer bits per symbol, and outputs an error protected data signal (*a second electrical data signal*) that is then input to error protection decoding module 1816. EX-1003 ¶119; EX-1006 [0113], FIG. 18.

b. Claim 2

[2pre] The pluggable optical transceiver module of claim 1, [2a] wherein the form factor of the pluggable optical transceiver module is a pluggable form factor standard.

Pang discloses [2a]. EX-1003 ¶120. As discussed above for [1pre], Pang discloses that pluggable fiber optic module 1700 is an “MTRJ-**SFP** pluggable fiber optic module,” which can be plugged into and out of a host system. EX-1007 [150], [0155], [0156], FIG. 17A; [1pre]. Pang discloses that the “form factor or size of the fiber optic module is of concern” and “it is desirable to reduce the footprint of the fiber optic module.” EX-1007 [0006]. A POSA understood that the acronym “**SFP**” referred to “**Small Form-Factor Pluggable**,” which, as discussed above, and the ’181 Patent admits, was a common *pluggable form factor standard* known in the art at the time of the alleged invention. EX-1003 ¶120; EX-1001 11:24-26, 34-37 (identifying “SFP and SFP+” as “[c]ommon” form factors); EX-1013 1. A POSA understood that pluggable form factor standards, such as SFP, had the advantage of allowing interoperability between pluggable transceivers and host systems. EX-1003 ¶120; EX-1013 1-3, 34-35.

c. Claim 3

[3pre] The pluggable optical transceiver module of claim 2, [3a] wherein the pluggable form factor standard of the pluggable optical transceiver module is a small form factor pluggable (SFP) or SFP+ form factor standard.

Pang, alone or in view of Vrazel, discloses claim 3 for the reasons discussed for claim 2. *See* [2a]; EX-1003 ¶121.

d. Claim 5

[5pre] The pluggable optical transceiver module of claim 1, [5a] wherein the m-ary modulator and the m-ary demodulator perform m-ary quadrature amplitude modulation and de-modulation, respectively, that uses two or more bits per symbol.

Vrazel discloses [5a]. EX-1003 ¶¶122-123. As discussed above for [1b] and [1j], Vrazel discloses the *m-ary modulator* and *demodulator* of claim 5. *See* [1b], [1j]; EX-1003 ¶122. Vrazel discloses that “quadrature amplitude modulation (QAM)” was a known multilevel modulation technique and that its system performs “2ⁿ-QAM” to increase system throughput. EX-1006 [0010], [0041] (QAM was a “representative advanced modulation technique”), [0042]. A POSA understood that “Quadrature Amplitude Modulation (QAM)” is an m-ary modulation technique that, as the ’181 Patent admits, was “known in the art” to increase the number of bits per symbol transmitted. EX-1003 ¶122; EX-1001 10:20-31; EX-1006 [0010], [0041], [0042].

A POSA would be motivated to modify Pang’s teaching to perform “quadrature amplitude modulation (QAM)” (*m-ary quadrature amplitude*

modulation and de-modulation) taught by Vrazel because it was a well-known modulation technique to increase the number of bits per symbol transmitted and adds little or no complexity to the optical components of the transmitter and receiver. EX-1003 ¶123; EX-1006 [0010], [0011], [0041], [0042]; EX-1001 10:20-31.

e. Claim 6

[6pre] The pluggable optical transceiver module of claim 1, [6a] wherein the m-ary modulator and the m-ary demodulator perform m-ary quadrature phase shift keying modulation and de-modulation, respectively, that uses two or more bits per symbol.

Vrazel discloses [6a]. EX-1003 ¶¶124-125. As discussed above for [1b] and [1j], Vrazel discloses the *m-ary modulator and demodulator* of claim 6. See [1b], [1j]; EX-1003 ¶124. Vrazel discloses that “ 2^n -ary phase shift keying (2^n -PSK)” was a known multilevel modulation technique and that its system performs “ 2^n -PSK” to increase system throughput. EX-1006 [0010], [0039] (“representative advanced modulation techniques include multilevel . . . phase shift keying modulations”), [0041], [0042]. A POSA understood that “Quadrature Phase Shift Keying (QPSK)” is a form of 2^n -ary phase shift keying where $n = 2$, and an *m-ary modulation technique* that, as the ’181 Patent admits, was “known in the art” to increase the number of bits per symbol transmitted. EX-1003 ¶124; EX-1001 10:20-31.

A POSA would be motivated to modify Pang’s teaching to perform “ 2^n -ary phase shift keying (2^n -PSK)” taught by Vrazel where $n=2$, which corresponds to *m-ary quadrature phase shift keying modulation and de-modulation* because it was a

well-known modulation technique to increase the number of bits per symbol transmitted and adds little or no complexity to the optical components of the transmitter and receiver. EX-1003 ¶125; EX-1006 [0010], [0011], [0039], [0041], [0042]; EX-1001 10:20-31.

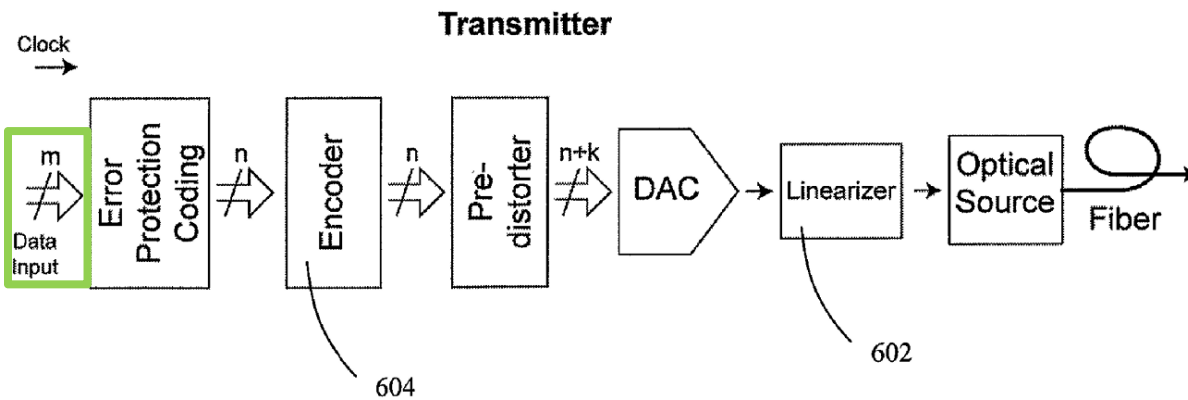
f. Claim 8

[8pre] The pluggable optical transceiver module of claim 1, [8a] wherein the electrical system interface includes parallel signals.

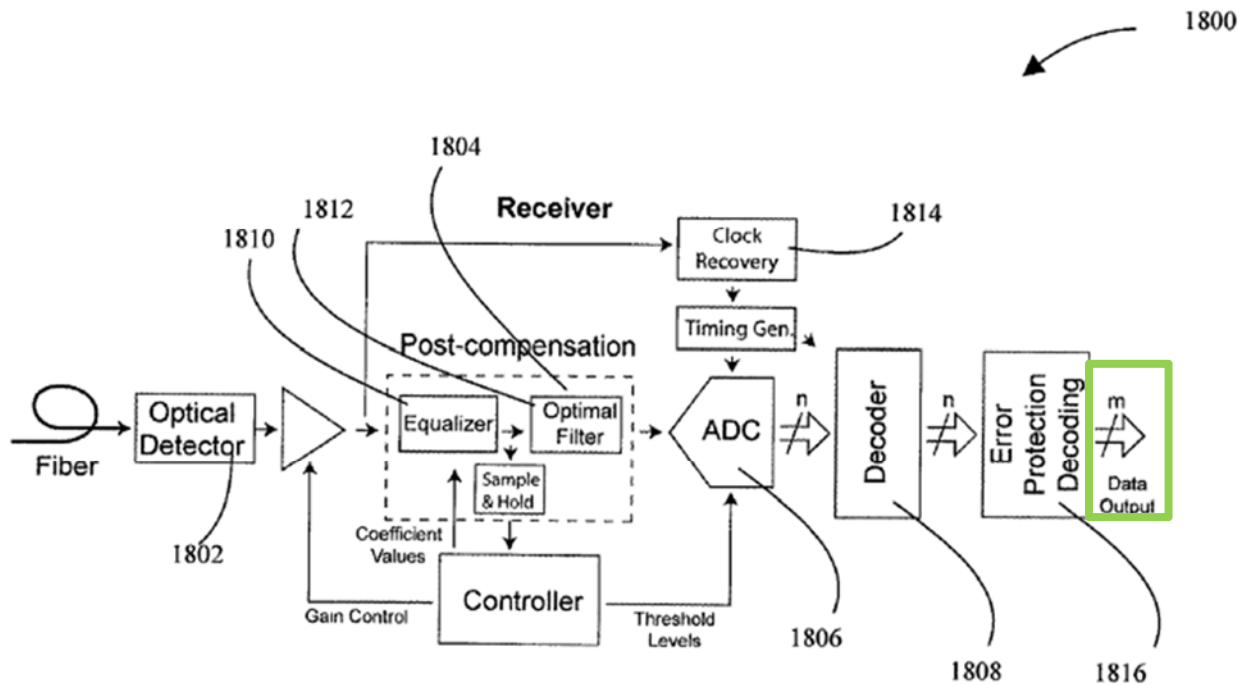
Pang, alone or in view of Vrazel, discloses [8a]. EX-1003 ¶¶126-129. As discussed above for [1a], Pang discloses a pluggable transceiver having an edge connection coupled to an edge connector where it connects to the host system (*an electrical system interface*). EX-1007 [0180], [0182], FIGs. 17A, 20. Pang discloses that this connection interface is used to provide “connections for signal or data lines.” EX-1007 [0190]. Pang discloses that the module can transmit/receive “a plurality of channels in parallel” (*parallel signals*). EX-1007 [0191]. Thus, a POSA understood that Pang’s *electrical system interface includes parallel signals*. EX-1003 ¶126.

To the extent that PO argues that Pang does not expressly disclose *parallel signals*, Vrazel discloses this limitation because the electrical signals transmitted/received at Vrazel’s electrical interfaces each consists of multiple data streams that are transmitted/received in parallel. EX-1003 ¶127. Vrazel discloses, in Figure 6, that its optical transmitter begins with an EPC module, which receives

an m-bit input word that consists of “m input data streams.” EX-1006 [0050]. This is depicted in Figure 6 by the parallel arrow (green) to the left of the electrical system interface (where the m-bit word inputs the EPC module as “Data Input”). EX-1006 FIG. 6; EX-1003 ¶127.



Vrazel discloses that its optical receiver includes an EPD module 1816, which decodes an n-bit word and, as shown in Figure 18, outputs an m-bit word, converting the received symbols back into “one or more binary output data streams.” EX-1006 [0113], FIG. 18; EX-1003 ¶128. This is depicted in Figure 18 by the parallel arrow (green) to the right of electrical system interface (where the one or more data streams output the EPD as “Data Output”). EX-1006 [0113], FIG. 18; EX-1003 ¶128.



A POSA understood that both the m-bit signal input to the EPC (depicted by the parallel arrow to the left of the EPC in Figure 6) and the m-bit signal output by the EPD (depicted by the parallel arrow to the right of the EPD in Figure 18) are *parallel signals* because they consist of corresponding data streams that are transmitted and received in parallel from the transmit side of the electrical interface to receive side of the electrical interface. EX-1003 ¶129. A POSA would be motivated to modify Pang’s teachings with Vrazel’s teachings for the reasons discussed in §VI.A.3. EX-1003 ¶129.

g. Claim 10

[10pre] The pluggable optical transceiver module of claim 1, [10a] wherein the first electrical data signal and second electrical data signal includes parallel electrical data signals.

Pang, alone or in view of Vrazel, discloses claim 10 for the reasons discussed for claim 8. *See* [8a]; EX-1003 ¶130.

h. Claim 12

[12pre] The pluggable optical transceiver module of claim 1, [12a] wherein the first optical signal on a first wavelength is configured to emit into a first optical fiber and the second optical signal on a second wavelength is configured to be received from the first optical fiber.

Pang, alone or in view of Vrazel, discloses [12a]. EX-1003 ¶¶131-133.

Pang discloses that fiber optic module 1700 has a nose receptacle for coupling to a fiber optic connector or plug of an optical fiber. EX-1007 [0163]. Pang explains that the optical fiber may provide “bi-directional” optical communication, meaning that signals are transmitted and received on the same optical fiber. EX-1007 [0163]; EX-1003 ¶132. A POSA understood that the technique of transmitting multiple wavelengths onto the same fiber optic cable is known as “Wavelength Division Multiplexing” (WDM). EX-1003 ¶132; EX-1006 [0004]. As evidenced by Tan, for example, a POSA would recognize that transmit data and receive data are multiplexed onto the same optical fiber using two different wavelengths because multiplexing data onto the transmit channel and demultiplexing data off of the output channel of the fiber optic cable was a well-known and conventional technique used

for bi-directional communication in optical transceivers. EX-1003 ¶132; EX-1006 [0010]; EX-1005 [0004], [0005], [0023], [0028], [0066], FIG. 6D.

A POSA would be motivated to modify Pang’s teaching with the signal processing techniques taught by Vrazel such that for bidirectional communication, *the first optical signal on a first wavelength is configured to emit into a first optical fiber and the second optical signal on a second wavelength is configured to be received from the first optical fiber* because Vrazel teaches, for example, that its techniques may be used in combination with WDM techniques to achieve even greater increases in data transmission rates, and that the use of such modulation techniques can achieve these increases without replacing existing optical fiber and adds little or no complexity to the optical components of the transmitter and receiver. EX-1003 ¶133; EX-1006 [0010], [0011].

i. Claim 13

[13pre] The pluggable optical transceiver module of claim 1, [13a] wherein the first optical signal on a first wavelength is configured to emit into a first optical fiber and the second optical signal on a second wavelength is configured to be received from a second optical fiber.

Pang discloses [13a]. EX-1003 ¶¶134-135. Pang discloses that fiber optic module 1700 has a nose receptacle for coupling to a fiber optic connector or plug of an optical fiber. EX-1007 [0163]. Pang explains that the optical fiber may provide “unidirectional” communication, such that optical signals are transmitted on one fiber and received on another. EX-1007 [0163] (disclosing the “optical fiber may

be one or more optical fibers to provide unidirectional . . . communication”), [0006] (stating that “in [certain] small form factor optical modules . . . the two optical fibers are separated by a distance of only 0.75 mm”), claim 12 (requiring transmission into a first optical fiber), claim 13 (requiring receiving from a second optical fiber); EX-1003 ¶134.

A POSA would find it obvious that, for unidirectional communication, Pang’s first optical signal is configured to emit *into a first optical fiber* and the second optical signal is configured *to be received from a second optical fiber* because Pang teaches that the optical fibers may be unidirectional and thus that optical signals are transmitted on one fiber and received on another. EX-1003 ¶135.

j. Claim 14

[14pre] The pluggable optical transceiver module of claim 1, [14a] wherein the noise removed by the equalizer includes intersymbol interference (ISI).

Vrazel discloses [14a]. EX-1003 ¶136. As discussed above for [1i], Vrazel discloses the *equalizer* of claim 14. See [1i]; EX-1003 ¶136. Vrazel discloses adaptive transversal filter 2000 that adjusts the amplitude of a received symbol based on equalizer tap gains that are “calculated in microcontroller 2002 in order to remove the effect of intersymbol interference.” EX-1006 [0117], FIG. 20.

k. Claim 15

[15pre] The pluggable optical transceiver module of claim 1, [15a] wherein the equalizer performs decision directed equalization on the second m-ary modulation signal to remove noise.

Vrazel discloses [15a]. EX-1003 ¶¶137-138. According to the '181 Patent, “[d]ecision-directed equalization is an equalization method in which a known training sequence is sent during the training period and the receiver/transceiver uses the knowledge of the training sequence to learn about the channel characteristics.” EX-1001 12:30-34. As discussed above for [1i], Vrazel discloses adaptive transversal filter 2000 (*the equalizer*) that adjusts the amplitude of a received symbol based on equalizer tap gains calculated in microcontroller 2002 to remove the effect of intersymbol interference. EX-1006 [0117], [0118], FIG. 20. Vrazel discloses that this circuit includes programmable transversal filter (PTF) 2016 that frequency equalizes the signal, followed by a low pass filter (optimal filter 2100) to remove noise. EX-1006 [0121]. Microcontroller 2002 selects the gain coefficients of the PTF and may use known numerical techniques including, “e.g., minimum mean-squared error method, ***gradient methods***, bisection, genetic algorithm.” EX-1006 [0118]. A POSA was aware that “gradient methods” refers to “gradient search algorithms,” (GSAs) which a POSA knew were “generally suitable for fiber-optic systems since their computational complexity is much lower.” EX-1017 982-83; EX-1003, ¶137. Further, a POSA was aware that GSAs include algorithms that

require “very reliable estimates of data symbols,” and that this was “generally achieved by initially using a known sequence to train the equalizer.” EX-1017 983; EX-1003, ¶137.

A POSA understood that Vrazel’s adaptive transversal filter 2000 *performs directed decision equalization on the second m-ary modulation signal to remove noise* because it adjusts the amplitude of the received symbol (*the second m-ary modulation signal*) based on equalizer tap gains to remove intersymbol interference and, via microcontroller 2002, calculates equalizer tap weights using known algorithms such as gradient search algorithms that rely on using a known sequence to train the equalizer to achieve initial channel estimates. EX-1003 ¶138; EX-1006 [0117], [0118], [0121]; EX-1017 982-983.

I. Claim 16

[16pre] The pluggable optical transceiver module of claim 1, [16a] wherein the equalizer performs blind equalization on the second m-ary modulation signal to remove noise.

Vrazel discloses [16a]. EX-1003 ¶¶139-141. According to the ’181 Patent, “[b]lind equalization is a process during which an unknown input data sequence is recovered from the output signal of an unknown channel.” EX-1001 12:36-38. As discussed above for [1i], Vrazel discloses an adaptive transversal filter 2000 (*the equalizer*) that adjusts the amplitude of a received symbol based on equalizer tap gains calculated in the microcontroller to remove the effect of intersymbol

interference. EX-1006 [0117], [0118], FIG. 20. Vrazel discloses that this circuit includes programmable transversal filter (PTF) 2016 that frequency equalizes the signal, followed by a low pass filter (optimal filter 2100) to remove noise. EX-1006 [0121].

Vrazel explains that “[s]ince there may be no knowledge of the frequency content of the random data at any given time . . . the microcontroller must perform a multidimensional optimization to minimize a single scalar quantity.” EX-1006 [0118]; EX-1003 ¶140.

A POSA understood that Vrazel’s adaptive transversal filter 2000 *performs blind equalization on the second m-ary modulation signal to remove noise* because it adjusts the amplitude of the received symbol (*the second m-ary modulation signal*) based on equalizer tap gains to remove intersymbol interference and, via PTF 2016, frequency equalizes the signal to remove noise where there may be no knowledge of the frequency content of the random data at any given time. EX-1003 ¶141; EX-1006 [0117], [0118], [0121].

m. Claim 17

[17pre] The pluggable optical transceiver module of claim 1, [17a] wherein the digital to analog converter is configured to shape, condition, or emphasize the first electrical m-ary analog modulation signal for improved transmission performance.

Vrazel discloses [17a]. EX-1003 ¶¶142-143. As discussed above for [1c], Vrazel discloses a *digital to analog converter* (DAC) that receives, e.g., an *n*-bit

input data signal in the digital domain and outputs an analog electrical signal (*first electrical m-ary analog modulation signal*) “that can be used to modulate the optical source.” EX-1006 [0051]. Vrazel, in Figure 5, discloses analog precompensation circuitry 506 that includes pre-distortion circuit 511 and linearizer 512 that modify the transmitted signal based on known link performance and known non-linearities of the optical source in order “to produce a faithful output at the receiver.” EX-1006 [0069]. These circuits modify the transmitted signal to account for transmission impairments, *i.e.*, they *condition the first electrical m-ary analog modulation signal for improved transmission performance*. EX-1003 ¶142.

A POSA understood that because the DAC converts the digital input data signal to an analog signal that can be used to modulate the optical source, it *conditions the first electrical m-ary analog modulation signal for improved transmission performance*, since the DAC’s operation is necessary for transmission of the analog signal via the optical transmitter to the receive side of the optical transceiver. EX-1006 [0051]; EX-1003 ¶143.

n. Claim 22

[22pre] A pluggable optical transceiver module comprising of:

See [1pre]; EX-1003 ¶144.

[22a] an electrical system interface for receiving a first electrical data signal and for transmitting a second electrical data signal;

See [1a]; EX-1003 ¶145.

[22b] an m-ary modulator for increasing the number of bits per symbol in the first electrical data signal to produce a first m-ary modulation signal;

See [1b]; EX-1003 ¶146.

[22c] a digital to analog converter for converting the first m-ary modulation signal to a first electrical m-ary analog modulation signal;

See [1c]; EX-1003 ¶147.

[22d] a driver for amplifying the first electrical m-ary analog modulation signal to an amplified first electrical m-ary analog modulation signal to drive an optical transmitter;

See [1d]; EX-1003 ¶148.

[22e] the optical transmitter for emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary analog modulation signal from the driver;

See [1e]; EX-1003 ¶149.

[22f] an optical detector for receiving a second optical signal on a second wavelength to produce an electrical analog signal;

See [1f]; EX-1003 ¶150.

[22g] an amplifier for amplifying the electrical analog signal to an amplified electrical analog signal;

See [1g]; EX-1003 ¶151.

[22h] a clock data recovery unit for recovering clock and data information to produce a second m-ary modulation signal from the amplified electrical analog signal;

See [1h]; EX-1003 ¶152.

[22i] an equalizer for performing equalization on the second m-ary modulation signal to remove noise;

See [1i]; EX-1003 ¶153.

[22j] an m-ary demodulator for decreasing the number of bits per symbol in the equalized second m-ary modulation signal to produce the second electrical data signal; and

See [1j]; EX-1003 ¶154.

[22k] wherein the m-ary modulator and the m-ary demodulator perform m-ary pulse amplitude modulation and de-modulation, respectively, that uses two or more bits per symbol.

Vrazel discloses [22k]. EX-1003 ¶¶155-156. As discussed above for [1b] and [1j], Vrazel discloses the *m-ary modulator* and *demodulator* of claim 22. *See* [1b], [1j]; EX-1003 ¶155. Vrazel discloses that “ 2^n -ary amplitude shift keying (ASK)” was a known multilevel modulation technique. EX-1006 [0010]. A POSA understood that, for values of n greater than 1, 2^n -ary ASK is “Pulse Amplitude Modulation (PAM),” which the ’181 Patent admits is an *m-ary* modulation technique “known in the art” to increase the number of bits per symbol transmitted. EX-1003 ¶155; EX-1001 10:20-31. A POSA would know that, when $n=2$ for example, 4-ary ASK has four levels or amplitudes, and thus is the same as PAM-4, which *uses two or more bits per symbol*. EX-1003 ¶155; EX-1021 1:59-60 (referring to *m-ary* amplitude shift keying as pulse amplitude modulation).

A POSA would be motivated to modify Pang’s teaching to perform “ 2^n -ary amplitude shift keying (ASK)” modulation taught by Vrazel for values of n greater

than 1, which corresponds to *m*-ary pulse amplitude modulation and de-modulation, because it was a well-known modulation technique to increase the number of bits per symbol transmitted and adds little or no complexity to the optical components of the transmitter and receiver. EX-1003 ¶156; EX-1006 [0010], [0011]; EX-1001 10:20-31.

o. Claim 23

[23pre] pluggable optical transceiver module comprising of:

See [1pre]; EX-1003 ¶157.

[23a] an electrical system interface for receiving a first electrical data signal and for transmitting a second electrical data signal;

See [1a]; EX-1003 ¶158.

[23b] an m-ary modulator for increasing the number of bits per symbol in the first electrical data signal to produce a first m-ary modulation signal;

See [1b]; EX-1003 ¶159.

[23c] a digital to analog converter for converting the first m-ary modulation signal to a first electrical m-ary analog modulation signal;

See [1c]; EX-1003 ¶160.

[23d] a driver for amplifying the first electrical m-ary analog modulation signal to an amplified first electrical m-ary analog modulation signal to drive an optical transmitter;

See [1d]; EX-1003 ¶161.

[23e] the optical transmitter for emitting a first optical signal on a first wavelength responsive to and representative of the amplified first electrical m-ary analog modulation signal from the driver;

See [1e]; EX-1003 ¶162.

[23f] an optical detector for receiving a second optical signal on a second wavelength to produce an electrical analog signal;

See [1f]; EX-1003 ¶163.

[23g] an amplifier for amplifying the electrical analog signal to an amplified electrical analog signal;

See [1g]; EX-1003 ¶164.

[23h] a clock data recovery unit for recovering clock and data information to produce a second m-ary modulation signal from the amplified electrical analog signal;

See [1pre]; EX-1003 ¶165.

[23i] an equalizer for performing equalization on the second m-ary modulation signal to remove noise;

See [1i]; EX-1003 ¶166.

[23j] an m-ary demodulator for decreasing the number of bits per symbol in the equalized second m-ary modulation signal to produce the second electrical data signal; and

See [1j]; EX-1003 ¶167.

[23k] wherein the equalizer includes coefficients or weights configured to remove noise from the second m-ary modulation signal.

Vrazel discloses [23k]. EX-1003 ¶¶168-169. Vrazel discloses adaptive transversal filter 2000 that adjusts the amplitude of a received symbol based on equalizer tap gains calculated in microcontroller 2002 in order to remove the effect

of intersymbol interference. EX-1006 [0117], FIG. 20. Vrazel discloses that “the job of the microcontroller 2002 *is to appropriately select the gain coefficients.*” EX-1006 [0118]. Vrazel explains that one of the techniques employed by the microcontroller is to “repeat this procedure to determine the appropriate equalizer tap gains (*weights*).” EX-1006 [0118]; EX-1003 ¶168. As discussed for [1i], a POSA understood that adjusting the amplitude of a received symbol based on equalizer tap gains is a technique for noise removal well-known in the art. EX-1003 ¶168; EX- 1020 1:14-20.

A POSA understood that Vrazel’s adaptive transversal filter is *an equalizer that includes coefficients or weights adapted to remove noise from the second m-ary modulation signal* because it adjusts the amplitude of the received symbol based on equalizer tap gains (weights) and selected gain coefficients to remove intersymbol interference and via the PTF 2016, frequency equalizes the signal to remove noise. EX-1003 ¶169; EX-1006 [0117], [0118], [0121], FIG. 20.

B. Ground 2: Claim 11 Is Obvious Over Pang in view of Vrazel and Fujimori

1. Fujimori (EX-1028)

a. Analogous Art

Fujimori is analogous art to the claimed invention. Fujimori is in the same field of endeavor as the ’181 Patent because it relates to “optical networking hardware,” including “optical-based transceiver[s]” and “small form factor optical

modules.” EX-1028 1:34-35, 2:36-41, 2:42-43, FIG. 3; EX-1003 ¶170. Fujimori is reasonably pertinent to the problem addressed by the ’181 Patent’s claim invention because Fujimori’s solution provides for “higher bandwidth in digital communications,” “higher data rates and bandwidth” and “high-speed” optical transceivers. EX-1028 1:43-44, 2:7-12; EX-1001 Title, 1:1-3; 6:12-13; EX-1003 ¶170.

b. Overview of Fujimori

Fujimori discloses a method and system for adjusting a gain and/or frequency response of an input signal for a multimode device, including an optical transceiver. EX-1028 Abstract, 2:9-10, 2:36. In one embodiment, Fujimori describes the use of a XAUI (attachment unit interface) that allows for higher-speed communications between the optical transceiver and host system. EX-1028 5:65-67, FIG. 1. Fujimori discloses that the host system may interface with transceiver module 100 through a 10 Gbps Ethernet attachment unit interface (XAUI) 135. EX-1028 6:43-46. Fujimori discloses that the XAUI may configured via its transmit and receive interfaces to achieve “compatible . . . operational speeds” and “throughput of about 10 Gbps.” EX-1028 6:58-64.

2. Motivation to Combine Pang, Vrazel, and Fujimori

A POSA at the time of the alleged invention was aware of the 10 Gigabit Attachment Unit Interface, or “XAUI.” EX-1033.002. XAUI is “a full duplex

interface” that “dramatically improves and simplifies the routing of electrical interconnections,” and was known to be “ideal for chip-to-chip, board-to-board, and chip to optics module applications.” EX-1033.002. A POSA was aware that by 2002, “ASIC, FPGA, and optical module vendors [were] all introducing products with XAUI interfaces” and industry efforts were underway to ensure that “vendors’ offerings [were] interoperable.” EX-1033.002; EX-1034 8. XAUI had been selected as the electrical interface for pluggable module MSAs such as XGP and XENPAK. EX-1033.006.

A POSA would be motivated to combine Pang’s teaching of a pluggable optical transceiver, as modified with Vrazel’s m-ary modulation and signal processing techniques, with Fujimori’s teaching of a XAUI interface because a POSA would know that XAUI had been widely adopted by 2002 and was known to be suitable for “chip to optics module applications,” *i.e.*, XAUI was suitable for pluggable optical transceivers and optics module vendors were introducing products with XAUI interfaces. EX-1003 ¶¶172-173. A POSA would have a reasonable expectation of success because Fujimori teaches that the use of XAUI interfaces was conventional and well known in the art for use in optical transceiver systems requiring higher data rates and bandwidth, and both Pang and Vrazel involve high transmission rate communications over fiber optic networks. EX-1003 ¶173; EX-

1028 2:7-11; EX-1007 [0005], [0006]; EX-1006 [0002] (addressing “increasing the throughput of data transmission over an optical fiber communication system”).

Further, a POSA would be motivated to implement Fujimori’s teaching of using a XAUI interface in modified-Pang’s teaching to achieve higher communication speeds and adding little or no complexity to the transceiver’s optical components. EX-1003 ¶174; EX-1028 2:7-11, 6:58-64; EX-1006 [0010]-[0012].

3. Detailed Application to the Challenged Claims

a. Claim 11

[11pre] The pluggable optical transceiver module of claim 1, [11a] wherein the electrical system interface includes an attachment unit interface (AUI) based interface.

Pang in view of Vrazel and Fujimori discloses claim 11. Pang in view of Vrazel discloses [11pre] for the reasons discussed above for claim 1. EX-1003 ¶175.

Fujimori discloses [11a]. EX-1003 ¶176. As discussed for [1a], Pang or modified-Pang discloses *the electrical system interface*. EX-1003 ¶175. Fujimori describes the use of a XAUI that allows for higher-speed communications between the optical transceiver and host system. EX-1028 5:65-67, 6:43-46, FIG. 1. 6:43-46. Based on Fujimori’s disclosure, a POSA would find it obvious to include a XAUI (*an attachment unit interface (AUI) based interface*) because, as the ’181 Patent admits, it was a “conventional interface[]” and well known in the art for use with optical transceivers for high speed communications. EX-1001 9:22-26; EX-1028

6:43-7:2, FIGs. 1, 3; EX-1029 1:13-16, 3:49-5:1, FIG. 1; EX-1030 16, 27; EX-1003 ¶176. A POSA would be motivated to modify modified-Pang's teachings with the XAUI taught by Fujimori for the reasons discussed in §VI.B.2. EX-1003 ¶176.

VII. THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. The Board Should Not Deny Institution Under 35 U.S.C. §325(d)

The Board should not exercise its discretion to deny institution under §325(d) because the grounds asserted in this Petition are neither the same nor substantially the same as nor cumulative to art or arguments presented during prosecution or asserted in IPR2021-01359 or IPR2023-00681. The Board uses a two-part framework in determining whether to exercise discretion under §325(d). *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 (PTAB Feb. 13, 2020) (precedential).

Under the first part of the *Advanced Bionics* framework, none of the references or the combinations asserted in this Petition were “previously presented to the Office.” *Advanced Bionics*, Paper 6 at 7-8. None of Pang, Vrazel, or Fujimori were cited or considered by the Examiner during prosecution; nor were the combinations of references in Grounds 1 and 2 ever considered. These references also are not cumulative of any art considered during prosecution; nor cumulative of any art presented in IPR2021-01359 or IPR2023-00681. The Examiner never

applied any combination of references in the same or substantially the same manner as applied in this Petition.

The Examiner relied on Brede as a primary reference, alone and in combinations with Aronson and Sheth. EX-1004 126, 174, 177. Unlike Pang, however, Brede does not disclose a pluggable optical transceiver. Rather, Brede discloses an HDT device mounted with screws to a metal frame of a shelf/rack that does not function as a pluggable unit. EX-1004 69. Pang, on the other hand, is directed to pluggable optical transceivers. Pang's disclosure is neither the same as or substantially the same as, nor cumulative of Brede's. The Examiner also never applied a pluggable optical transceiver reference such as Pang as the primary reference in any obviousness combination.

In contrast to how the Examiner applied Aronson and Sheth during prosecution, here, Vrazel is applied in a completely different manner with a completely different motivation to combine. *See* §VI.A. Vrazel discloses the well-known use of conventional signal processing and modulation techniques for increasing data transmission rates that add little or no complexity to the optical components of the transmitter and receiver. Vrazel [0002], [0039]. Neither Aronson nor Sheth include this same disclosure. Vrazel's disclosure is neither the same as nor substantially the same as Aronson's or Sheth's. None of the secondary references

discussed by the Examiner or identified in the grounds of IPR2021-01359 or IPR2023-00681 provides the same or substantially the same disclosure as Vrazel.

Because the conditions of the first part of the *Advanced Bionics* framework are not met, the Board should decline to exercise its discretion to deny institution under §325(d) and need not address the second part.

Even if the Board were to consider the second part of the *Advanced Bionics* framework, the Office nonetheless erred in a manner material to the patentability of Challenged Claims. The Examiner never considered or identified any combination with Pang as a primary reference or Vrazel and Fujimori as secondary references. In failing to identify and consider these references, the Examiner materially erred.

This Petition presents extensive analysis explaining how the combinations of Pang and Vrazel (Ground 1) and Pang, Vrazel, and Fujimori (Ground 2) disclose the limitations of the Challenged Claims, as well as the reasons a POSA would be motivated to combine the references' teachings. This additional evidence, not previously considered during prosecution or in IPR2021-01359 or IPR2023-00681, warrants consideration in this proceeding. For example, this Petition is supported by the expert testimony of Dr. Min (EX-1003), which explains how a POSA would have understood the references and why a POSA would have combined their teachings. This new evidence weighs against discretionary denial. *See, e.g., Puma N. Am., Inc. v. Nike, Inc.*, IPR2019-01058, Paper 10, 19 (PTAB Oct. 31, 2019)

(granting institution where “new non-cumulative evidence.... helpful to our consideration of a prior art combination that was not before the Examiner”).

Accordingly, for at least the above reasons, the Board should not exercise its discretion to deny institution under §325(d).

B. The Board Should Not Deny Institution Under 35 U.S.C. §314(a)

In *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential), the Board set forth factors to guide whether to discretionarily deny institution in view of an earlier trial date in a parallel proceeding. On June 21, 2022, the Director issued interim procedure regarding application of the *Fintiv* factors (“Interim Procedure”). The Interim Procedure states that “the PTAB will not deny institution of an IPR ... under *Fintiv* (i) when a petition presents compelling evidence of unpatentability . . . or (iii) where a petitioner stipulates not to pursue in a parallel district court proceeding the same grounds as in the petition or any grounds that could have reasonably been raised in the petition.” Interim Procedure 9.

Petitioner satisfies both of these requirements. First, Petitioner presents compelling evidence of unpatentability of the Challenged Claims. Petitioner details how the primary reference, Pang, in combination with Vrazel, and with Vrazel and Fujimori, render the claims obvious. The evidence presented, if unrebutted in trial, would plainly lead to a conclusion that one or more claims are unpatentable by a preponderance of the evidence. Second, Petitioner adopts the identical stipulation

from *Sotera*, namely, that if the IPR is instituted, Petitioner will not pursue in the district court litigation any ground raised or that could have been reasonably raised in an IPR for the challenged patent. Thus, under the Interim Procedure, the Board should not deny institution.

Nevertheless, a holistic view of the remaining *Fintiv* factors also weighs in favor of institution.

Factor 1 is neutral because no stay has yet been requested in the district court.

Under factor 2, the trial date has been set for all defendants in the co-pending litigation for May 2024. EX-1025 1. According to the most recent statistics on median time-to-trial for civil actions in E.D. Texas, the median time from filing to trial is 21 months. EX-1026 35. The co-pending litigation was filed on August 9, 2022 and thus would be expected to go to trial shortly after May 8, 2024 according to the median time to trial statistics. A Final Written Decision is expected in October 2024. Considering the inherent uncertainties of litigation scheduling, particularly where multiple trials are scheduled for the same date, this factor weighs against discretionary denial.

Factor 3 favors institution. The co-pending litigation is in its early stages, and the investment in it has been minimal. The parties have not exchanged proposed claim terms or constructions, and will not complete claim construction briefing until October 25, 2023. The *Markman* hearing is not until November 2023. Fact discovery

is not set to close until November 8, 2023, and expert discovery is not set to close until January 22, 2024.

Under factor 4, as stated above, Petitioner stipulates under *Sotera* that it will not pursue in the district court litigation any ground raised or that could have been reasonably raised in this IPR. Thus, this factor weighs against discretionary denial.

Under factor 5, Petitioner is a defendant in the co-pending litigation.

Under factor 6, other circumstances weigh in favor of institution. Here, the merits of the Petition are strong and supported by compelling evidence of unpatentability. When viewed holistically, the timing of the present Petition was reasonable, there has been relatively limited investment in the co-pending litigation, and there is minimal overlap between the present IPR and the co-pending. Thus, the efficiency and integrity of the IPR process is best served by instituting review.

C. The Board Should Not Deny Institution Under the *General Plastics* Factors

The *General Plastic* factors do not apply because this is the first and only IPR petition filed by Petitioner challenging claims of the '181 Patent. Petitioner was not involved in any previously-filed IPRs challenging the '181 Patent and there is no overlap between the art and grounds asserted in this Petition and the art and grounds asserted in previous IPRs.

VIII. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Party-in-Interest (37 C.F.R. §42.8(b)(1))

Petitioner certifies that Petitioner Infinera Corporation is a real party-in-interest. Petitioner further certifies that Cisco Systems, Inc. is a real party-in-interest.

B. Related Matters (37 C.F.R. §42.8(b)(2))

1. Judicial Matters

The '181 Patent is the subject of litigation pending against Petitioner filed on August 9, 2022 captioned *NextGen Innovations, LLC v. Infinera Corporation*, No. 2:22-cv-00306-JRG-RSP (E.D. Tex.).

As of the filing date of this Petition and to the best knowledge of Petitioner, the '181 Patent has been involved in the following additional litigations: *NextGen Innovations, LLC v. Nokia of America Corporation et al.*, No. 2:22-cv-00309-JRG-RSP (E.D. Tex.); *NextGen Innovations, LLC v. II-VI, Inc. et al.*, No. 4:20-cv-00854-SDJ (E.D. Tex.); *NextGen Innovations, LLC v. II-VI, Inc. et al.*, No. 4:21-cv-07477-YGR (N.D. Cal.); *NextGen Innovations, LLC v. Fujitsu Network Communications, Inc. et al.*, No. 2:22-cv-00307-JRG-RSP (E.D. Tex.); and *NextGen Innovations, LLC v. AT&T Services, Inc. et al.*, No. 2:22-cv-00308-JRG-RSP (E.D. Tex.)

Petitioner is not aware of any other judicial matter that would affect or be affected by a decision in this IPR.

2. Administrative Matters

As of the filing date of this Petition and to the best knowledge of Petitioner, the '181 Patent has been the subject of the following other *inter partes* reviews: *II-VI, Inc. v. Alexander Soto and Walter Soto*, IPR2021-01359 and *Nokia of America Corporation v. Alexander Soto and Walter Soto*, IPR2023-00681.

Petitioner is not aware of any other administrative matter that would affect or be affected by a decision in this IPR.

C. Lead/Back-up Counsel (37 C.F.R. §42.8(b)(3))

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D. Notice of Service Information (37 C.F.R. §42.8(b)(4))

Please direct all correspondence to lead and back-up counsel at the above addresses. Petitioner consents to electronic service at the email addresses above.

IX. CONCLUSION

For the reasons set forth above, Petitioner has shown a reasonable likelihood of prevailing on all Challenged Claims of the '181 Patent and requests that the Board institute *inter partes* review and cancel all claims as unpatentable.

Dated: April 14, 2023

Respectfully submitted,

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CERTIFICATION OF SERVICE ON PATENT OWNER

Pursuant to 37 C.F.R. §§42.6(e), 42.8(b)(4) and 42.105, the undersigned certifies that on the 14th of April, 2023, a complete and entire copy of this Petition for *Inter Partes* Review of U.S. Patent 10,771,181 and all supporting exhibits were served via Federal Express, postage prepaid, to the correspondence address of record for the '181 Patent:

ALEXANDER SOTO
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Dated: April 14, 2023

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. §42.24 *et seq.*, the undersigned certifies that this document complies with the type-volume limitations. This document contains 13,999 words as calculated by the “Word Count” feature of Microsoft Word for Office 365, the word processing program used to create it.

Dated: April 14, 2023

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