IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

REGENTS OF THE UNIVERSITY OF MINNESOTA, Plaintiff, vs. LSI CORPORATION and AVAGO TECHNOLOGIES U.S. INC., Defendants.	Civil Action No. 0:16-cv-02891-WMW-SER **JURY TRIAL DEMANDED**

FIRST AMENDED COMPLAINT

Regents of the University of Minnesota ("the University"), by and through its undersigned counsel, hereby files this First Amended Complaint against LSI Corporation and Avago Technologies U.S. Inc. (collectively, "Defendants"), alleging as follows:

NATURE OF THE ACTION

1. This action arises under the patent laws of the United States, 35 U.S.C. §§ 1, *et seq.*, from Defendants' willful direct and indirect infringement of the method claims of United States Patent No. 5,859,601 ("the '601 Patent").

2. The University has long supported research and development of innovative data storage technologies. With this support, Jaekyun Moon, a former University professor, and Barrett J. Brickner, a Ph.D. student, developed the invention described in the '601 Patent during their tenure at the University and assigned the '601 Patent to the University. The invention generally claims a method for encoding data to be written to a magnetic disk in a hard disk drive ("HDD") that increases the accuracy with which the

data are subsequently read off of those magnetic disks, thereby substantially improving the performance of the HDD and allowing for increased data density.

3. In the United States, Defendants knowingly designed, developed, tested, and adopted this invention and incorporated it into HDD chips sold by them in the United States, thereby gaining a competitive advantage through the resulting improvement in HDD performance. Rather than compensate the University for this use of University technology, Defendants have instead willfully infringed the ’601 Patent.

PARTIES

4. The University is a public institution of higher education created by charter and perpetuated by the Constitution of the State of Minnesota, Article XIII, Section 3. The University has its principal place of business in Minneapolis, Minnesota.

5. The University is Minnesota’s flagship research university, with about 30,000 undergraduate students, 16,000 graduate and professional students, 400,000 alumni, and 4,000 faculty.

6. The University has a long history of innovation, teaching, outreach, and public service. The University supports and facilitates a wide range of research that directly benefits the public both in and beyond the State of Minnesota, including educators, researchers, businesses, employees, and consumers. In fact, from 2009 to 2015, inventions by University researchers generated more than $320 million in revenue for the University.

7. Such research requires substantial funding, which the University obtains from both public and private sources. In 2015, for example, University faculty and staff

were awarded over $700 million in research funds. Researchers in the College of Science and Engineering won over $140 million of those funds. The University consistently ranks among the top U.S. public universities in its amount of research spending.

8. To maximize the public benefit that its research generates, the University in some instances patents and/or commercializes inventions generated by its researchers. It then reinvests a portion of those profits back into its education and research programs in accordance with its mission of serving the people of the State of Minnesota.

9. Over the past 20 years, the United States Patent and Trademark Office ("USPTO") has awarded hundreds of patents to the University, including the '601 Patent, thereby recognizing the innovative technologies generated by the University's researchers.

10. Defendant LSI Corporation ("LSI") is a Delaware corporation with a principal place of business at 1320 Ridder Park Drive, San Jose, California 95131.

11. During certain times relevant to this action, LSI maintained offices in this judicial district, including in Rochester, Mendota Heights, and Bloomington, Minnesota.

12. Defendant Avago Technologies U.S. Inc. ("Avago U.S.") is a Delaware corporation with a principal place of business at 1320 Ridder Park Drive, San Jose, California 95131.

13. Avago U.S. or one of its affiliate companies maintains a design office with over 100 employees in this judicial district.

14. LSI and Avago U.S. are both wholly owned indirect subsidiaries of holding company Avago Technologies Limited, which is in turn a wholly owned indirect subsidiary of holding company Broadcom Limited.

15. LSI was formed as a result of the merger of LSI Logic Corporation and Agere Systems Inc. ("Agere") in 2007. Avago Technologies Limited then acquired LSI in 2014. The ultimate parent company, Broadcom Limited, was formed on February 1, 2016, as a result of a merger between Avago Technologies Limited and Broadcom Corporation. As of November 1, 2015, Avago Technologies Limited and its subsidiaries employed about 8,200 persons globally, with 56% of the workforce located in North America.

16. LSI designs, develops, and supplies storage and networking integrated circuits, including HDD chips ("HDD Chips"). HDD Chips include but are not limited to HDD controller systems-on-a-chip ("SOCs") and/or stand-alone read channel chips, both of which are sold under the TrueStore tradename.

17. Since March 2015, Avago U.S. has handled the U.S. sale and distribution of LSI products, including the product line of SOCs sold under the TrueStore tradename.

18. Defendants have a "direct sales force focused on supporting large OEMs [original equipment manufacturers]" and also distribute "a substantial portion of [] products through [a] broad distribution network," including "large global electronic components distributors." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 4.

19. U.S. distributors of Defendants' products include Avnet Electronics Marketing and Digi-Key. Avnet Electronics Marketing maintains an office in this

judicial district, at 2740 American Boulevard West, Suite 150, Bloomington, Minnesota 55431. Digi-Key maintains an office in this judicial district, at 701 Brooks Avenue South, Thief River Falls, Minnesota 56701.

20. Defendants have provided and currently provide customized HDD Chip information, data, simulators, and chips incorporating the invention described in the ’601 Patent to customers who manufacture HDDs, including Seagate Technology PLC (“Seagate”) and HGST, Inc. (“HGST”). Defendants have also provided and currently provide both Seagate and HGST with know-how regarding the invention of the ’601 Patent and support and instructions to implement and operate the invention of the ’601 Patent.

21. Seagate maintains facilities in this judicial district, in Bloomington and Shakopee, Minnesota.

22. HGST maintains a facility in this judicial district, in Rochester, Minnesota.

23. These Seagate and HGST facilities undertake, among other things, research and development on HDDs that incorporate Defendants’ HDD Chips, and, in that regard, Seagate and HGST personnel have worked and currently work with Defendants’ personnel on all manner of HDD technology, including the invention of the ’601 Patent.

24. Defendants locate their field application engineers and design engineers “in many cases near [their] top customers” to “enhance[] their customer reach and [their] visibility into new product opportunities and enable[them] to support [their] customers in each stage of their product development cycle, from early stages of production design

through volume manufacturing and future growth." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 8.

25. Defendants have "a diversified and well-established base of thousands of end customers, located throughout the world, which [they] serve through [their] multi-channel sales and fulfillment system." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 4.

26. Products incorporating Defendants' HDD Chips that infringe the '601 Patent when operated are offered for sale and/or sold at retail stores throughout Minnesota. End users within this state use those products, which perform the methods claimed in the '601 Patent millions of times per second when in use.

JURISDICTION AND VENUE

27. This is an action for patent infringement arising under the patent laws of the United States, 35 U.S.C. § 271 *et seq*.

28. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331, 1332 and 1338(a).

29. This Court has personal jurisdiction over Defendants because Defendants regularly conduct business in the State of Minnesota and this judicial district, either directly or through agents, including distributors. Defendants have also committed acts of infringement or contributed to or induced acts of infringement by others in the State of Minnesota and this judicial district, including working directly with Defendants' customers located in the state regarding the design, development, testing, and use of the invention. Defendants have further voluntarily placed infringing products and/or

components of products into the stream of commerce with the expectation that their products or products incorporating their components would be shipped into, offered for sale in, sold and used in the State of Minnesota and this judicial district.

30. As a result, Defendants have intentionally availed themselves of the privilege of conducting business in this state and district, have purposefully directed activity at this state and district, and have established sufficient minimum contacts with this state and district such that Defendants can reasonably and fairly anticipate being haled into this Court.

31. Venue is proper in this district pursuant to 28 U.S.C. §§ 1400(b) and 1391(b)-(c) because Defendants are subject to personal jurisdiction in, and so reside in, this district.

FACTUAL BACKGROUND

A. Data Storage

32. An HDD is a ubiquitous device that stores digital information on one or more rotating disks, also sometimes referred to as "platters," that are coated with magnetic material.

33. Data are stored in sequential, individual magnetically coated regions on the disk by means of controlling the direction of magnetization of each individual region.

34. An HDD comprises a read/write device that includes both a write head that writes the data to the disk and a read head that reads the data once they are written.

35. When user data are to be written to the disk, the data are encoded and then the encoded data are converted into an analog signal that is sent to the write head. The

write head records the resulting signal on the magnetic disk by magnetically polarizing the regions on the disk in accordance with the received signal.

36. Each polarized region on the magnetic recording layer of the disk has a magnetic polarization that, once written by the write head, is oriented in a particular direction. The magnetic polarity of these regions can be changed from one direction to its opposite by the write head in order to write the data to the disk.

37. An HDD also includes a read channel that performs the "immensely tricky task of converting the analog data signal" generated from the disk of the HDD "into binary bits." *See* www.avagotech.com/products/hard-disk-drives/socs-read-channel.

38. When adjacent polarized regions are magnetized in opposing directions, there is a "transition" in the polarity of the regions that is detected by the read channel of the HDD when reading the data.

39. When reading the data from the disk, the read head hovers over the disk as the disk rotates below it. The read head senses the magnetic fields from the magnetic medium and converts the sensed magnetic fields into an analog "readback" signal.

40. A sequence detector in the read channel converts the analog readback signal into binary data by determining from the signal the likely sequence of transitions and non-transitions recorded to the magnetic medium, where detected transitions can indicate a binary "1" and a nontransition can indicate a binary "0".

41. One performance metric for a read channel is the bit error rate ("BER"), which is the rate at which the read channel makes errors in determining the data written to the disk.

42. "Data continues to grow, driven by video, social media, enterprise applications and the cloud. To meet this demand, hard drive manufacturers continually drive more capacity per platter in hard drives." *See* www.avagotech.com/products/hard-disk-drives/socs-read-channel.

43. The data written and corresponding readback waveform in an HDD include noise that limits the reliability of the HDD.

44. A major and increasing source of noise in HDDs over the past 15 years is media noise, which includes noise resulting from transitions on the magnetic media.

45. Increasing the data capacity of an HDD increases the density of the transitions on the magnetic disk, which in turn increases the amount of noise in the analog data signal generated by the read head as it passes over the bit regions.

B. The University's Patent

46. On January 12, 1999, the USPTO issued the '601 Patent, titled "Method and Apparatus for Implementing Maximum Transition Run Codes." A true and correct copy of the '601 Patent is attached as Exhibit 2.

47. The invention described by the '601 Patent relates generally to a coding scheme for an HDD, referred to in the '601 Patent by the coined phrase "Maximum Transition Run" ("MTR") codes, that improves the BER of sequence detectors in the read channels of an HDD by "eliminat[ing] certain error-prone data patterns from the allowable set of input patterns that are to be recorded" on the disks of the HDD. *See* '601 Patent at col. 2:40-47.

48. The named inventors for the ’601 Patent are Jaekyun Moon and Barrett J. Brickner.

49. Drs. Moon and Brickner also described their invention in a seminal academic paper, “Maximum Transition Run Codes for Data Storage Systems,” *IEEE Trans. Magn.*, vol. 32, no. 5, September 1996 (“the Moon 1996 IEEE Paper”).

50. A true and correct copy of the Moon 1996 IEEE Paper is attached as Exhibit 3.

51. The Moon 1996 IEEE Paper is substantially similar to the ’601 Patent.

52. For example, the Moon 1996 IEEE Paper discloses all of the elements of claim 13 of the ’601 Patent, including an encoding scheme where m-bit datawords are encoded into n-bit codewords with the dual constraints of (1) a limit on the maximum number j of consecutive transitions that can occur in the written magnetization pattern, where $j \geq 2$, and (2) a limit on the maximum number k of sample periods without a transition. They also include many of the same figures.

53. When the University filed the application that matured into the ’601 Patent (application Serial No. 08/730,716), Dr. Moon was a professor in the Department of Electrical Engineering at the University and Dr. Brickner was Dr. Moon’s Ph.D. student.

54. On or around 2005, CRC Press published Coding and Signal Processing for Magnetic Recording Systems, edited by Bane Vasic and Erozan M. Kurtas.

55. A true and correct copy of Chapter 17 of Coding and Signal Processing for Magnetic Recording Systems is attached as Exhibit 4.

56. In Chapter 17, titled "Runlength Limited Sequences," author Kees A. Schouhamer Immink states that "[m]aximum transition run (MTR) codes" were "introduced by Moon and Brickner." Exhibit 4 at § 17.3.1, p. 17-4.

57. On or around 1997, authors Kelly Knudson and Cory S. Modlin published a paper entitled "Time-varying MTR Codes for High Density Magnetic Recording" in the *Proceedings of the IEEE Global Telecommunications Conference 1997.*

58. A true and correct copy of the Knudson-Modlin paper is attached as Exhibit 5.

59. In that paper, as authority for the proposition that "[m]aximal transition run (MTR) codes have been suggested as a means of achieving coding gain for high density magnetic recording," the authors cite an invention disclosure and a paper written by Drs. Moon and Brickner about MTR codes: (1) J. Moon and B. Brickner, "MTR codes for data storage systems," *Invention Disclosure No. 96025, University of Minnesota*, September 1995, and (2) J. Moon and B. Brickner, "Maximum Transition Run Codes for Data Storage Systems," *1996 Digests of Intermag* '96, HB-IO, April 1996 (which is substantially similar to the Moon 1996 IEEE Paper).

60. The invention disclosure and *Intermag* paper by Drs. Moon and Brickner are the sole support that Knudson and Modlin cite for the use of MTR codes.

61. In April 2001, a paper authored by four IBM Research members, Roy D. Cideciyan, Evangelos Eleftheriou, Brian Marcus, and Dharmendra Modha, entitled "Maximum Transition Run Codes for Generalized Partial Response Channels," appeared

in the *IEEE Journal on Selected Areas in Communications*, Vol. 19, No. 4 ("IBM Research Paper").

62. A true and correct copy of the IBM Research Paper is attached as Exhibit 6.

63. The IBM Research Paper states, "maximum transition run (MTR) (*j*, *k*) codes have been introduced by Moon and Brickner to provide coding gain for extended partial response channels."

64. As support for this statement, the IBM Research Paper cited the Moon 1996 IEEE Paper.

65. As described in the ’601 Patent, a dataword that is to be recorded on a disk of an HDD is encoded using a selected MTR code with specified so-called *j* and *k* constraints, to thereby create a codeword for writing to the disk.

66. As described in the ’601 Patent, the *j* constraint imposes a limit on the maximum number of consecutive transitions that are written to the disk of an HDD. *See* ’601 Patent at col. 2:59-61.

67. As described in the ’601 Patent, the *k* constraint imposes a limit on the maximum number of consecutive regions on the disk without a transition. *See* ’601 Patent at col. 1:27-33.

68. Claim 13 of the ’601 Patent claims "[a] method for encoding m-bit binary datawords into n-bit binary codewords in a recorded waveform, where m and n are preselected positive integers such that n is greater than m, comprising the steps of: receiving binary datawords; and producing sequences of n-bit codewords; imposing a pair of constrains (j;k) on the encoded waveform; generating no more than j consecutive

transitions of said sequence in the recorded waveform such that $j \geq 2$; and generating no more than k consecutive sample periods of said sequences without a transition in the recorded waveform." '601 Patent at col. 10:46-59.

69. Claim 14 of the '601 Patent claims the method as in claim 13 "wherein the consecutive transition limit is defined by the equation $2 \leq j < 10$." '601 Patent at col. 10:60-61.

70. Eliminating error-prone transition runs with an MTR code in an HDD read channel improves the BER of the read channel.

71. The improvement in the BER provided by MTR codes in an HDD read channel "can be traded for an increase in storage density if the error rate performance [of the read channel] is already satisfactory." '601 Patent at col. 2:49-51.

72. The MTR coding scheme described in the '601 Patent improves a physical process by overcoming limitations in physical devices—i.e., improving the accuracy of determining what data are recorded on a magnetic medium in an HDD from what the read/write head in the HDD has sensed.

73. The University is the owner and assignee of all right, title, and interest in and to the '601 Patent and holds the right to sue and recover damages for infringement thereof, including past damages.

74. Since MTR codes were "introduced by Moon and Brickner," *see* Exs. 4, 5 and 6, the term "MTR" when referring to codes used in HDD read channels is understood in the HDD industry to refer to the encoding scheme described in the Moon 1996 IEEE Paper, namely the encoding scheme where m-bit datawords are encoded into n-bit

codewords with the dual constraints of (1) a limit on the maximum number j of consecutive transitions that can occur in the written magnetization pattern, where $j \geq 2$, and (2) a limit on the maximum number k of sample periods without a transition, and such codes are covered by claim 13 of the ‘601 Patent.

C. Defendants’ Unauthorized Use of the Methods Claimed in the ’601 Patent

75. Defendants make, use, and sell devices with so-named “MTR” code capability, including all read channel/SOC HDD Chips currently sold under the tradename TrueStore and simulators for reading MTR-encoded recorded waveforms (“the MTR-enabled Products”). MTR-enabled Products in the TrueStore product line include but are not limited to the RC5101 Spyder ELP PS Azure, the RC5110 Spyder ELP PS Boxster, and the RC5200 Spyder ELP PS Corvette read channels and SOCs that include those read channels.

76. The MTR-enabled Products cannot be reverse-engineered to confirm their use of MTR code, but published statements by senior executives of LSI, other statements by LSI senior employees, and publicly available materials show that these Products infringe the ’601 Patent.

77. At least one senior engineering executive of Defendants has admitted to developing MTR coding technology for LSI.

78. Specifically, Dr. Shaohua Yang states on his LinkedIn page that he “[d]eveloped RLL/MTR modulation coding solutions” while employed as Director, Distinguished Engineer, DSP System Architecture at “LSI, an Avago Technologies Company” between June 2007 and May 2014. Dr. Yang is now a Director of

Engineering at "Avago Technologies." *See* www.linkedin.com/in/shaohua-yang-9520641.

79. A true and correct redacted copy of Dr. Yang's LinkedIn page dated August 17, 2016, is attached as Exhibit 7.

80. Another senior engineering executive of Defendants has publically indicated that LSI uses MTR coding technology.

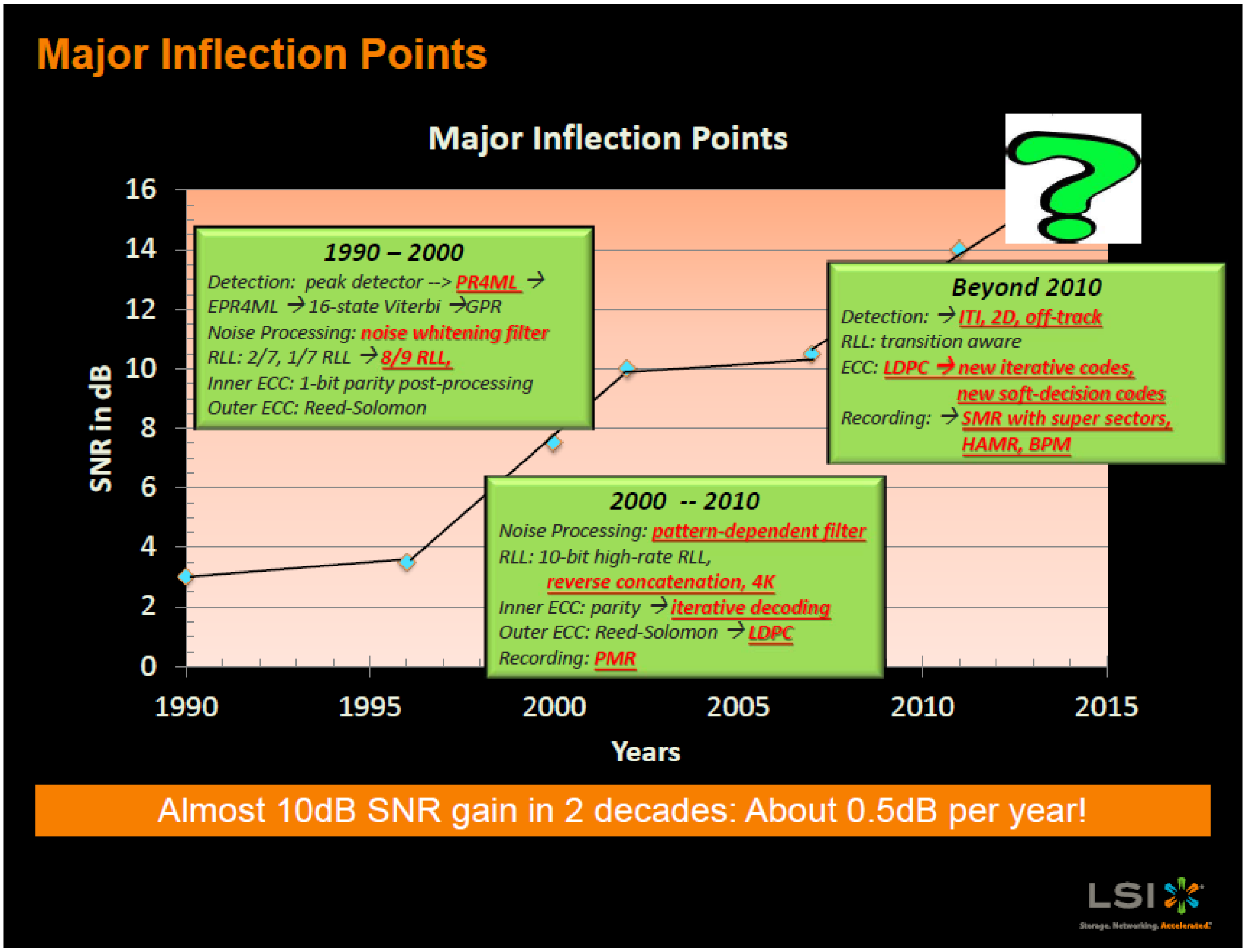
81. Dr. Yuan Xing Lee was an LSI Vice President from 2007 to 2014 and is now a "vice president for the Data Controller Division Engineering in Broadcom Limited." *See* https://www.linkedin.com/in/yuan-xing-lee-5906225.

82. A true and correct redacted copy of Dr. Lee's LinkedIn page dated August 17, 2016, is attached as Exhibit 8.

83. In 2012, Dr. Lee gave a presentation at the Chinese American Information Storage Society ("CAISS") Annual Conference titled "Read Chanel [*sic*] Technologies for Data Storage."

84. A true and correct copy of the slides for Dr. Lee's presentation to CAISS at its 2012 annual conference is attached as Exhibit 9.

85. In Slide 6 of his presentation, shown below, Dr. Lee declared "RLL: transition aware" was a "major" technology for HDDs in the "Beyond 2010" period.



86. “RLL” in this context means “run length limited.”

87. Upon information and belief, in this slide, “RLL: transition aware” refers to MTR codes.

88. Additionally, Dr. Lee is a co-author of the paper K. Cai et al., “Distance-Enhancing Constrained Codes with Parity-Check Constraints for Data Storage Channels,” 28-2 *IEEE J. Sel. Areas Commun.* (Feb. 2010) (“Cai Paper”).

89. A true and correct copy of the Cai Paper is attached as Exhibit 10.

90. In the Cai Paper, Dr. Lee and his coauthors wrote that "[i]n recent years, a maximum transition run (MTR) constraint j has been further introduced to magnetic recording channels," citing as authority to the Moon 1996 IEEE Paper. Ex. 10 at 208.

91. Dr. Lee also referred in the Cai Paper to an MTR code where m = 17, n = 18, j = 3, and k=13. Dr. Lee further stated that the "code rate of the state of the art j = 3 MTR codes is 16/17." Ex. 10 at 211. This means MTR codes where j=3, m=16, and n=17 were "state of the art" as of 2010, the publication date of the paper.

92. At least one publicly available product specification also indicates the Defendants use the inventions claimed in the '601 Patent.

93. An excerpt of the "TrueStore® RC5100/5200 Series Spyder Read Channel Product Specification" generated by LSI for Seagate and dated February 2013, filed at Compl. Ex. G, D.I. 1-9 at 10, *Spectra Licensing Group, LLC v. LSI Corporation et al.*, 3:16-cv-00899 (S.D. Cal. Apr. 14, 2016), states that LSI's product models RC5100 and 5200 have an "MTR code option."

94. Defendants have designed, tested, and used the MTR-enabled Products in the United States in a manner that performs the methods described in one or more method claims of the '601 Patent, including but not limited to claims 13 and 14.

95. Defendants provide HDD Chips and simulators to customers that include HDD manufacturers. Defendants provide these chips and simulators to HDD manufacturers in the United States for, among other purposes, design, development, testing, and qualification of the chips.

96. The Defendants have provided to customers HDD Chips and simulators that are MTR-enabled.

97. At Defendants' direction, Defendants' HDD manufacturer customers have operated the HDD Chips and simulators provided by Defendants in the United States.

98. Defendants' HDD manufacturer customers have operated the HDD Chips and simulators, including MTR-enabled Products, at Defendants' direction in the United States in a manner that performs the methods described in one or more method claims of the '601 Patent, including but not limited to claims 13 and 14.

99. Defendants' MTR-enabled Products, when operated in the United States by Defendants, their customers, or end users (who purchase Defendants' customers' HDD products incorporating the MTR-enabled Products), as the case may be, encode m-bit binary datawords into n-bit codewords in a recorded waveform, where m and n are preselected positive integers such that n is greater than m, by performing steps that comprise receiving binary datawords; imposing a pair of constraints (j;k) on the encoded waveform; generating no more than j consecutive transitions of said sequence in the recorded waveform such that $j \geq 2$; and generating no more than k consecutive sample periods of said sequences without a transition in the recorded waveform.

100. Defendants' MTR-enabled products can be and are programmed by Defendants or at Defendants' direction to use a j value of 2 or greater.

101. Defendants' MTR-enabled products can be and are programmed by Defendants or at Defendants' direction to use a k value of about 25.

102. Defendants' MTR-enabled Products use a value of "n" for the bit length of the binary codewords that is greater than the value of "m," the bit length of the datawords that is encoded into the codewords. In particular, information publicly available from Defendants shows that Defendants' MTR-enabled Products use m/n rates of 17/18, 19/20, 20/21, 21/22, 22/23, 23/24, and/or 24/25.

103. Defendants direct, instruct, and assist their HDD manufacturer customers regarding the use of the MTR-enabled Products such that when operated, the MTR-enabled Products encode m-bit binary datawords into n-bit codewords in a recorded waveform, where m and n are preselected positive integers such that n is greater than m, by performing steps that comprise receiving binary datawords; imposing a pair of constraints (j;k) on the encoded waveform; generating no more than j consecutive transitions of said sequence in the recorded waveform such that $j \geq 2$; and generating no more than k consecutive sample periods of said sequences without a transition in the recorded waveform.

104. Defendants direct, instruct, and assist their HDD manufacturer customers to use the MTR-enabled Products in an infringing manner through documentation, including product specifications, user guides, and register maps, which provides instructions to the customers on how to operate the MTR-enabled Products in an infringing manner.

105. For example, among other things, the MTR-enabled Products have firmware through which the MTR code option is enabled. When the MTR code option is enabled, the MTR-enabled Products perform the methods claimed in the '601 Patent. Defendants provide verbal and written instructions to engineers of Defendants' HDD

manufacturer customers to enable the MTR code option in the MTR-Enabled Products through firmware and provide MTR-enabled Products to Defendants' HDD manufacturer customers with the MTR code option enabled through the firmware.

106. Upon information and belief, the written instructions for enabling the MTR code option provided by Defendants to the engineers of its HDD manufacturer customers include, among other things, register maps that instruct customers to program the firmware of the MTR-enabled Products so that the MTR code option is enabled.

107. Defendants are aware that enablement of the MTR option improves the performance of the MTR-enabled Products, and Defendants intend for both they and their customers to make use of the performance gains resulting from use of the MTR technology. Accordingly, Defendants or their customers on instruction from Defendants enable the option and leave it enabled to take advantage of that improved performance. Defendants further intend that both they and their customers infringe at least claim 13 of the '601 Patent.

108. Defendants also direct, instruct, and assist their HDD manufacturer customers in operating MTR-enabled Products in an infringing manner through meetings, phone calls, and emails between Defendants' engineers and Defendants' HDD manufacturer customers' engineers, in which Defendants' engineers provide technical briefings, demonstrate the benefits of MTR coding, and instruct the customer's engineers about how to use the MTR-enabled Products in an infringing manner with the intent that they do so, such as by enabling the MTR code option in the firmware.

109. Defendants provide their HDD manufacturer customers with HDD Chips that are enabled with MTR functionality such that when operated the HDD Chips infringe method claims of the ’601 Patent.

110. The components of the read channel in Defendants’ MTR-enabled Products that encode the MTR code are specifically designed to perform methods claimed in the ’601 Patent, and Defendants intend that these components be so used.

111. The components of the read channel in Defendants’ MTR-enabled Products that encode the MTR code cannot be used in a noninfringing manner.

112. The read channels in the MTR-enabled Products include an encoder for encoding the data to be written to the HDD using the MTR j and k constraints. Components of those MTR encoders are specifically designed to perform the steps of claims 13 and 14, and have no substantial use other than to perform the methods of at least claims 13 and 14.

113. The infringing MTR code option is enabled because of the improved BER performance that it provides, which is crucial to the Defendants’ HDD manufacturer customers.

D. Defendants’ Sales Cycle for the MTR-enabled Products

114. Defendants have engaged and continue to engage in an extensive design, development, and sales cycle (“Sales Cycle”) to sell their HDD Chips.

115. The Sales Cycle is “typically lengthy” and requires Defendants “to incur significant design and development expenditures and to dedicate … engineering

resources in pursuit of a single customer." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 17.

116. The Sales Cycle "involves a significant investment of money, time, and effort on the part of both the chip supplier and the OEM," e.g., Western Digital, Toshiba, Seagate and HGST. *See* Pl. Mem. In Supp. of Mot. For Entry of Prelim. Inj. at 8, *Broadcom Corp. v. Emulex Corp.*, No. SACV09-1058 JVS (ANx) (C.D. Cal. Jan. 18, 2012).

117. During this Sales Cycle, Defendants work closely with potential customers to optimize and customize their HDD Chips for incorporation into customers' HDD products. "By collaborating with [their] customers, [Defendants] have opportunities to develop high value-added customized products for them …." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 8.

118. During the Sales Cycle, Defendants make substantial U.S.-based use of their HDD Chips and simulators both at their own U.S. facilities and at the U.S. facilities of their HDD manufacturer customers. Such use includes extensive testing, performance validation, qualification, and demonstrations of the HDD Chips and simulators.

119. Defendants instruct and encourage their HDD manufacturer customers to extensively test, evaluate, validate, and qualify Defendants' HDD Chips and simulators throughout the Sales Cycle in the United States.

120. Defendants' "business is dependent on [their] winning competitive bid selection processes, known as 'design wins,' to develop semiconductors for use in [their] customers' end products." Exhibit 1 (Avago Technologies Limited 2015 10-K) at 17.

121. "Design wins are not simply sale-by-sale decisions; rather, they represent the culmination of a process that includes multiple stages and carries with it ramifications that can last for years." *See* Br. of Pl.-Appellee Broadcom Corp. at 52, *Broadcom Corp. v. Emulex Corp*., No. 2012-1309 (Fed. Circ. July 26, 2012).

122. Use of the HDD Chips and simulators by both Defendants and their HDD manufacturer customers during the Sales Cycle results in lucrative "design wins" with Defendants' HDD manufacturer customers.

123. Defendants' "design wins" in the United States result in substantial orders from customers for Defendants' HDD Chips, such that the "design wins" constitute sales of the HDD Chips in the United States.

124. In addition to and as part of the U.S. "design wins" that constitute the sales of Defendants' HDD Chips, substantial activities of the sales transaction occur in the United States.

125. Without Defendants' and their HDD manufacturer customers' U.S.-based use of the HDD Chips during the Sales Cycle, Defendants would not have achieved critical design wins (i.e., sales), would not have shipped hundreds of millions of their HDD Chips to customers, and would not have obtained the resulting profits.

126. Defendants use and sell all of their MTR-enabled Products through this Sales Cycle.

127. During the Sales Cycle, Defendants, through use of the MTR-enabled Products, perform method claims of the '601 Patent, including at least claims 13 and 14.

128. During the Sales Cycle, Defendants instruct and encourage their HDD manufacturer customers to use the MTR-enabled Products in modes that practice one or more methods claimed in the ’601 Patent with the intent that such customers will purchase MTR-enabled Products for use in the customers’ HDD products in MTR-enabled modes.

129. The BER performance gain provided by infringing use of MTR codes in Defendants’ MTR-enabled Products was necessary for Defendants to secure design wins with their HDD manufacturer customers.

E. Defendants’ Knowledge of the ’601 Patent

130. MTR code is industry standard read-channel technology.

131. Any commercially-viable implementation of MTR coding requires performance of the methods of claim 13 of the ’601 Patent.

132. Drs. Moon and Brickner’s invention and subsequent patenting of the MTR code is widely known in the HDD industry, including among engineers designing HDD chips for Defendants and other companies.

133. The Moon 1996 IEEE Paper and its correspondence to the ’601 Patent are widely known in the HDD industry.

134. Numerous senior personnel and executives of the Defendants and their predecessor companies specifically were aware of and had knowledge of the ’601 Patent.

135. Dr. Lee, LSI Vice President from 2007 to 2014, had knowledge of the ’601 Patent from at least 2006 and knew that LSI was infringing it.

136. Dr. Lee was the first named inventor on U.S. Patent No. 7,164,371, which issued on January 16, 2007 and is titled "Method and Apparatus for Data Coding for High Density Recording Channels Exhibiting Low Frequency Contents." That patent cites both the '601 Patent and the Moon 1996 IEEE Paper as references. The Moon 1996 IEEE Paper cites to the University invention disclosure made by Drs. Moon and Brickner.

137. Dr. Lee also cited the seminal Moon 1996 IEEE Paper in multiple papers, including at least I. Demirkan and Y. X. Lee, "The Combined Constraints for Perpendicular Recording Channels," 42-2 *IEEE Trans. Magn.* (Feb. 2006) and Y. X. Lee et al., "Distance-Enhancing Constrained Codes with Parity-Check Constraints for Data Storage Channels," 28-2 *IEEE J. Sel. Areas Commun.* (Feb. 2010).

138. Dr. Bruce Wilson, another senior executive at LSI and its successor companies, had knowledge of the '601 Patent during the period in which Defendants infringed the '601 Patent and likewise knew that LSI was infringing it.

139. Dr. Bruce Wilson was Director of Read Channel Architecture at LSI and at "Avago Technologies" during the period in which Defendants infringed the '601 Patent. Dr. Wilson is currently Senior Director of Architecture at "Broadcom Limited."

140. Dr. Wilson cited the Moon 1996 IEEE Paper in multiple papers, including at least B. Wilson et al., "Reverse Concatenation with Maximum Transition Run (MTR) Codes for High-Density Perpendicular Recording," *IEEE GLOBECOM 2008 Proceedings* (2008), and B. Wilson et al., "On Modulation Coding for Channels with Cost Constrains," *2014 IEEE Int. Symp. Inf. Theory* (2014).

141. Dr. Yang, LSI Director from 2007 to 2014, had knowledge of the ’601 Patent during the period when Defendants infringed the ’601 Patent and likewise knew that LSI was infringing it.

142. Dr. Yang cited the Moon 1996 IEEE Paper in multiple papers, including at least S. Yang et al., “On Modulation Coding for Channels with Cost Constrains,” *2014 IEEE Int. Symp. Inf. Theory* (2014) and S. Yang et al., “Precoding Mapping Optimization for Magnetic Recording channels,” 50-11 *IEEE Trans. Magn.* (Nov. 2014).

143. Dr. Brickner was an LSI executive during the period when Defendants infringed the ’601 Patent and, as co-inventor on the ’601 Patent, had knowledge of the ’601 Patent during that same time.

144. In October 2011, Dr. Moon, co-inventor of the ’601 Patent, and Dr. Lee, then LSI Vice President, discussed Dr. Moon’s invention. After Dr. Moon gave a presentation at LSI, Dr. Lee thanked Dr. Moon for his invention of MTR Code and noted that it was becoming popular in the industry. Dr. Lee indicated that LSI would be in touch regarding licensing.

145. In 2013, Dr. Moon contacted Dr. Lee to initiate a licensing discussion regarding his invention between the University’s Office of Technology Commercialization and LSI.

146. Dr. Lee investigated how to proceed with the negotiation and subsequently directed Dr. Moon to contact Ryan Phillips, LSI’s in-house intellectual property counsel (now the Director and Managing IP Counsel for Avago and Broadcom Limited). On this

email, Dr. Lee copied Dr. Wilson, another senior LSI executive with direct knowledge of LSI's MTR code and the '601 Patent.

147. As Dr. Lee suggested, in April 2013, a representative of the University's Office of Technology Commercialization emailed LSI's counsel, Mr. Phillips, to schedule a call to discuss "technology developed by Dr. Jae Moon while he was at the University of Minnesota."

148. During the April 2013 call that followed, the University's representative stated that Dr. Lee had referred him to Mr. Phillips for a discussion of licensing.

149. Dr. Lee referred the University to Mr. Phillips for a discussion of licensing the inventions Drs. Lee and Moon previously had discussed, namely the MTR Codes that Dr. Lee had said were now popular in the industry and that LSI would be in touch to license.

150. Despite the fact that the conversation had been set up by Dr. Lee, who had knowledge of the '601 Patent and LSI's use of the inventions described therein, Mr. Phillips summarily denied using outside intellectual property and, upon information and belief, willfully blinded himself from gaining additional knowledge of the '601 patent and LSI's admitted use of the claimed technology.

151. Based on LSI's denial, the University did not proceed further with the licensing discussion.

152. The Defendants are also aware of the '601 Patent and their use of the methods claimed in the '601 Patent based on the prosecution history of several of their patents.

153. In January 2014, a patent examiner cited the ’601 Patent during the examination of LSI’s U.S. Patent No. 8,730,067.

154. U.S. Patent No. 8,730,067 has been assigned to Avago Technologies General IP (Singapore) Pte. Ltd.

155. Dr. Yang is a named inventor for U.S. Patent No. 8,730,067.

156. In August 2000, the ’601 Patent was included in the list of references considered during the examination of Lucent Technologies, Inc.’s U.S. Patent No. 6,097,321. Lucent is a predecessor of LSI.

157. Numerous other patents from LSI, its predecessor Agere, and entities owned by LSI’s parent company Avago Technologies Limited reference the Moon 1996 IEEE Paper, including U.S. Patent Nos. 8,700,981; 9,337,866; 8,788,921; 8,625,221; 8,797,668; and 8,929,009.

158. LSI also was or should have been aware of the papers attached as Exs. 5-6 that attribute invention of the MTR code to Drs. Moon and Brickner, including because LSI patents cite those documents.

<u>COUNT I—INFRINGEMENT OF THE ’601 PATENT</u>

159. The allegations set forth in Paragraphs 1-158 are incorporated herein by reference.

160. Defendants are now and/or have been directly and/or indirectly infringing method claims of the ’601 Patent, as proscribed by 35 U.S.C. § 271, *et seq.*, by, without permission or authority from the University, using within the United States, including this district, the MTR-enabled Products such that when the MTR-enabled Products are

operated, they perform and directly infringe methods claimed in the ’601 Patent, including at least claims 13 and 14.

161. Defendants have directly infringed and continue to directly infringe method claims of the ’601 Patent, including at least claims 13 and 14, by using the MTR-enabled Products in the United States without authority.

162. As a direct and proximate result of Defendants’ infringement of the ’601 Patent, the University has been and continues to be damaged.

163. Defendants have indirectly infringed and continue to indirectly infringe method claims of the ’601 Patent, including at least claims 13 and 14, by actively inducing their HDD manufacturer customers to use the MTR-enabled Products in the United States, without authority, in a manner that, when the MTR-enabled Products are operated, they perform and directly infringe methods claimed in the ’601 Patent, including at least claims 13 and 14. Among other things, Defendants provide the MTR-enabled Products to their HDD manufacturer customers with instructions on how to use MTR codes that infringe at least claims 13 and 14 of the ’601 Patent. Furthermore, Defendants were aware of the ‘601 Patent or were willfully blind to it. Defendants knew or should have known that their actions would induce direct infringement by their HDD manufacturer customers of methods claimed in the ’601 Patent, including at least claims 13 and 14, and intended that their actions would induce direct infringement by such HDD manufacturer customers.

164. Defendants have also indirectly infringed and continue to indirectly infringe method claims of the ’601 Patent, including at least claims 13 and 14, by

contributing to the direct infringement by HDD manufacturer customers and end-users of the method claims of the ’601 Patent, including at least claims 13 and 14. The components of the read channel in Defendants’ MTR-enabled products that encode the MTR code are a material part of the invention. Defendants offer to sell and sell in the United States the MTR-enabled Products, knowing that the components of the read channel in Defendants’ MTR-enabled products that encode the MTR code are especially made or especially adapted for use in the infringement of the ’601 Patent and are not a staple article or commodity of commerce suitable for any substantial noninfringing use.

165. As a direct and proximate result of Defendants’ indirect infringement of the ’601 Patent, the University has been and continues to be damaged.

166. By engaging in the conduct described herein, Defendants have injured the University and are thus liable for infringement of the ‘601 Patent, pursuant to 35 U.S.C. § 271.

167. Defendants have committed these acts of infringement without license or authorization.

168. Defendants have committed these acts of infringement with knowledge of the ’601 Patent and thus have acted recklessly and willfully with regard to the University’s rights in the ’601 Patent.

169. As a result of Defendants’ willful infringement of the ’601 Patent, the University has suffered monetary damages and is entitled to a monetary judgment in an amount adequate to compensate for Defendants’ past infringement, together with enhanced damages, attorneys’ fees, interest, and costs.

PRAYER FOR RELIEF

WHEREFORE, the University respectfully requests that this Court hereby enter judgment against Defendants and provide relief as follows:

A. A judgment that Defendants have infringed the ’601 Patent;

B. A judgment that Defendants’ infringement of the ’601 Patent has been willful;

C. An award of damages sufficient to compensate the University for Defendants’ infringement of the ’601 Patent, together with pre-judgment interest and costs;

D. An award of all other damages permitted by 35 U.S.C. § 284, including increased damages up to three times the amount of compensatory damages found;

E. A declaration that this is an exceptional case and an award to the University of its costs and reasonable attorneys’ fees incurred in this action as provided by 35 U.S.C. § 285; and

F. Such other relief that this Court deems just and proper.

JURY DEMAND

Pursuant to Federal Rule of Civil Procedure 38(b), the University hereby demands a trial by jury on all issues triable of right by a jury.

Dated: November 11, 2016

DOUGLAS R. PETERSON
General Counsel
University of Minnesota

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CERTIFICATE OF SERVICE

I hereby certify that on November 11, 2016, I caused the foregoing to be electronically filed with the Clerk of the Court using CM/ECF, which will send notification of such filing to all registered participants.

/s/ Anna Shabalov
Anna Shabalov (PA #315949)