IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

RAMOT AT TEL AVIV UNIVERSITY LTD.,	)	Case No. 2:19-cv-00225-JRG
Plaintiff,	)	JURY TRIAL DEMANDED
v.	)	
CISCO SYSTEMS, INC.,	)	
Defendant.	)	

FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT

TO THE HONORABLE JUDGE OF SAID COURT:

Plaintiff, Ramot at Tel Aviv University Ltd. ("Ramot"), for its First Amended Complaint against Defendant Cisco Systems, Inc. ("Cisco") requests a trial by jury and alleges as follows upon actual knowledge with respect to itself and its own acts and upon information and belief as to all other matters:

NATURE OF THE ACTION

1. This is an action for patent infringement. Ramot alleges that Cisco infringes U.S. Patent Nos. 10,270,535 ("the '535 patent"), 10,033,465 ("the '465 patent") and 10,461,866 ("the '866 patent") (collectively, the "Asserted Patents"), copies of which are attached hereto as Exhibits A-C.

2. Ramot alleges that Cisco directly and indirectly infringes the Asserted Patents by making, using, offering for sale, selling and importing networking equipment with corresponding line cards and optical transceiver modules providing advanced electro-optical modulation techniques—including, without limitation, certain of Cisco's various 100G, 200G, and 400G optical modules and associated circuitry and software. Ramot further alleges that Cisco induces and contributes to the infringement of others. Ramot seeks damages and other relief for Cisco's infringement of the Asserted Patents.

THE PARTIES

1. Ramot is a limited liability company organized under the laws of Israel with its principal place of business at Tel Aviv University, Senate Building at Gate no. 4, George Wise Street, Tel Aviv, Israel.

2. Ramot is the Business Engagement Center of Tel Aviv University ("TAU") and acts as the University's liaison to industry. Ramot connects cutting-edge promising innovations at the University with the global commercial marketplace through collaboration with industry

partners around the world as well as the formation of new companies. TAU was founded in 1956 and is the largest academic and research institution in the State of Israel. It is the most multidisciplinary with many young scientists that graduated from some of the leading research institutions around the world, which resulted in accomplishing the third highest position among the EU scientific community for the young scientist category. Ramot provides the resources, as well as the business and legal frameworks for inventions made by TAU's faculty, students, and researchers, protecting the discoveries with IP and working jointly with industry and the venture community to bring scientific innovations to the global markets.

3. Ramot manages a portfolio of more than 2,271 patents and patent applications worldwide, and approximately half have been licensed to industry for commercialization. This number represents 615 distinct technology families of which more than 30 percent are already commercialized to multi-national companies as well as newly founded companies. Ramot is the owner of more than 400 United States patents and more than 300 United States patent applications.

4. Ramot is the assignee and owner of the Asserted Patents. The Asserted Patents are based on and claim the inventions of Dr. Yossef Ehrlichman, Dr. Amrani Ofer, and Professor Shlomo Ruschin. Each of the inventors was affiliated with TAU's School of Electrical Engineering during the relevant time period of the inventions, and assigned his rights to the Asserted Patents to Ramot.

5. On information and belief, Defendant Cisco is a corporation organized under the laws of California with its principal place of business at 170 W. Tasman Dr., San Jose, CA 95134. Cisco is registered to do business in the State of Texas. Cisco has appointed the Prentice-Hall Corporation System, Inc., 211 E. 7th St., Suite 620, Austin, TX 78701 as its agent for service of process.

6. On information and belief, Cisco maintains places of business and does business in Texas and in the Eastern District of Texas, *inter alia*, at its campus at 2250 East President George Bush Turnpike, Richardson, Texas 75082, and at its data center at 2260 Chelsea Blvd., Allen, Texas 75013. Cisco's Richardson and Allen facilities were appraised and taxed together by the Collin County Appraisal District at a combined value of over $300,000,000.

7. By registering to conduct business in Texas and by having facilities where it regularly conducts business in this District, Defendant has a permanent and continuous presence in Texas and a regular and established place of business in the Eastern District of Texas.

JURISDICTION

8. This is an action arising under the patent laws of the United States, 35 U.S.C. § 271, *et seq*. Accordingly, this Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

9. This Court has personal jurisdiction over Cisco due, *inter alia*, to its continuous presence in, and systematic contact with, this judicial district and its registration in Texas and domicile in this judicial district. Cisco is subject to this Court's jurisdiction pursuant to due process and/or the Texas Long Arm Statute due at least to its substantial business in this State and judicial district, including at least part of its past infringing activities, regularly doing or soliciting business at its Richardson and Allen facilities, and engaging in persistent conduct and/or deriving substantial revenue from goods and services provided to customers in the State of Texas, including in the Eastern District of Texas. Cisco directly and/or through subsidiaries or intermediaries (including distributors, retailers, and others), has committed and continues to commit acts of infringement in this judicial district by, among other things, making, using, importing, offering for sale, and/or selling products and/or services that infringe the Asserted Patents.

VENUE

10. Venue is proper in this judicial district pursuant to 28 U.S.C. §§1391(b), (c), (d) and 1400(b) because Cisco has a permanent and continuous presence in, has committed acts of infringement in, and maintains a regular and established place of business in this district. Upon information and belief, Cisco has committed acts of direct and indirect infringement in this judicial district, including using and purposefully transacting business involving the Accused Products in this judicial district such as by sales to one or more customers in the State of Texas, including in the Eastern District of Texas, and maintains regular and established places of business in this judicial district, as set forth above.

FACTUAL ALLEGATIONS

Ramot Patents

11. Ramot is the Business Engagement Center at Tel Aviv University, Israel's foremost research and teaching university. Ramot's mission is to foster, initiate, lead and manage the transfer of new technologies from the laboratory to the marketplace. Ramot helps commercialize promising scientific discoveries by providing the resources, business, Intellectual Property, and legal framework for researchers—creating successful business connections between Tel Aviv University's scientists and researchers, and technology companies ranging from startups to Fortune 500 companies.

12. Since 1999, Ramot has helped found more than 150 technology startup companies. Within the area of electronics and electro-optics, Ramot is currently affiliated with about 68 accomplished researchers who are developing dozens of distinct cutting-edge technologies. Ramot owns approximately 1000 granted patents worldwide that span various fields of technology.

13. Co-Inventor Dr. Yossef Ehrlichman, received the B.Sc.(EE) and MBA degrees

from the Technion, Haifa, Israel, in 1999 and 2002, respectively. He received the M.Sc.(EE) and Ph.D. degrees from Tel Aviv University, Tel Aviv, Israel, in 2007 and 2015, respectively. During his Ph.D., he worked on photonic integrated mixed signal circuits, such as photonic digital-to-analog and analog-to-digital converters. He co-invented a direct digital drive method which allows the integration of digital CMOS circuits with photonic integrated modulators. Between 2013-2015 he worked as a Radiometry Engineer at SemiConductor Devices (SCD), Israel, developing advanced cooled-IR detectors. Between 2015-2017 he held a position of a Postdoctoral Research Associate at the University of Colorado Boulder investigating silicon photonics devices and circuits for RF photonics applications. Between 2017-2018 he held a position of Postdoctoral Researcher at University of California San Diego, continuing his research on silicon photonic devices and circuits for RF photonics applications. Since 2018 he is a Senior Member of the Technical Staff at Axalume, San Diego, CA, developing silicon-photonics hybrid lasers, and electronics-photonics circuits for data centers. Dr. Ehrlichman is a senior member of the IEEE.

14. Co-Inventor Dr. Ofer Amrani is faculty at Tel Aviv University's School of Electrical Engineering, Tel Aviv, Israel. He received the Ph.D. degree in Electrical Engineering with honors from Tel Aviv University in November 2000. In 1999 he co-founded CUTE-systems and served as its CTO. In October 2001 he joined Tel Aviv University in the department of Electrical Engineering-Systems. In 2006 he was a visiting scientist at the Dept. of Electrical Engineering, Technion-Israel Institute of Technology. Since 2007 he has been with Tel Aviv University as a senior lecturer. His main research interests include various aspects of digital communications; as well as optical components and new transistor architectures for interfacing between electronic and optical signals. Dr. Amrani currently heads the newly-initiated nano-satellite laboratory and leads the development and construction of two nano-

satellites to be launched in 2020. Since 1994 he has been consulting to various industrial companies.

15. Co-Inventor and Professor Shlomo Ruschin received the B.Sc. degree in Physics and Mathematics from the Hebrew University in Jerusalem in 1969. He continued his graduate studies at the Technion-Israel Institute of Technology in Haifa where he specialized in the fields of Lasers and Quantum Optics. He received the M.Sc. degree in 1973 and the D.Sc. in 1977. During the period 1978-79 he completed Postdoctoral studies at Cornell University where he was involved in the research of laser diagnostics of molecules and bistability effects. In 1980, Dr. Ruschin joined the Department of Physical Electronics at the Faculty of Engineering of Tel Aviv University, where he presently is Professor Emeritus of Electrical Engineering. During the years 2013-2018 he was Incumbent of the Chana and Heinrich Manderman Chair in Optoelectronics. His fields of research include Laser Physics and electro-optics, and he presently leads the Photonic Devices group at the University. The group is dedicated to various aspects of theory and practice of wave guided devices for optical communication and sensing. Other topics of his research interest are the shaping of coherent beams, and near-field optics. He published more than 165 articles in reviewed periodicals in subjects related to quantum optics, electro-optics, and lasers. In 2001, Shlomo Ruschin co-founded ColorChip Inc., a company marketing integrated optics components and high-speed optical transceivers for data centers. During 1995-1999, Prof. Ruschin acted as Head of the Department of Electrical Engineering-Physical Electronics at Tel Aviv University.

16. United States Patent No. 10,270,535 ("the '535 Patent"), entitled "Linearized Optical Digital-to-Analog Modulator," was duly and lawfully issued April 23, 2019. Ramot is the owner of all right, title, and interest in the '535 Patent. A true and correct copy of the '535 Patent is attached hereto as Exhibit A.

17. The ’535 Patent describes problems and shortcomings in the field of optical modulators for converting high speed digital data into modulated optical signals, and claims novel and inventive technological improvements and solutions to such problems and shortcomings. For example, the ’535 patent discloses and claims methods for performing advanced modulation techniques that meet the need for “high-performance and large bandwidth” signal conversion for multi-GHz communication systems. In one aspect of the invention, the disclosed and claimed features enable actuating a plurality of electrodes so as to modulate the optical signal according to a QAM (Quadrature Amplitude Modulation) modulation scheme. In another aspect of the invention, the disclosed and claimed features enable using multiple actuating voltage levels so as to modulate amplitude of the optical signal according to a pulse modulation (*e.g.*, PAM) scheme.

18. United States Patent No. 10,033,465 (“the ’465 Patent”), entitled “Linearized Optical Digital-to-Analog Modulator,” was duly and lawfully issued July 24, 2018. Ramot is the owner of all right, title, and interest in the ’465 Patent. A true and correct copy of the ’465 Patent is attached hereto as Exhibit B.

19. The ’465 Patent also describes problems and shortcomings in the field of optical modulators for converting high speed digital data into modulated optical signals and claims novel and inventive technological improvements and solutions to such problems and shortcomings. For example, the ’465 patent explains that Mach-Zehnder Interferometer modulators used in fiber-optic communications applications exhibited serious problems at higher speeds due to the “inherent non-linear response of the modulator.” The ’465 patent discloses and claims solutions to this problem that “offer improved linearity of response without sacrificing efficiency or dynamic range.” In one aspect of the invention, the disclosed and claimed features enable mapping of data bits to electrode voltages, so as to select the electrode actuation pattern

that best models a desired optical signal output for a given digital input. In this and other disclosed aspects of the invention, the mapping function, in combination with the disclosed and claimed advanced modulation techniques, enables multi-GHz optical communication with improved speed, clarity, and/or linearity.

20. United States Patent No. 10,461,866 ("the '866 Patent"), entitled "Linearized Optical Digital-to-Analog Modulator," was duly and lawfully issued October 29, 2019. Ramot is the owner of all right, title, and interest in the '866 Patent. A true and correct copy of the '866 Patent is attached hereto as Exhibit C.

21. The '866 Patent also describes problems and shortcomings in the field of optical modulators for converting high speed digital data into modulated optical signals and claims novel and inventive technological improvements and solutions to such problems and shortcomings. For example, the '866 patent discusses the use of the claimed invention to provide "linearization of a modulator device which inherently has a non-linear response" as well as in other applications that require conversion of the natural response of a modulator according to a first function into a desired response according to a second function. *See, e.g.*, Ex. C ('866 Patent) at 8:55-67. The independent and dependent claims of the '866 Patent claim multiple system and method embodiments for providing "pulse modulated output optical signals" with improved linear response and/or improved response according to other desired functions, including with the use of the innovative digital to digital converter aspect of the inventions.

Cisco's Use of the Patented Technology

Cisco Optical Transceiver Modules and Line Cards

22. On information and belief, Cisco makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States various networking equipment including routers and switches. For example, Cisco makes, uses, and sells converged networking routers

and switches, for use in high-speed local, metro, and wide-area networks, that include high-speed optical networking ports. In addition, Cisco sells datacenter and cloud switches that include high-speed optical networking ports.

23. Many of these Cisco router and switch products include line cards and associated optical transceiver modules that together enable high-speed optical communications of 100 Gbps or higher per port. *See, e.g.*, Cisco Brochure c02-741700, "The Next Frontier for Cloud Networking: Cisco Nexus 400G" (Jan. 2019), *available at* https://www.cisco.com/c/dam/en/us/solutions/collateral/data-center/high-capacity-400g-data-center-networking/brochure-c02-741700.pdf; Cisco Datasheet c78-729222, "Cisco Network Convergence System 4000 Series" (Nov. 2018), *available at* https://www.cisco.com/c/en/us/products/collateral/optical-networking/network-convergence-system-4000-series/data_sheet_c78-729222.pdf.

24. Cisco's various routers and switches include line cards, including removable blades and built in circuit boards, that include functionality to provide digital signal processing for various optical networking ports, including Optical Transport Network (OTN) or Ethernet ports operating at speeds up to and including 100, 200, and 400 Gbps. *See, e.g.*, Cisco Datasheet c78-736495, "Cisco NCS 4000 400 Gbps DWDM/OTN/Packet Universal Line Card" (Sept. 2017), *available at* https://www.cisco.com/c/en/us/products/collateral/optical-networking/network-convergence-system-4000-series/datasheet-c78-736495.pdf ("Up to 2x 200 Gbps Dense Wavelength-Division Multiplexing (DWDM) wavelengths using the CFP2 ports"); *see also* Cisco Datasheet c78-741557, "Cisco Nexus 3432D-S Switch" (Apr. 2019), *available at* https://www.cisco.com/c/en/us/products/collateral/switches/nexus-3000-series-switches/datasheet-c78-741557.pdf ("Each QSFP-DD port can operate at 400, 100, 50, 40, and 25 Gbps").

25. Cisco makes, uses, and/or sells various optical transceiver modules for use with the optical networking ports on its routers and switches. *See, e.g.*, Cisco Datasheet c78-736495 at 2 ("CFP2 ACO pluggables"); Cisco Datasheet c78-741557 at 3 ("The Cisco Nexus 3400-S are Quad Small Form factor pluggable – Double Density (QSFP-DD) platforms that support the full range of optical transceviers [sic]"); Cisco Brochure c02-741700 at 2("400G optics: QSFP-DD" and "QDD-400G-FR4-S"); Cisco Product Brief c45-740242, "Cisco 40/100Gb QSFP100 BiDi Pluggable Transceiver" (Feb. 2018), *available at* https://www.cisco.com/c/dam/en/us/products/collateral/interfaces-modules/transceiver-modules/at-a-glance-c45-740242.pdf. These modules are sold in a variety of configurations, varying in form factor, communication speed, optics supported, and type of modulator employed. Numerous variations of these transceiver modules operating at speeds of 100Gbps and above, along with associated digital signal processing functionality in the modules and/or on the associated line cards, infringe the Asserted Patents, as further detailed herein.

26. Cisco participates in and leads various industry standards, multi-vendor implementation agreements, and specification efforts to define the physical form factor, operation, requirements, and capabilities of its optical transceiver modules. For example, the CFP2 ACO pluggable modules used, *inter alia*, with the NCS 4000 400 Gbps DWDM/OTN/Packet Universal Line Card, are defined and specified in part in Optical Internetworking Forum, OIF-CFP2-ACO-01.0, Implementation Agreement for Common Analog Coherent Optics Module (Jan. 22, 2016). Cisco's QSFP-DD and other modules are also defined in various industry standards and implementation agreements in which Cisco participates, such as the 100G Lambda MSA Group's 100G-FR, 100G-LR, and 400G-FR4 Technical Specifications, Rev 2.0 (Sept. 18, 2018), and the QSFP-DD MSA's Common Management Interface Specification, Rev 3.0 and Hardware Specification, Rev 4.0 (Sept. 18, 2018), as well as

related IEEE standards and standardization efforts. Cisco promotes these industry standards and implementation agreements, and their resulting specifications, including on its website and blogs.

27. Cisco's infringing products achieve optical networking transport speeds of 100 Gbs and above by employing the advanced modulation techniques of the Asserted Patents, including via signal processing in its line cards and/or optical transceiver modules. *See, e.g.*, Cisco Datasheet c78-736495 at 2 ("The NCS 4000 Universal line card also provides two 200 Gbps ***16-QAM*** DWDM Long Haul transmission ports through the CFP2 ACO pluggables" and "latest generation of Digital Signal Processor (DSP) technology dramatically increases the performance of 100 Gbps QPSK and ***200 Gbps 16-QAM*** optical transport"); Cisco Datasheet c78-741557 at 3 ("The Cisco Nexus® 3400-S is the first 400G programmable switch series in the Nexus 3000 portfolio with 50 Gbps ***PAM4*** Serial-Deserializers (SerDes), and is designed for data centers with industry-leading performance-per-watt power efficiency at low latency"); Cisco Product Brief c45-740242 at 1 ("***PAM4*** optical modulation") (emphases added).

28. Cisco has publicly acknowledged and endorsed the need for, and adoption of, the advanced modulation techniques of the Asserted Patents in order to achieve data rates of 100 Gbps and higher using fewer lines or channels. *See, e.g.*, Cisco Blog SP360: Service Provider, "PAM4 for 400G Optical Interfaces and Beyond (Part 1)," *available at* https://blogs.cisco.com/sp/pam4-for-400g-optical-interfaces-and-beyond-part-1 ("In order to avoid costly electrical and optical design, there has been a recent revival of research on coherent technology and multi-level modulation formats to achieve greater than 25G channel rates. 4-level pulse amplitude modulation (PAM4), a relatively low-cost solution, has been adopted in the transceiver industry, enabling high-speed data rates, toward 400G and beyond.").

29. Cisco's infringing products also achieve optical networking transport speeds of 100 Gbs and above by employing the digital signal mapping techniques of the Asserted Patents.

Mapping of the digital symbols to correct for modulator non-linearity and other such signal degradations is necessary at the high per-lane speeds at which the infringing products operate. Industry standards, including for example the IEEE 802.3bs-2017 standard amendment, have included, *inter alia*, transmitter linearity and signal quality requirements and tests in recognition of this need. *See* IEEE Standard for Ethernet, "Amendment 10: Media Access Control Parameters, Physical Layers, and Management Parameters for 200 Gb/s and 400 Gb/s Operation," IEEE Std 802.3bs-2017 at §§ 120D.3.1.1 - 120D.3.1.8. Cisco's infringing products comply with these and similar transmission signal quality requirements, including through the use of the digital signal mapping techniques of the Asserted Patents.

30. Cisco's infringing transceiver modules and associated DSP functionality (the "Accused Products") support advanced mapping and modulation techniques, including without limitation Quadrature Modulation (*e.g.*, 16-QAM) and Pulse Amplitude Modulation (*e.g.*, PAM4). The Accused Products include, but are not limited to: 100, 200, and 400 Gbps pluggable CFP2 modules; 100, 200, and 400 Gbps QSFP56 and QSFP-DD modules, including modules that operate at speeds at or above 50 Gbps per optical or electrical lane; "BiDi" modules that communicate at or above 100 Gbps, including 100G BiDi or 400G BiDi products; modules that communicate according to the 100G-FR, 100G-LR, and 400G-FR4 Technical Specifications; and other modules that include similar functionality, along with the associated digital signal processing functionality, whether implemented in the module itself or in an associated circuit or processor.

31. Cisco makes, uses, offers to sell, sells (including by technology leases to its customers), and/or imports into the United States the Accused Products. Cisco further uses and offers its Accused Products at industry trade shows and demonstrations to existing or potential customers. *See, e.g.*, Cisco Blog, SP360: Service Provider, "OFC 2017 Demo: Cisco 400GbE

Optical Module," *available at* https://blogs.cisco.com/sp/ofc-2017-demo-cisco-400gbe-optical-module; Cisco Blog, SP360: Service Provider, "Cisco Optics On Display and Demonstrated at OFC 2018," *available at* https://blogs.cisco.com/sp/cisco-optics-on-display-and-demonstrated-at-ofc-2018 ("live demo of the QSFP-DD form factor for 400G optical interfaces" and "dual-rate 40/100 Gb QSFP BiDi transceiver"); Cisco Blog, SP360: Service Provider, "Cisco Optics Demos and Displays at OFC 2019," *available at* https://blogs.cisco.com/sp/cisco-optics-demos-and-displays-at-ofc-2019 ("100G 1-λ Silicon Photonics For 10km. Cisco's silicon photonics will be on display in a live demo, showing single-lambda PAM4 performance over 10km of duplex SMF.").

FIRST COUNT
(Infringement of U.S. Patent No. 10,270,535)

32. Ramot incorporates by reference the allegations set forth in Paragraphs 1-31 of this Complaint as though fully set forth herein.

33. Cisco makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States products that directly infringe the '535 Patent, including the above identified Cisco Accused Products that use advanced 8-QAM, 16-QAM, PAM4, or similar or higher-order modulation techniques ('535 Accused Products). Cisco's '535 Accused Products that use advanced QAM modulation infringe claim 2 of the '535 Patent. Cisco's '535 Accused Products that use advanced PAM4 modulation infringe claim 1 of the '535 Patent.

34. As an example, the '535 Accused Products implement modulating and transmitting an optical signal over an optical fiber in response to inputting N bits of digital data. Cisco's optical routers and switches include line cards and modules that manipulate digital data in the form of multi-bit words or symbols, which is converted and transmitted as optical signals. For example, and without limitation, Cisco's Network Convergence System (NCS) 4000 Series

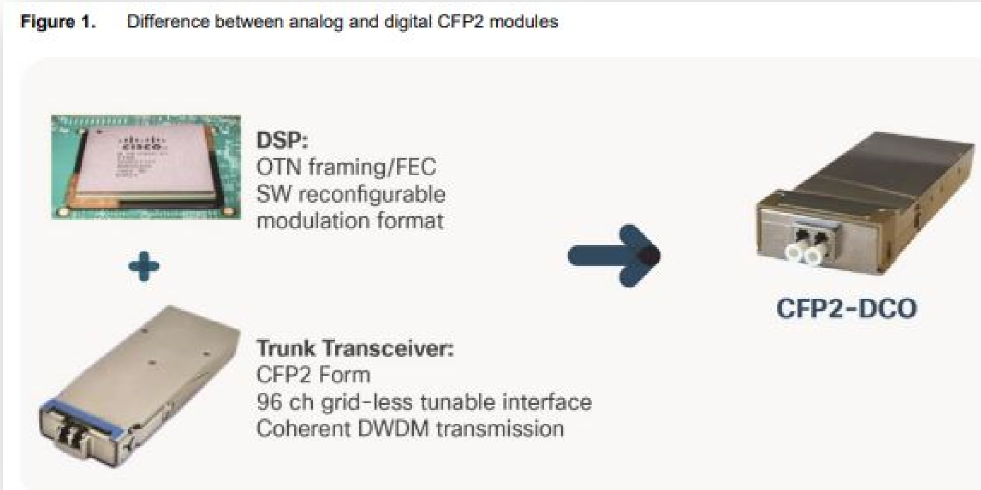
products route and switch packet-based digital data and provide optical transmission for transport across networks. *See, e.g.*, Cisco Datasheet c78-729222 at Figure 1:

Figure 1. Cisco NCS 4016 Chassis (Right) and NCS 4009 Chassis (Left)

see also Cisco Datasheet c78-736495 at Figure 1:

Figure 1. Cisco® NCS 4000 400 Gbps WDM/OTN/Packet Universal Line Card

Id. at 2 ("The NCS 4000 Universal line card also provides two 200 Gbps 16-QAM DWDM Long Haul transmission ports through the CFP2 ACO pluggables."); Cisco Datasheet c78-741079, "Cisco Digital CFP2 Pluggable Optical Module" (July 2018) at Figure 1:



35. As an additional example, Cisco's Nexus 400G products switch digital data and provide optical transmission for transport across networks, including within advanced data centers. *See, e.g.*, Cisco Brochure c02-741700; Cisco Datasheet c78-741557 at 3, Figure 1:

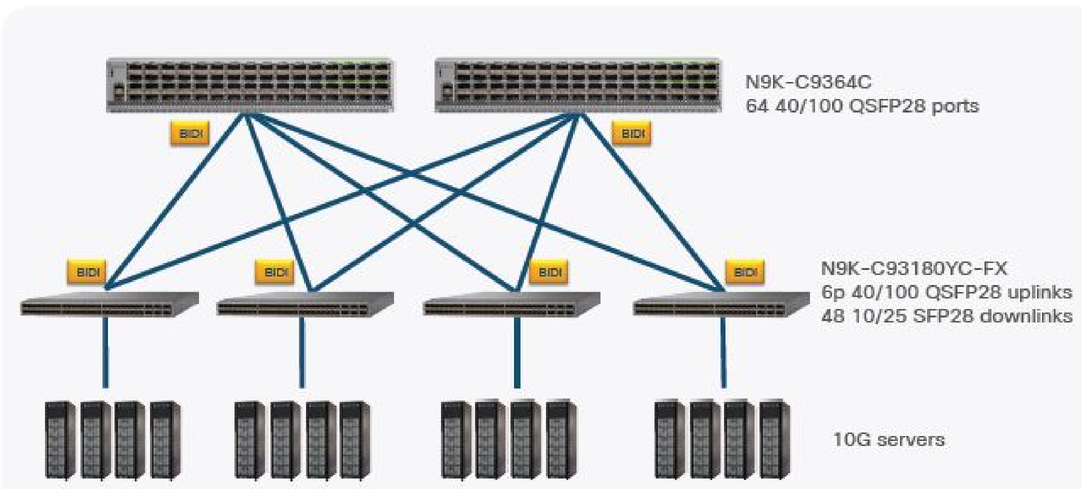
Cisco Blog, "OFC 2017 Demo: Cisco 400GbE Optical Module":

QSFP-DD Form Factor

See also Cisco Product Brief c45-740242 at 2 ("In 100Gb mode, it operates 50Gb PAM4 channels, for a total aggregate bandwidth of 100Gb. PAM4 technology enables 50Gb data rate with signaling at 25Gbaud rates. The 40/100G BiDi contains a gearbox to translate the signal from a 4x25G format, native to the QSFP28 form factor, to the 2x50Gb format for the optical domain. It also employs onboard forward-error-correction (FEC) to reduce bit error rate."), Figures 1 and 2:

Figure 1. 40/100G QSFP BiDi transceiver module

Figure 2. Example of 40/100G QSFP BiDi in a leaf-spine architecture with Cisco Nexus 9k switches



36. The optical modulators of the ’535 Accused Products have a plurality of waveguide branches, where each branch has an input of an unmodulated optical signal. For example, and without limitation, the OIF-CFP2-ACO-01.0 Implementation Agreement for CFP2 modules specifies an unmodulated laser driving the various arms (*i.e.*, waveguide branches) of a nested Mach-Zehnder type modulator. *See*, *e.g.*, OIF-CFP2-ACO-01.0 at Figure 3:

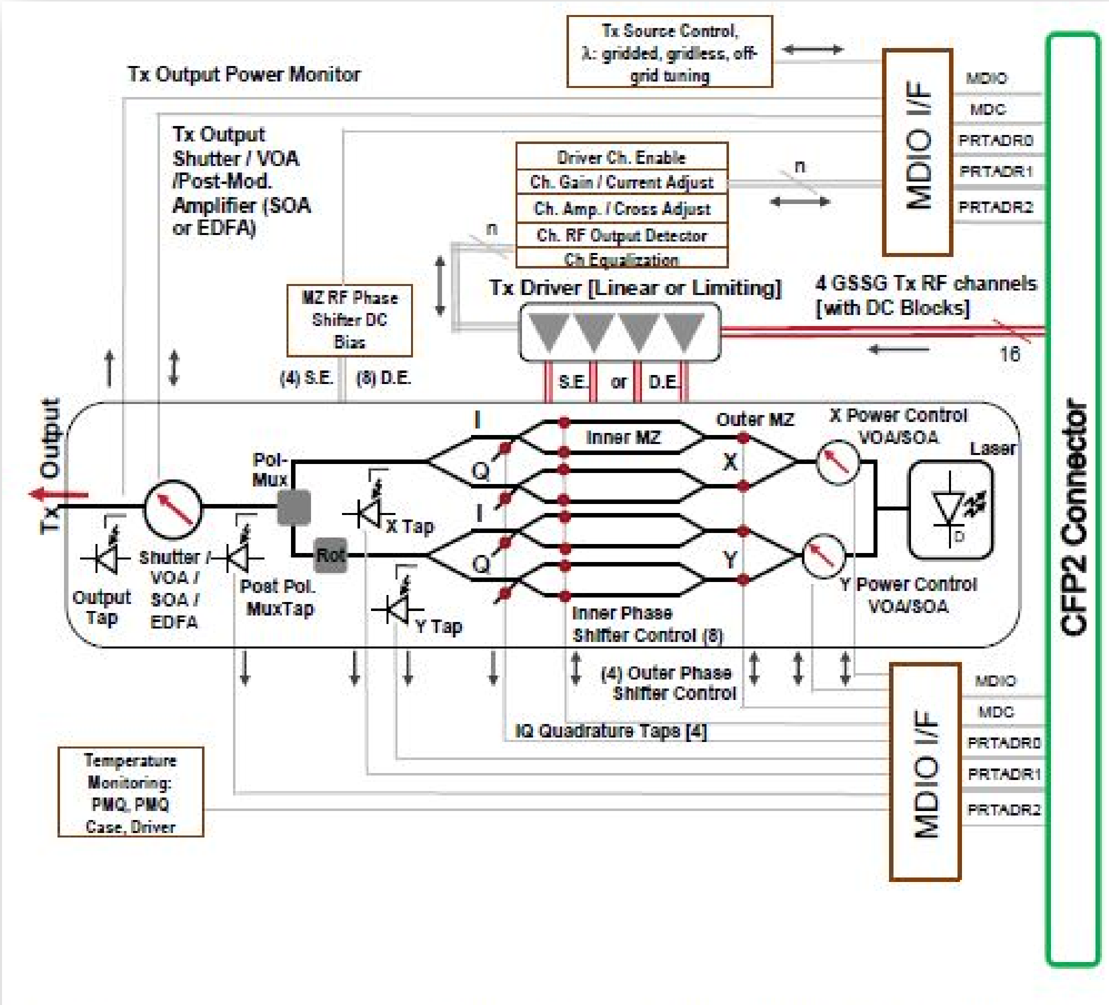


Figure 3: Superset Transmit Function Block Diagram with an MDIO Only Control Interface

A Cisco technical journal paper describes the "[t]ypical components in a CFP2-ACO module" accordingly. *See, e.g.*, Fludger, *et al.*, "1Tb/s Real-Time 4 x 40 Gbaud DP-16QAM Super-Channel Using CFP2-ACO Pluggable Modules Over 625 km of Standard Fiber," IEEE J. Lighwave Tech. 35, pp. 949, Figure 1 (Feb. 2017):

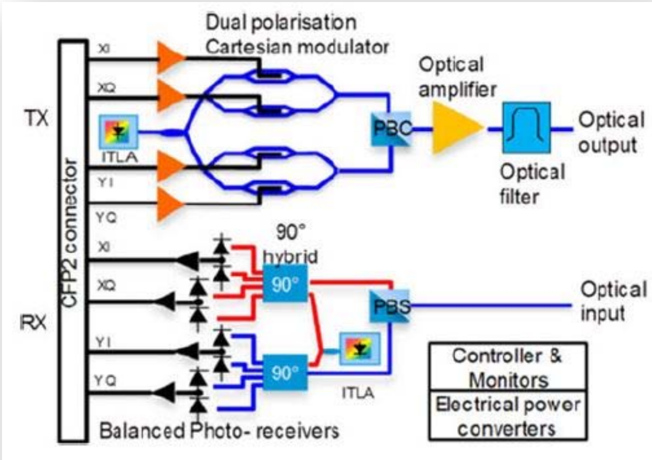
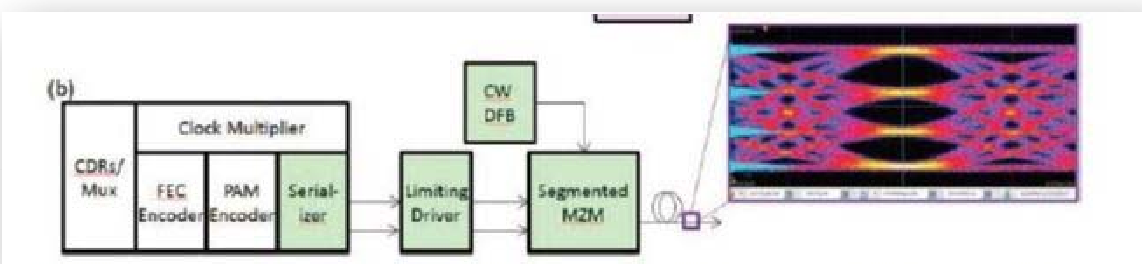


Fig. 1. Typical components in a CFP2-ACO module.

Similarly, another Cisco technical journal paper describes Cisco's use of "Segmented MZM [Mach-Zehnder]" type modulators in QSFP form factor devices to achieve PAM-4 modulation. *See, e.g.*, Mazzini, *et al.*, "25GBaud PAM-4 Error Free Transmission over both Single Mode Fiber and Multimode Fiber in a QSFP form factor based on Silicon Photonics," 2015 Optical Fiber Conference, paper Th5B.3 at 1, Figure 1(b) ("(b) Segmented MZI PAM-4 transmitter block diagram with Cisco PAM-4 optical eye diagrams."):



A continuous-wave (CW) distributed feedback laser (DFB) provides the unmodulated optical signal to the MZM in this example. *Id.*

37. The '535 Accused Products implement converting the N bits of digital data to M

drive voltage values, where M>N and N>1. For example, and without limitation, Cisco's CFP2 pluggable modules (including signal processing components on the line card in the case of CFP2-ACO modules or integrated into the module in the case of CFP2-DCO modules), receive multiple-bit inputs of digital data, then process those digital symbols via mapping, encoding, QAM symbol mapping, and signal conditioning modules that convert the digital data into symbols and corresponding voltage values for driving electrodes of the optical modulator arms. *See, e.g.*, Fludger *et al.* at Figure 2(a):

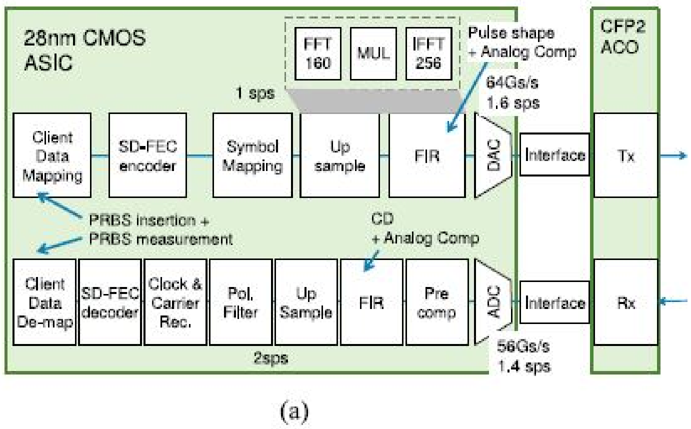
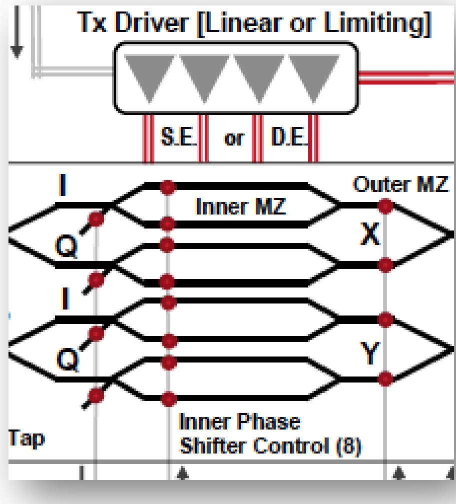


Fig. 2. (a) ASIC processing, interface and CFP2-ACO pluggable. (b)

See also Mazzini, *et al.*, at Figure 1(b) (describing FEC and PAM4 encoding modules used with a segmented Mach-Zehnder modulator in a QSFP form factor solution).

38. The '535 Accused Products implement coupling the M drive voltage values to the unmodulated optical signal, thereby enabling modulation of the unmodulated optical signal to generate either a QAM (according to claim 2) or a pulse modulated (according to claim 1) optical signal. For example, and without limitation, in Cisco's CFP2 pluggable modules the QAM modulated symbols and corresponding voltage values described above are coupled to the unmodulated optical signal via drivers for the branches of the Mach-Zehnder modulator

structures. *See, e.g.*, OIF-CFP2-ACO-01.0 at Figure 3 (detail below):



Similarly, in Cisco's PAM-4 modules the PAM modulated symbols and corresponding voltage values are coupled to the unmodulated optical signal via drivers for the segmented branches of the Mach-Zehnder modulator structures therein. *See, e.g.*, Mazzini, *et al.*, at Figure 1(b).

39. The '535 Accused Products implement transmitting the QAM or pulse modulated optical signals over an optical fiber. Cisco's Accused Products have optical fiber ports for transmitting over optical fibers of various lengths, types, and wavelengths. *See, e.g.*, Cisco Datasheet c78-741079 at 2 ("16-QAM schemes could offer up to 400km of reach on standard G.652 Single mode fiber"); Cisco Brochure c02-741700 at 2 ("2km duplex SMF (LC)"); Cisco Datasheet c78-736282, "Cisco 100GBASE QSFP-100G Modules" (May 2018), *available at* https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/transceiver-modules/datasheet-c78-736282.pdf, at 2 ("The Cisco QSFP 40/100 Gb dual-rate bi-directional (BiDi) transceiver is a pluggable optical transceiver with a duplex LC connector interface for short-reach data communication and interconnect applications using Multi-Mode Fiber (MMF).").

40. By making, using, offering for sale, and/or selling products in the United States, and/or importing products into the United States, including but not limited to the ’535 Accused Products, Cisco has injured Ramot and is liable to Ramot for directly infringing one or more claims of the ’535 Patent, including without limitation claim 2 pursuant to 35 U.S.C. § 271(a).

41. Cisco also infringes the ’535 Patent under 35 U.S.C. § 271(b) & (c).

42. Cisco knowingly encourages and intends to induce infringement of the ’535 Patent by making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’535 Accused Products, with knowledge and specific intention that such products will be used by its customers. For example, Cisco instructs its customers on how to use and implement the technology claimed in the ’535 patent. *See e.g.,* Cisco Datasheet c78-736495; Cisco Datasheet c78-741557; Cisco Brochure c02-741700; Cisco Product Brief c45-740242.

43. Cisco also contributes to the infringement of the ’535 Patent. Cisco makes, uses, sells, and/or offers to sell products in the United States, and/or imports them into the United States, including but not limited to the ’535 Accused Products, knowing that those products constitute a material part of the claimed invention, that they are especially made or adapted for use in infringing the ’535 Patent, and that they are not staple articles or commodities of commerce capable of substantial non-infringing use.

44. On information and belief, Cisco was aware of the ’535 Patent and related Ramot patents, had knowledge of the infringing nature of its activities, and nevertheless continues its infringing activities. For example, on November 5, 2014, Ramot sued Cisco for infringement of two parent patents of the ’535 patent. *See Ramot at Tel Aviv University Ltd. v. Cisco Systems, Inc.*, Case No. 2:14-cv-1018 (E.D. Tex. Nov. 5, 2014), Dkt. 1 at ¶ 1. Cisco filed papers in that action, which was later voluntarily dismissed without prejudice. *Id.* at Dkt. 12, 16. In addition, a

parent of the '535 Patent was cited by and relied on by the patent examiner in at least one patent prosecution of a Cisco patent. *See* U.S. Patent No. 8,320,720 at 1.

45. Cisco's infringement of the '535 Patent has been and continues to be deliberate and willful, and, this is therefore an exceptional case warranting an award of enhanced damages and attorneys' fees pursuant to 35 U.S.C. §§ 284-285.

46. As a result of Cisco's infringement of the '535 Patent, Ramot has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Cisco's infringement, but in no event less than a reasonable royalty with interest and costs.

SECOND COUNT
(Infringement of U.S. Patent No. 10,033,465)

47. Ramot incorporates by reference the allegations set forth in Paragraphs 1-46 of this Complaint as though fully set forth herein.

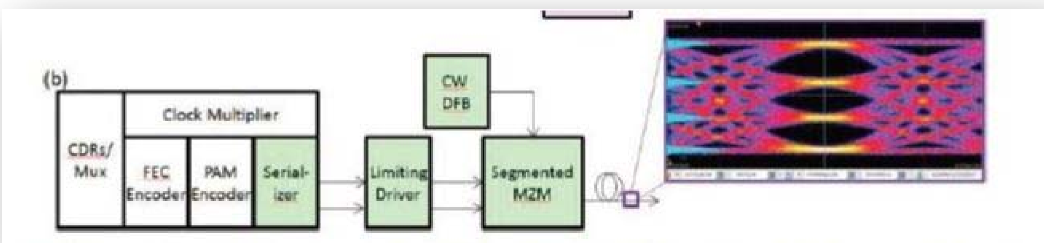
48. Cisco makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States products that directly infringe the '465 Patent, including the above identified Cisco Accused Products that use advanced PAM4, or similar or higher-order modulation techniques ('465 Accused Products). Cisco's '465 Accused Products that use advanced PAM4 modulation infringe one or more claims of the '465 Patent, including without limitation, claim 1. Cisco's '465 Accused Products that use advanced QAM modulation infringe one or more claims of the '465 Patent, including without limitation, claim 4.

49. As an example, the '465 Accused Products implement converting digital electrical data into modulated optical streams. For example, and without limitation, see the evidence cited and discussed above with respect to paragraphs 34-35.

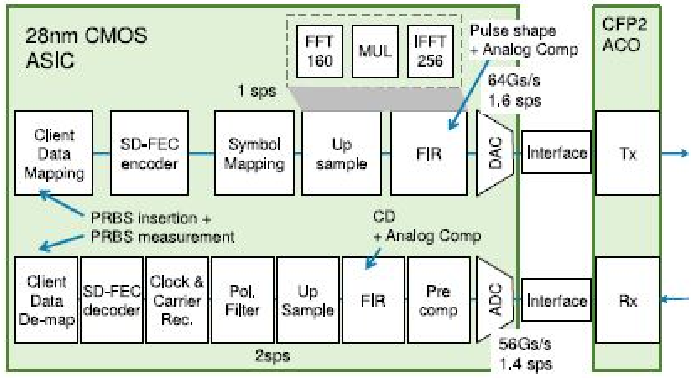
50. The '465 Accused Products implement inputting into an optical modulator N bits of digital data in parallel, N being larger than 1. For example, and without limitation, see the

evidence cited and discussed above with respect to paragraphs 34-35.

51. The ’465 Accused Products implement mapping a set of N input values corresponding to said N bits of digital data to a vector of M voltage values where M is equal to or larger than N. For example, and without limitation, Cisco’s various PAM4 modules and associated signal processing components receive multiple-bit inputs of digital data, then map those digital symbols to other digital symbols corresponding to voltage values for driving modulators to implement the advanced pulse modulation scheme. This mapping is performed via modules in the signal processing components, such as FEC encoder and/or PAM encoder modules. *See, e.g.*, Mazzini, *et al.*, at Figure 1(b):



As an additional example, Cisco’s CFP2 pluggable modules (including signal processing components on the line card in the case of CFP2-ACO modules or integrated into the module in the case of CFP2-DCO modules), receive multiple-bit inputs of digital data, then map those digital symbols to other digital symbols corresponding to voltage values for driving modulators to implement the advanced QAM modulation scheme. This mapping is performed via data mapping, encoding, QAM symbol mapping, and/or signal conditioning modules in the signal processing components. *See, e.g.*, Fludger *et al.* at Figure 2(a):



(a)

Fig. 2. (a) ASIC processing, interface and CFP2-ACO pluggable. (b)

52. The ’465 Accused Products implement driving at least M electrodes of the optical modulator, enabled to pulse modulate (according to claim 1) or modulate by QAM (according to claim 4) at least an input optical stream, responsively to the M voltage values, to provide at least a pulse modulated (according to claim 1) or QAM modulated (according to claim 4) output optical stream. For example, and without limitation see the evidence cited above with respect to paragraphs 38-39.

53. By making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’465 Accused Products, Cisco has injured Ramot and is liable to Ramot for directly infringing one or more claims of the ’465 Patent, including without limitation claim 1, pursuant to 35 U.S.C. § 271(a).

54. Cisco also infringes the ’465 Patent under 35 U.S.C. § 271(b) & (c).

55. Cisco knowingly encourages and intends to induce infringement of the ’465 Patent by making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’465 Accused Products, with knowledge and specific intention that such products will be used by its customers. For

example, Cisco instructs its customers on how to use and implement the technology claimed in the ’465 patent. *See e.g.*, Cisco Datasheet c78-741557; Cisco Brochure c02-741700; Cisco Product Brief c45-740242.

56. Cisco also contributes to the infringement of the ’465 Patent. Cisco makes, uses, sells, and/or offers to sell products in the United States, and/or imports them into the United States, including but not limited to the ’465 Accused Products, knowing that those products constitute a material part of the claimed invention, that they are especially made or adapted for use in infringing the ’465 Patent, and that they are not staple articles or commodities of commerce capable of substantial non-infringing use.

57. On information and belief, Cisco was aware of the ’465 Patent and related Ramot patents, had knowledge of the infringing nature of its activities, and nevertheless continues its infringing activities. For example, on November 5, 2014, Ramot sued Cisco for infringement of two parent patents of the ’465 patent. *See Ramot at Tel Aviv University Ltd. v. Cisco Systems, Inc.*, Case No. 2:14-cv-1018 (E.D. Tex. Nov. 5, 2014), Dkt. 1 at ¶ 1. Cisco filed papers in that action, which was later voluntarily dismissed without prejudice. *Id.* at Dkt. 12, 16. In addition, a parent of the ’465 Patent was cited by and relied on by the patent examiner in at least one patent prosecution of a Cisco patent. *See* U.S. Patent No. 8,320,720 at 1.

58. Cisco’s infringement of the ’465 Patent has been and continues to be deliberate and willful, and, this is therefore an exceptional case warranting an award of enhanced damages and attorneys’ fees pursuant to 35 U.S.C. §§ 284-285.

59. As a result of Cisco’s infringement of the ’465 Patent, Ramot has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Cisco’s infringement, but in no event less than a reasonable royalty with interest and costs.

THIRD COUNT
(Infringement of U.S. Patent No. 10,461,866)

60. Ramot incorporates by reference the allegations set forth in Paragraphs 1-59 of this Complaint as though fully set forth herein.

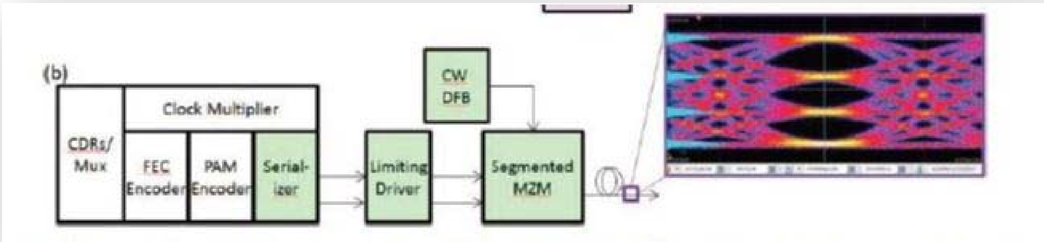
61. Cisco makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States products that directly infringe the ’866 Patent, including the above identified Cisco Accused Products that use advanced PAM4, or similar or higher-order modulation techniques (’866 Accused Products). Cisco’s ’866 Accused Products that use advanced PAM4 modulation infringe one or more claims of the ’866 Patent, including without limitation, claim 19.

62. As an example, the ’866 Accused Products implement converting digital electrical data into modulated optical streams using a modulation system. For example, and without limitation, see the evidence cited and discussed above with respect to paragraphs 34-35.

63. The ’866 Accused Products implement inputting into a digital to digital converter coupled to an electrically controllable optical modulator N bits of a digital data word, N being larger than 1. For example, and without limitation, see the evidence cited and discussed above with respect to paragraphs 34-35.

64. The ’866 Accused Products implement using a digital to digital converter for mapping a set of N input values corresponding to the N bits of digital data word to a digital drive vector corresponding to M drive voltage values where M = N. For example, and without limitation, Cisco’s various PAM4 modules and associated signal processing components receive multiple-bit inputs of digital data, then map those digital symbols to other digital symbols corresponding to M voltage values for driving modulators to implement the advanced pulse modulation scheme. This symbol mapping digital to digital conversion is performed, for

example, by modules in the signal processing components, such as FEC encoder and/or PAM encoder modules. *See, e.g.*, Mazzini, *et al.*, at Figure 1(b):

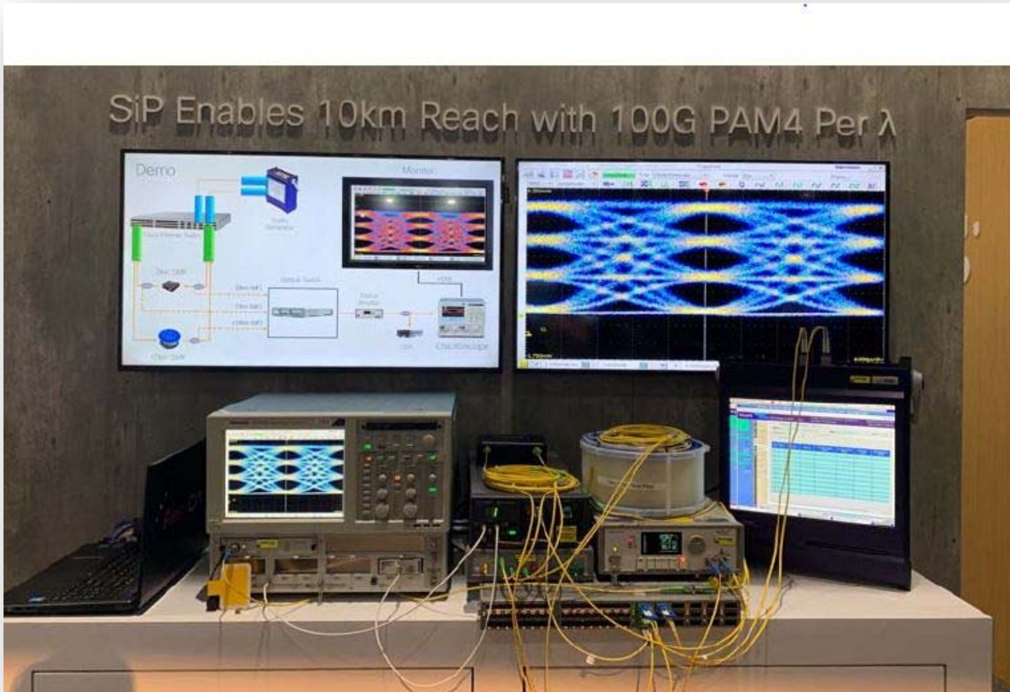


As an additional example, and without limitation, at least some of Cisco's QSFP-40/100G-SRBD "BiDi" modules contain a Broadcom BCM82251 ASIC, a "Single 100GbE/Dual 40GbE PHY [that] drives 40G/50G Serial PAM4.":

See, e.g., Broadcom, BCM82251 Overview, available at https://www.broadcom.com/products/ethernet-connectivity/optical-phy/bcm82251 ("In 100GbE mode, the BCM82251 converts 4 × 25GE traffic into 2 × 50GE PAM4 and is capable of driving

Direct Attached Cable and SR/LR optics"). The chip includes a digital to digital conversion that maps bits of digital data to a digital drive vector corresponding to drive voltage values.

65. The '866 Accused Products implement coupling the drive voltage values corresponding to the digital drive vector to an electrically controllable optical modulator, which is thereby responsively enabled to modulate by pulse modulation one or more unmodulated optical signals and provide one or more pulse modulated output optical signals. For example, and without limitation see the evidence cited above with respect to paragraphs 38-39. As an additional example, Cisco has made, demonstrated, sold, and offered to sell at least 40G/100G "BiDi," 100G "single lambda," and 400Gbps QSFP-DD pluggable modules that use PAM4 pulse modulation. Cisco Product Brief c45-740242 at 1 ("***PAM4*** optical modulation"); Cisco Blog, SP360: Service Provider, "Cisco Optics Demos and Displays at OFC 2019," *available at* https://blogs.cisco.com/sp/cisco-optics-demos-and-displays-at-ofc-2019 ("100G 1-λ Silicon Photonics For 10km. Cisco's silicon photonics will be on display in a live demo, showing single-lambda PAM4 performance over 10km of duplex SMF."); Cisco Blog, SP360: Service Provider, "Silicon Photonics Demonstration at OFC 2019," *available at* https://blogs.cisco.com/sp/silicon-photonics-demonstration-at-ofc-2019 ("We plugged two of our 100G single-wavelength PAM4 modules into a Cisco Nexus 9k ethernet switch. . . . The PAM4 modules (green in the diagram) had two different spools of single-mode fiber inserted, one for each direction of traffic."):



Cisco Datasheet c78-741560, "Cisco Nexus 9300-GX Series Switches" (updated November 18, 2019), *available at* https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-741560.pdf, at 3 ("16 x 400/100-Gbps QSFP-DD ports"); "Leviton Cabling Guide for Cisco 100G and 400G Optics" (October 2019) at 1, *available at* https://www.cisco.com/c/dam/en/us/products/collateral/interfaces-modules/transceiver-modules/cabling-guide-100-400g.pdf (listing 100G and 400G part numbers).

66. By making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the '866 Accused Products, Cisco has injured Ramot and is liable to Ramot for directly infringing one or more claims of the '866 Patent, including without limitation claim 19, pursuant to 35 U.S.C. § 271(a).

67. Cisco also infringes the '866 Patent under 35 U.S.C. § 271(b) & (c).

68. Cisco knowingly encourages and intends to induce infringement of the '866

Patent by making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’866 Accused Products, with knowledge and specific intention that such products will be used by its customers. For example, Cisco instructs its customers on how to use and implement the technology claimed in the ’866 patent. *See e.g.*, Cisco Datasheet c78-741557; Cisco Brochure c02-741700; Cisco Product Brief c45-740242.

69. Cisco also contributes to the infringement of the ’866 Patent. Cisco makes, uses, sells, and/or offers to sell products in the United States, and/or imports them into the United States, including but not limited to the ’866 Accused Products, knowing that those products constitute a material part of the claimed invention, that they are especially made or adapted for use in infringing the ’866 Patent, and that they are not staple articles or commodities of commerce capable of substantial non-infringing use.

70. On information and belief, Cisco was aware of the ’866 Patent and related Ramot patents, had knowledge of the infringing nature of its activities, and nevertheless continues its infringing activities. For example, on November 5, 2014, Ramot sued Cisco for infringement of two parent patents of the ’866 patent. *See Ramot at Tel Aviv University Ltd. v. Cisco Systems, Inc.*, Case No. 2:14-cv-1018 (E.D. Tex. Nov. 5, 2014), Dkt. 1 at ¶ 1. Cisco filed papers in that action, which was later voluntarily dismissed without prejudice. *Id.* at Dkt. 12, 16. In addition, a parent of the ’866 Patent was cited by and relied on by the patent examiner in at least one patent prosecution of a Cisco patent. *See* U.S. Patent No. 8,320,720 at 1. In addition, Cisco became aware of the specific application of claims of the ’866 patent to its products at least as of this Amended Complaint.

71. Cisco’s infringement of the ’866 Patent has been and continues to be deliberate and willful, and, this is therefore an exceptional case warranting an award of enhanced damages

and attorneys' fees pursuant to 35 U.S.C. §§ 284-285.

72. As a result of Cisco's infringement of the '866 Patent, Ramot has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Cisco's infringement, but in no event less than a reasonable royalty with interest and costs.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff prays for judgment and seeks relief against Cisco as follows:

(a) For judgment that U.S. Patent Nos. 10,270,535, 10,033,465, and 10,461,866 have been and continue to be infringed by Cisco;

(b) For an accounting of all damages sustained by Plaintiff as the result of Cisco's acts of infringement;

(c) For finding that Cisco's infringement is willful and enhancing damages pursuant to 35 U.S.C. § 284;

(d) For a mandatory future royalty payable on each and every future sale by Cisco of a product that is found to infringe one or more of the Asserted Patents and on all future products which are not colorably different from products found to infringe;

(e) For an award of attorneys' fees pursuant to 35 U.S.C. § 285 or otherwise permitted by law;

(f) For all costs of suit; and

(g) For such other and further relief as the Court may deem just and proper.

DEMAND FOR JURY TRIAL

Pursuant to Rule 38(b) of the Federal Rules of Civil Procedure and Local Rule CV-38, Plaintiff demands a trial by jury of this action.

Dated: December 12, 2019

Respectfully Submitted,

By: */s/ Corey Johanningmeier*

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CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing document was filed electronically in compliance with Local Rule CV-5(a) with a copy of this document via the Court's CM/ECF system.

Dated: December 12, 2019

/s/ Corey Johanningmeier
Corey Johanningmeier