UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
WACO DIVISION

MIMO RESEARCH, LLC, ***Plaintiff,*** v. **APPLE INC.,** ***Defendant.***	**Civil Action No. 6:22-cv-620** **JURY TRIAL DEMANDED**

COMPLAINT FOR PATENT INFRINGEMENT

MIMO Research, LLC ("MIMO Research" or "Plaintiff") brings this action and makes the following allegations of patent infringement relating to U.S. Patent Nos.: 7,091,854 (the "'854 patent"); 7,046,716 (the "'716 patent"); 7,133,646 (the "'646 patent"); 7,305,057 (the "'057 patent"); and 7,433,382 (the "'382 patent") (collectively, the "patents-in-suit"). Defendant Apple Inc. ("Apple" or "Defendant") infringes the patents-in-suit in violation of the patent laws of the United States of America, 35 U.S.C. § 1 *et seq*.

THE PARTIES

1. Plaintiff MIMO Research, LLC ("Plaintiff" or "MIMO Research") is a New York limited liability company established in 2017. MIMO Research owns a portfolio of patents that cover Multiple Input Multiple Output ("MIMO") wireless communication, powerline networking, and ultra-wideband ("UWB") technology. MIMO Research is the owner of all rights, title, and interest in and to the patents-in-suit.

2. Highlighting the importance of the patents-in-suit is the fact that the MIMO Research's patent portfolio has been cited by over 800 U.S. and international patents and patent

applications assigned to a wide variety of the largest companies operating in the wireless integrated circuit field. MIMO Research's patents have been cited by companies such as:

- Samsung Electronics Co., Ltd. [1]
- Broadcom Inc.[2]
- STMicroelectronics N.V. [3]
- Sony Group Corporation[4]
- Nokia Corporation[5]
- Qualcomm, Inc.[6]
- Siemens AG[7]
- Fujitsu Limited[8]

3. Apple has cited the MIMO Research patents in ten patents and patent applications including: U.S. Patent Nos. 7,548,577; 8,279,913; 8,705,641; 8,743,852; 8,958,760; 9,490,864; 9,614,578; and U.S. Patent Application Nos. 2006/0274842; 2009/0238249; and 2011/0142094.

4. Defendant Apple Inc. ("Apple") is a California corporation with its principal place of business at One Apple Park Way, Cupertino, California 95014. Apple maintains regular and established places of business in Texas, and in the Western District of Texas specifically, including offices at 5501West Parmer Lane, Austin, Texas and 12535 Riata Vista Circle, Austin, Texas.

[1] *See, e.g.*, U.S. Patent Nos. 8,478,271; 7,929,995; 7,305,250; 7,392,012; 7,969,859; 9,002,304; and 9,306,616.

[2] *See, e.g.*, U.S. Patent Nos. 7,885,323; 8,520,715; 7,680,083; 7,725,096; 7,795,973; 7,808,985; 7,860,146; 7,873,324; 7,877,078; 7,899,436; 7,956,689; 8,160,127; 8,213,895; 8,406,239; 8,437,387; 8,509,707; 8,750,362; 8,750,392; 8,885,814; 9,042,436; 9,065,465; 9,313,828; and 9,936,439.

[3] *See, e.g.*, U.S. Patent Nos. 7,660,342; 7,656,932; 7,660,341; 7,817,763; and 8,817,935.

[4] *See, e.g.*, U.S. Patent Nos. 9,265,004; 7,542,728; 7,545,787; 7,567,820; 7,688,784; 7,822,436; 7,881,252; 8,045,447; 8,121,144; 8,160,001; 8,259,823; 8,462,746; 9,036,569; 9,237,572; 9,258,833; 8,660,196; and 9,276,649.

[5] *See, e.g.*, U.S. Patent Nos. 7,499,674; 7,643,811; 7,697,893; 7,782,894; and 9,913,248.

[6] *See, e.g.*, U.S. Patent Nos. 8,767,812; 9,300,491; 7,916,081; 8,009,775; 8,054,223; 8,401,503; 8,452,294; 8,467,331; 8,472,551; 8,743,903; 8,745,137; 8,745,695; 8,774,334; and 8,824,477.

[7] *See, e.g.*, U.S. Patent Nos. 7,378,980; 7,382,271; 7,408,839; 8,155,664; and 10,051465.

[8] *See, e.g.*, U.S. Patent Nos. 7,702,022; 7,995,680; 8,761,275; and 8,938,017.

5. Apple may be served through its Texas registered agent for service of process, CT Corporation System, 1999 Bryan St., Ste. 900, Dallas, Texas 75201.

6. Apple operates retail establishments in the Western District of Texas, including retail stores in Barton Creek, Austin, Texas and Domain Northside, Austin, Texas.

7. Apple manufactures its products in Austin and has done so since at least 2013. Apple employs thousands of people based in the Western District of Texas and does business in this District and across Texas. Apple's employees in Austin include Software Engineers; Senior Software Engineers; and UI and UX Designers.

JURISDICTION AND VENUE

8. This action arises under the patent laws of the United States, Title 35 of the United States Code. Accordingly, this Court has exclusive subject matter jurisdiction over this action under 28 U.S.C. §§ 1331 and 1338(a).

9. This Court has personal jurisdiction over Apple in this action because Apple has committed acts within the Western District of Texas giving rise to this action and has established minimum contacts with this forum such that the exercise of jurisdiction over Apple would not offend traditional notions of fair play and substantial justice. Defendant Apple, directly and/or through subsidiaries or intermediaries (including distributors, retailers, and others), has committed and continues to commit acts of infringement in this District by, among other things, offering to sell and selling products and/or services that infringe the patents-in-suit. Moreover, Apple is registered to do business in the State of Texas, has offices and facilities in the State of Texas, and actively directs its activities to customers located in the State of Texas.

10. Venue is proper in this district under 28 U.S.C. §§ 1391(b)-(d) and 1400(b). Defendant Apple is registered to do business in the State of Texas, has offices in the State of Texas,

has transacted business in the Western District of Texas and has committed acts of direct and indirect infringement in the Western District of Texas.

11. Apple has a regular and established place of business in this District and has committed acts of infringement in this District. Apple has permanent office locations at 5501West Parmer Lane, Austin, Texas and 12535 Riata Vista Circle, Austin, Texas, both of which are located within this District. Apple employs full-time personnel such as sales personnel and engineers in this District, including in Austin, Texas. Apple has also committed acts of infringement in this District by commercializing, marketing, selling, distributing, testing, and servicing certain Accused Products.

12. This Court has personal jurisdiction over Apple. Apple has conducted and does conduct business within the State of Texas. Apple, directly or through subsidiaries or intermediaries (including distributors, retailers, and others), ships, distributes, makes, uses, offers for sale, sells, imports, and/or advertises (including by providing an interactive web page) its products and/or services in the United States and the Western District of Texas and/or contributes to and actively induces its customers to ship, distribute, make, use, offer for sale, sell, import, and/or advertise (including the provision of an interactive web page) infringing products and/or services in the United States and the Western District of Texas. Apple, directly and through subsidiaries or intermediaries (including distributors, retailers, and others), has purposefully and voluntarily placed one or more of its infringing products and/or services, as described below, into the stream of commerce with the expectation that those products will be purchased and used by customers and/or consumers in the Western District of Texas. These infringing products and/or services have been and continue to be made, used, sold, offered for sale, purchased, and/or imported by customers and/or consumers in the Western District of Texas. Apple has committed

acts of patent infringement within the Western District of Texas. Apple interacts with customers in Texas, including through visits to customer sites in Texas. Through these interactions and visits, Apple directly infringes the patents-in-suit. Apple also interacts with customers who sell the Accused Products into Texas, knowing that these customers will sell the Accused Products into Texas, either directly or through intermediaries.

13. Apple has minimum contacts with this District such that the maintenance of this action within this District would not offend traditional notions of fair play and substantial justice. Thus, the Court therefore has both general and specific personal jurisdiction over Apple.

THE ASSERTED PATENTS

U.S. PATENT NO. 7,091,854

14. U.S. Patent No. 7,091,854 (the "'854 patent") entitled, *Multiple-Input Multiple-Output Wireless Sensor Networks Communications*, was filed on April 9, 2004. The '854 patent is subject to a 35 U.S.C. § 154(b) term extension of 187 days. MIMO Research, LLC is the owner by assignment of the '854 patent. A true and correct copy of the '854 patent is attached hereto as Exhibit A.

15. The '854 patent claims specific systems for wireless multiple-input multiple-output communication devices.

16. The '854 patent teaches the use of a MIMO sensor transmitter that improves array gain, diversity, and reduces channel interference and inter-symbol interference.

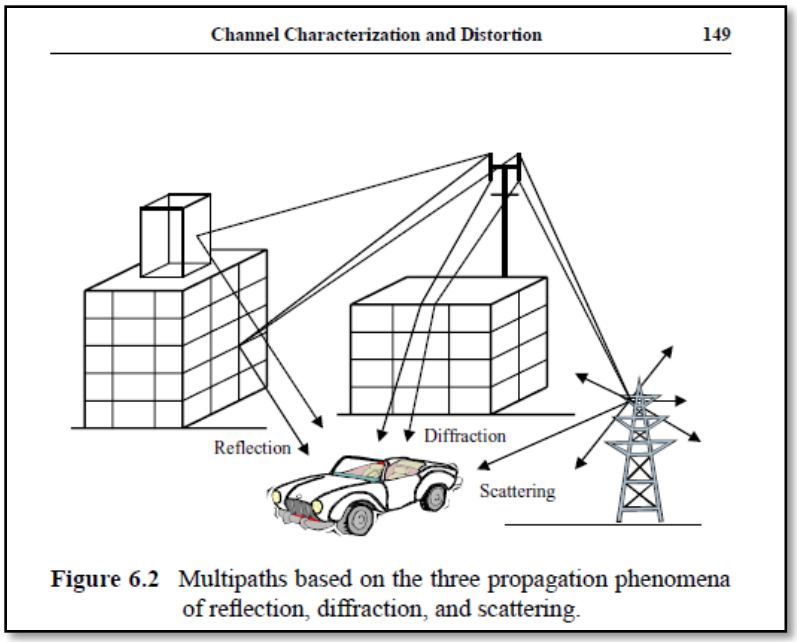
17. The '854 patent teaches the use of a sensor array unit coupled to an analog-to-digital converter which is coupled to a signal processing and data computing unit. The signal processing and data computing unit are coupled to a MIMO transceiver containing multiple antennas. This system improves average signal power, mitigates fading, and reduces channel interference and intersymbol interference. The reduction in channel and intersymbol interference allows the

systems claimed in the '854 patent to significantly improve the capacity, coverage, and quality of wireless communication.

18. The inventions taught in the '854 patent boost the data rate not only on uplink channels but also on downlink channels, which allows for better communication and control between wireless devices.

19. The '854 patent teaches the use of a MIMO transceiver to overcome multipath propagation. Multipath propagation arises from scattering, reflection, refraction or diffraction of the radiated energy off objects in the environment. Thus, received signals are much weaker than transmitted signals due to mean propagation loss. In addition to a mean path loss, the received signals exhibit fluctuations in a signal level that is referred to fading.

20. The '854 patent is directed to overcoming problems attendant to multipath propagation which occurs through the reflection, diffraction, and scattering of a wireless signal. "The multipath propagation arises from scattering, reflection, refraction or diffraction of the radiated energy off objects in the environment." '854 patent, col. 2:43-45. The inventor of the '854 patent illustrated the problem of multipath propagation in a subsequent textbook on signal processing.



George J. Maio, SIGNAL PROCESSING IN DIGITAL COMMUNICATIONS at 149 (2006).

21. The '854 patent teaches the use of a MIMO transceiver which turns multipath propagation into a benefit. By combining the use of the transmitter antennas at one end and receiver antennas, the systems taught in the '854 patent enhance wireless transmission over the MIMO channel.

22. The inventor of '854 patent described the problem of multipath propagation in a 2006 textbook on signal processing:

> Wireless channels experience multipath propagation due to reflection, diffraction, and/or scattering of radiated energy off of objects located in the environment. Signals at the receiver are much feebler than transmitted signals because of propagation path loss. In addition, received signals may display fading over traveling distance from the transmitter. The fading includes large-scale fading and small-scale fading.

George J. Maio, SIGNAL PROCESSING IN DIGITAL COMMUNICATIONS at 184-85 (2006).

23. The '854 patent has been cited by 61 United States and international patents and patent applications as relevant prior art. Specifically, patents issued to the following companies and research institutions have cited the '854 patent as relevant prior art:

- Qualcomm, Inc.

- NEC Corporation
- Samsung Electronics Co., Ltd.
- Allied Telesis Holdings K.k.
- University Of Virginia
- Texas Instruments Incorporated
- Honeywell International Inc.
- Shanghai Jiaotong University
- Zebra Technologies Corp.
- The Boeing Company
- Chinese Academy of Sciences
- Itron, Inc.
- HBX Control Systems, Inc.

U.S. PATENT NO. 7,046,716

24. U.S. Patent No. 7,046,716 (the "'716 patent") entitled, *Dual-Mode Ultra Wideband and Wireless Local Area Network Communications*, was filed on July 14, 2003. The '716 patent is subject to a 35 U.S.C. § 154(b) term extension of 342 days. MIMO Research, LLC is the owner by assignment of the '716 patent. A true and correct copy of the '716 patent is attached hereto as Exhibit B.

25. The '716 patent discloses the use of a dual-mode UWB and wireless local area network transceiver.

26. The '716 patent is directed to enabling network devices operating using wireless spectrum occupied by existing radio services without causing interference, thereby permitting scare spectrum resources to be used more efficiently.

27. The '716 patent discloses novel systems for allowing the coexistence of a UWB and WLAN transceiver in an environment.

28. The inventions disclosed in the '716 patent enable the use of communications device that operates using a transceiver that operates using more than one wireless networking standard and enables the same communication device to operate in areas in which there is a need for short-range wireless broadband communications using UWB.

29. The communication transceiver disclosed in the '716 patent can be implemented in hardware such as an in an Application Specific Integrated Circuits (ASIC), digital signal processor, field programmable gate array (FPGA), software, or a combination of hardware and software.

30. The '716 patent has been cited by 93 patents and patent applications as relevant prior art. Specifically, patents issued to the following companies have cited the '716 patent as relevant prior art:

- Samsung Electronics Co., Ltd.
- Qualcomm, Inc.
- Huawei Investment & Holding Co., Ltd.
- Nokia Corporation
- NXP B.V.
- Intel Corporation
- Microchip Technology Inc.
- Corning Incorporated
- L3Harris Technologies Inc.
- Siemens AG
- Kawasaki Microelectronics, Inc.

U.S. PATENT NO. 7,133,646

31. U.S. Patent No. 7,133,646 (the "'646 patent") entitled, *Multimode and Multiband MIMO Transceiver of W-CDMA, WLAN and UWB Communications*, was filed on December 29, 2003. The '646 patent is subject to a 35 U.S.C. § 154(b) term extension of 456 days. MIMO Research, LLC is the owner by assignment of the '646 patent. A true and correct copy of the '646 patent is attached hereto as Exhibit C.

32. The '646 patent discloses novel methods and systems for implementing a processor-based system to receive W-CDMA, WLAN, and UWB signals.

33. The inventions disclosed in the '646 patent enable large-scale computer networks to quickly recover from a component failure.

34. The ‘646 patent discloses a method implemented on a transceiver system for multimode receipt of W-CDMA, WLAN, and UWB signals.

35. The ‘646 patent has been cited by 108 patents and patent applications as relevant prior art. Specifically, patents issued to the following companies have cited the ‘646 patent as relevant prior art:

- Sharp Corporation
- Apple Inc.
- Sony Group Corporation
- International Business Machines Corp.
- Qualcomm, Inc.
- Huawei Investment & Holding Co., Ltd.
- NXP B.V.
- Koninklijke Philips Electronics, N.V.
- Broadcom Limited
- Intel Corporation
- Fujitsu Limited
- Electronics And Telecommunications Research Institute
- Infineon Technologies AG

U.S. PATENT NO. 7,305,057

36. U.S. Patent No. 7,305,057 entitled, *Multichannel Filter-Based Handheld Ultra Wideband Communications*, was filed on July 7, 2003. The ‘057 patent is subject to a 35 U.S.C. § 154(b) term extension of 922 days. MIMO Research, LLC is the owner by assignment of the ’057 patent. A true and correct copy of the ‘057 patent is attached hereto as Exhibit D.

37. The ‘057 patent discloses novel systems for multichannel filter based UWB transceivers that avoid interference with WLAN 802.11a devices.

38. The inventions disclosed in the ‘057 patent teach systems that permit a UWB device to operate using spectrum occupied by existing radio services without causing interference, thereby permitting scarce spectrum resources to be used more efficiently.

39. The ‘057 patent improves the operation of wireless networks by disclosing technologies that enable new products incorporating UWB technology.

40. The ‘057 patent discloses the use of a multichannel filter for a UWB transceiver. The multichannel filter allows the UWB transceiver to operate in the frequency band from 3.1 GHz to 10.6 GHz, with a conservative out of band emission mask to address interference with other devices.

41. The ‘057 patent has been cited by 16 patents and patent applications as relevant prior art. Specifically, patents issued to the following companies and research institutions have cited the ‘057 patent as relevant prior art:

- University Of Minnesota
- Sorbonne Université
- Qualcomm, Inc.
- Nokia Corporation
- Huawei Technologies Co., Ltd.
- Industrial Technology Research Institute
- Graz University of Technology (Austria)

U.S. PATENT NO. 7,433,382

42. U.S. Patent No. 7,433,382 entitled, *Spread Spectrum Based Multichannel Modulation for Ultra Wideband Communications*, was filed on July 7, 2003. The ‘382 patent is subject to a 35 U.S.C. § 154(b) term extension of 704 days. MIMO Research, LLC is the owner by assignment of the ’382 patent. A true and correct copy of the ‘382 patent is attached hereto as Exhibit E.

43. The ‘382 patent discloses novel UWB devices that enable the transmission of data while avoiding interference with WLAN 802.11a devices.

44. The inventions disclosed in the ‘382 patent are directed to solving the problem of interference between UWB devices and other devices, such as WLAN 802.11a devices.

Interference between UWB and 802.11a transmission was a problem at the time the inventions disclosed in the '382 patent were invented because the WLAN 802.11a devices operated in the frequency ranges 5.15 GHz to 5.35 GHz and 5.725 GHz to 5.825 GHz which overlapped with UWB signals that could operate in the frequency band of 3.1 GHz to 10.6 GHz.

45. The inventions disclosed in the '382 patent teach technologies that permit the transmission of data using UWB without interfering with the transmission of data using non-UWB signals that overlap with the UWB frequency band.

46. To address the issue of interference between devices operating in the UWB frequency band and non-UWB signals sent in an overlapping frequency band, the '382 patent teaches the use of multichannel pseudorandom noise mapping comprising N-I delay units coupled to N down sampling units followed by N Exclusive OR (XOR) units in parallel.

47. The '382 patent discloses systems that improve the operation of wireless networks by disclosing technologies that reduce interference with WLAN signals using a multichannel pseudorandom noise look-up table coupled to a multichannel sequence mapping component.

48. The '382 patent discloses the use of a digital finite impulse response shaping filter that attenuates signals with frequencies higher then specific thresholds. By using the disclosed filter, the systems taught in the '382 patent reduce interference with non-UWB signal.

49. The '382 patent has been cited by 10 patents and patent applications as relevant prior art. Specifically, patents issued to the following companies and research institutions have cited the '382 patent as relevant prior art:

- STMicroelectronics N.V.
- Industrial Technology Research Institute
- Huawei Technologies Co., Ltd.
- East China Normal University
- Beifang Tongyong Electronics Group Co., Ltd.
- Universite De Provence

COUNT I
INFRINGEMENT OF U.S. PATENT NO. 7,091,854

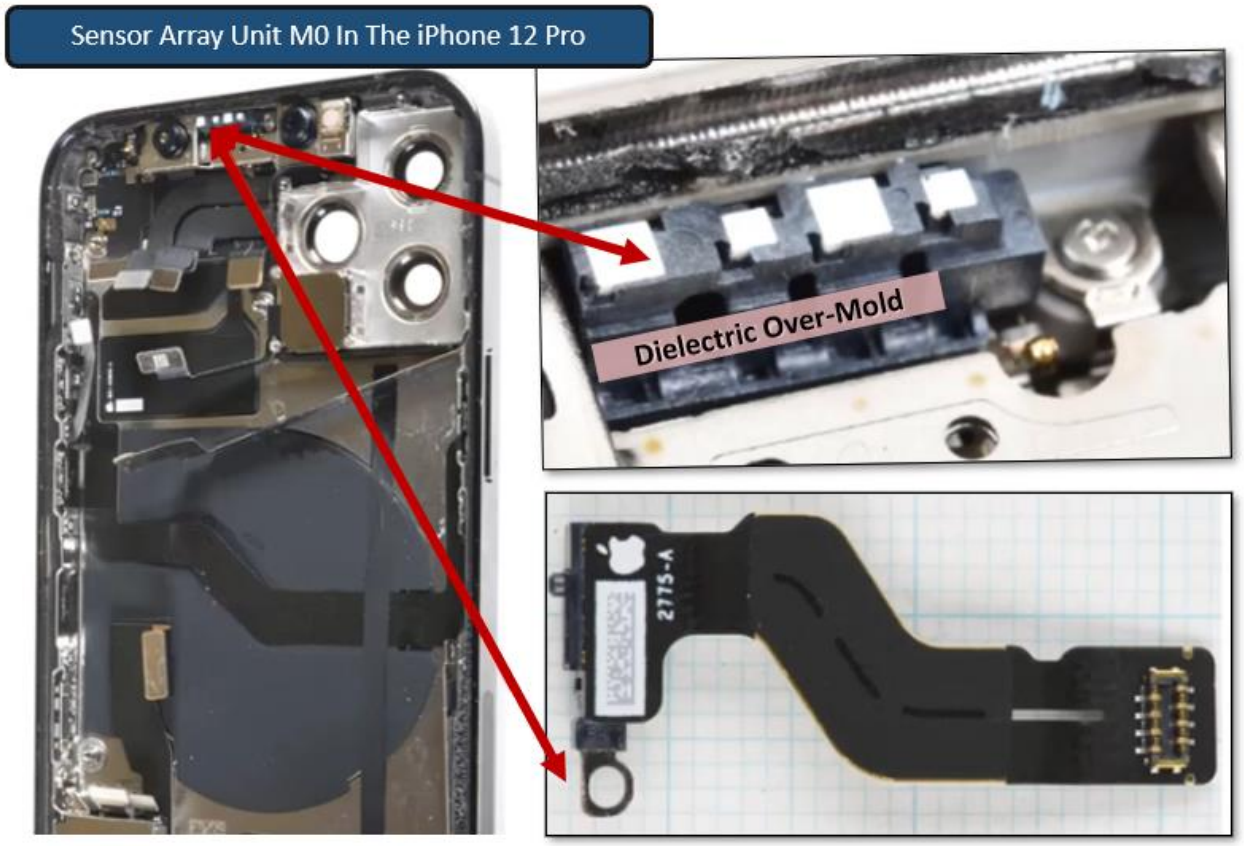
50. Plaintiff references and incorporates by reference the preceding paragraphs of this Complaint as if fully set forth herein.

51. Apple designs, makes, uses, sells, and/or offers for sale in the United States products comprising a MIMO wireless sensor and transceiver system.

52. Apple designs, makes, sells, offers to sell, imports, and/or uses the following products: iPhone 11 Pro Max (A2161), iPhone 11 Pro (A2160), iPhone 11 (A2111), iPhone 12 Pro Max (A2342), iPhone 12 Pro (A2341), iPhone 12 (A2172), iPhone 12 mini (A2176), iPhone 13 Pro Max (A2484), iPhone 13 Pro (A2483), iPhone 13 (A2482), and iPhone 13 mini (A2481) (the "Apple '854 Product(s)").

53. One or more of the Apple '854 Products include technology for a wireless multiple-input multiple-output sensor node and transceiver system. For example, the iPhone 13 Pro Max (A2484) contains MIMO sensor nodes and a connected transceiver system. The iPhone 13 Pro Max contains functionality for 5G (sub 6 GHz and mmWave) with 4x4 MIMO, Gigabit LTE with 4x4 MIMO, and Wi-Fi 6 (802.11ax) with 2x2 MIMO. The iPhone 13 Pro Max MIMO sensor nodes are connected to a Qualcomm SDR868 RF transceiver and Snapdragon X60 5G modem.

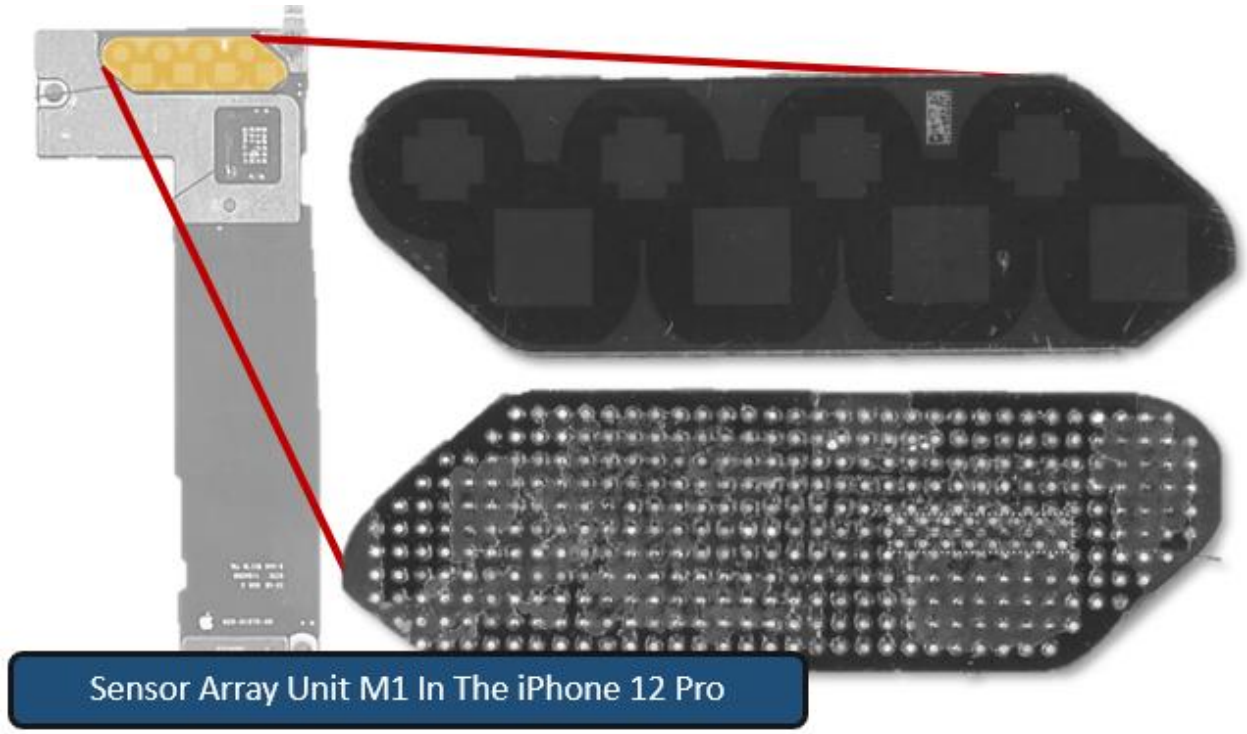
54. The accused Apple '854 Products include multiple MIMO sensor nodes. For example, the Apple iPhone 12 Pro contains sensor array units including the ANT M0 sensor array unit which is depicted in the below teardown of an iPhone 12 Pro.



IPHONE 12 PRO (A2341) TEARDOWN (annotation added).

55. One or more Apple subsidiaries and/or affiliates use the Apple '854 Products in regular business operations.

56. The Apple '854 Products contain MIMO sensor nodes including antenna arrays. The following teardown image of an iPhone 12 Pro shows the antenna array M1 package. The top image shows the side facing the rear cover of the Apple '854 device. The bottom image shows the antenna array M1 package showing the side facing the RF printed circuit board (PCB). The antenna array M1 package contains an RF Front End Module (FEM) that allows for the RF signal to be passed from the antenna to the RF FEM and transceiver.

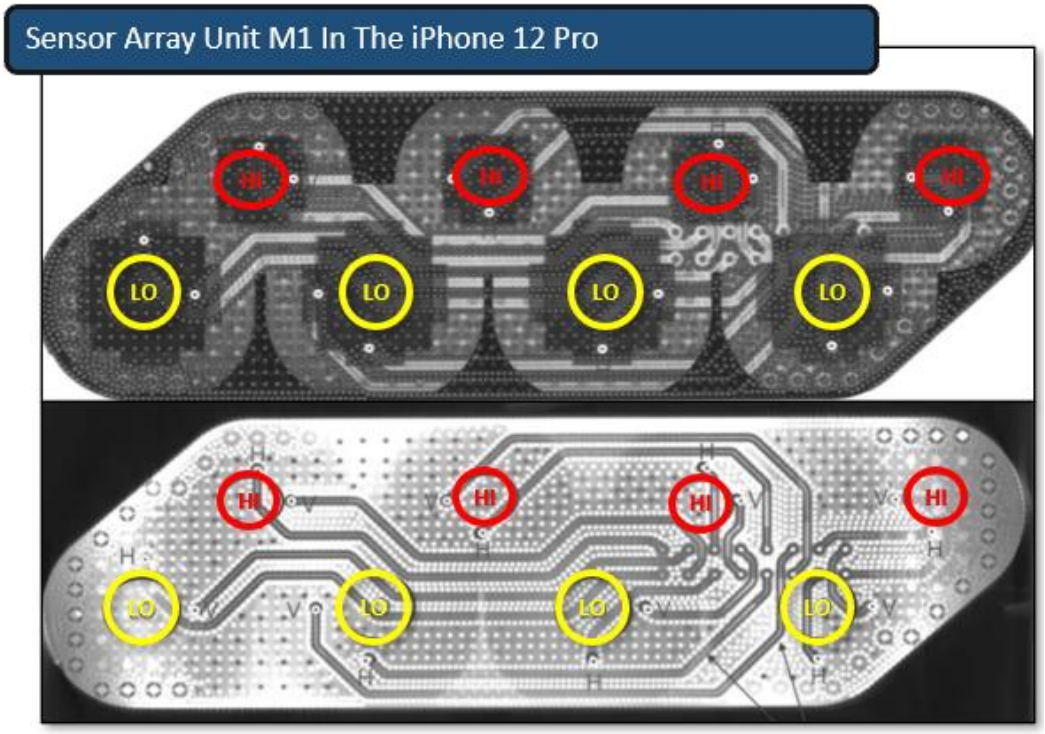


IPHONE 12 PRO (A2341) TEARDOWN (annotation added).

57. The Apple '854 Products contain MIMO sensor nodes such as the M1 sensor node that contain multiple patch antenna structures. For example, the following black and white histogram images of the M1 antenna structure shows the high frequency band patch antenna structures and low frequency band patch antenna structures identified with the "HI" and "LO" annotations respectively.

58. The Apple '854 Products include a signal processing and data computing unit that is coupled to a multiple-input multiple-output space-time transceiver that is connected to 2 or more antennas.

59. The Apple '854 Products include memory that is coupled to the analog-to-digital converter unit, the signal processing and data computing unit, and the multiple-input multiple-output space-time transceiver.



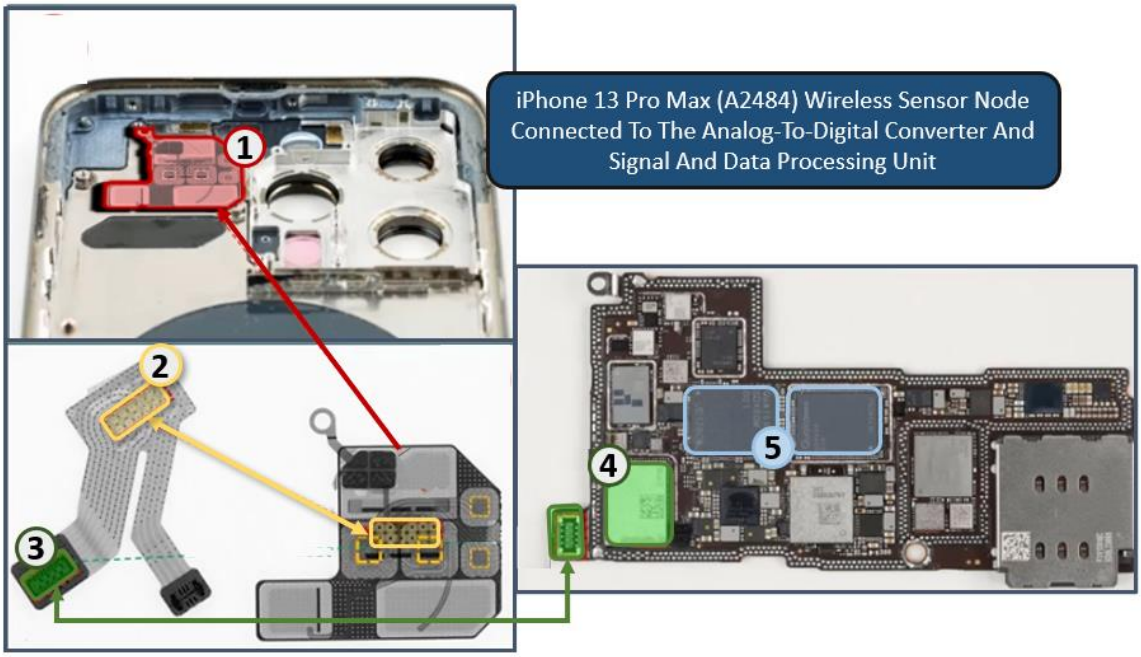
IPHONE 12 PRO (A2341) TEARDOWN – HISTOGRAM IMAGE (annotation added).

60. The Apple '854 Products contain an analog-to-digital (ADC) converter unit coupled to a signal processing and data computing unit. Specifically, the Apple '854 Products contain central processing unit(s) to perform signal processing and data computing.

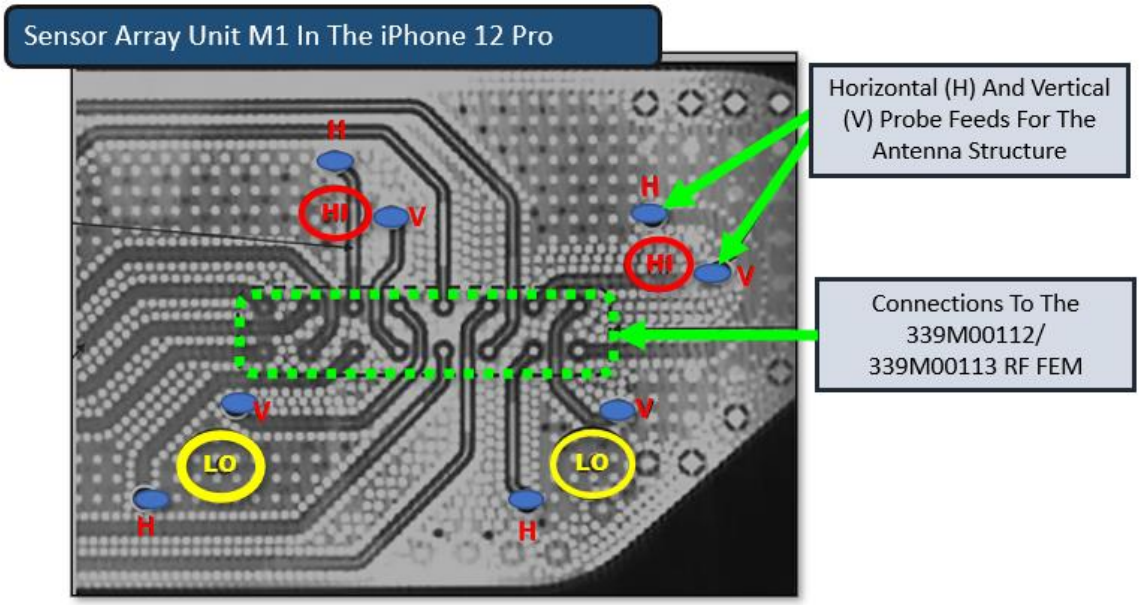
61. The Apple '854 Products contain antenna array units that include transmission line connection points and transmission lines that connect the antenna array (wireless sensor node) to the analog-to-digital converter unit, signal processing unit, and data computing unit. These connection points and transmission lines are shown in the following histogram image of the iPhone 12 Pro device.

62. The Apple '854 Products contain MIMO sensor array nodes that are connected to a transceiver through a Flat Flex Cable (FFC). The below teardown of the M0 antenna array in the iPhone 13 Pro Max shows that the antenna array ("1") is connected via a FFC ("2" & "3") to

the Murata SS1813063 RF Front-End (FE) module ("4") and the signal processing and data computing unit ("5").

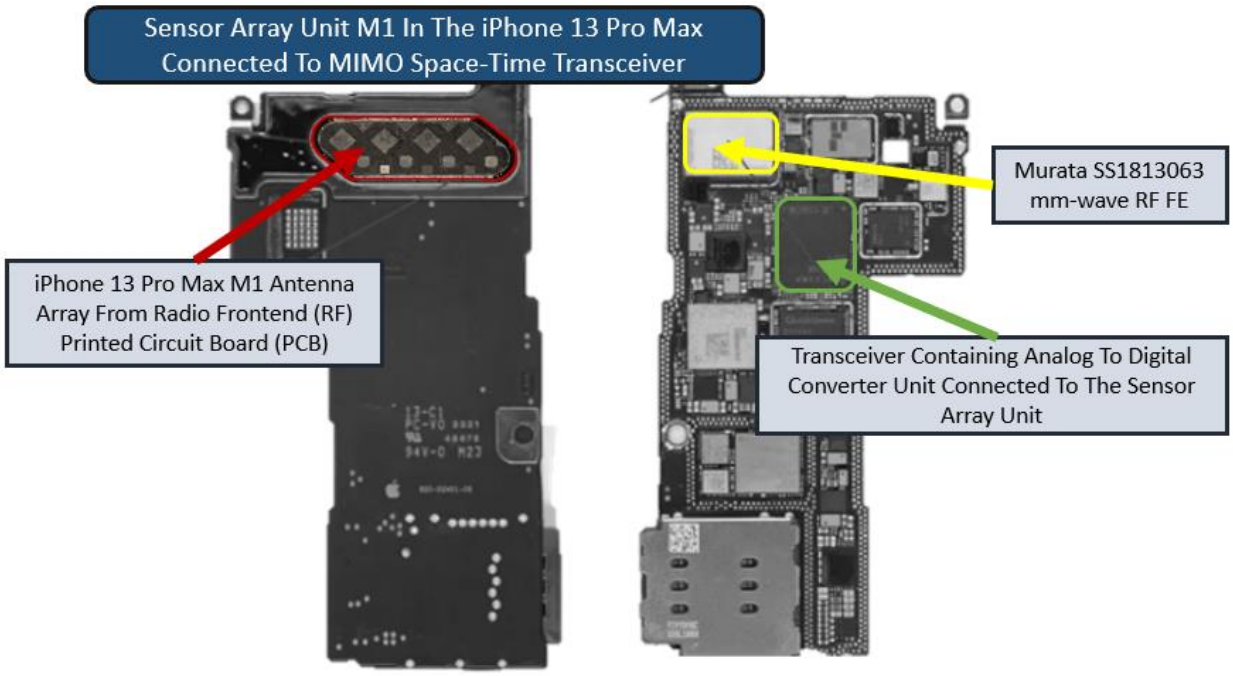


IPHONE 13 PRO MAX (A2484) TEARDOWN IMAGE (annotation added).



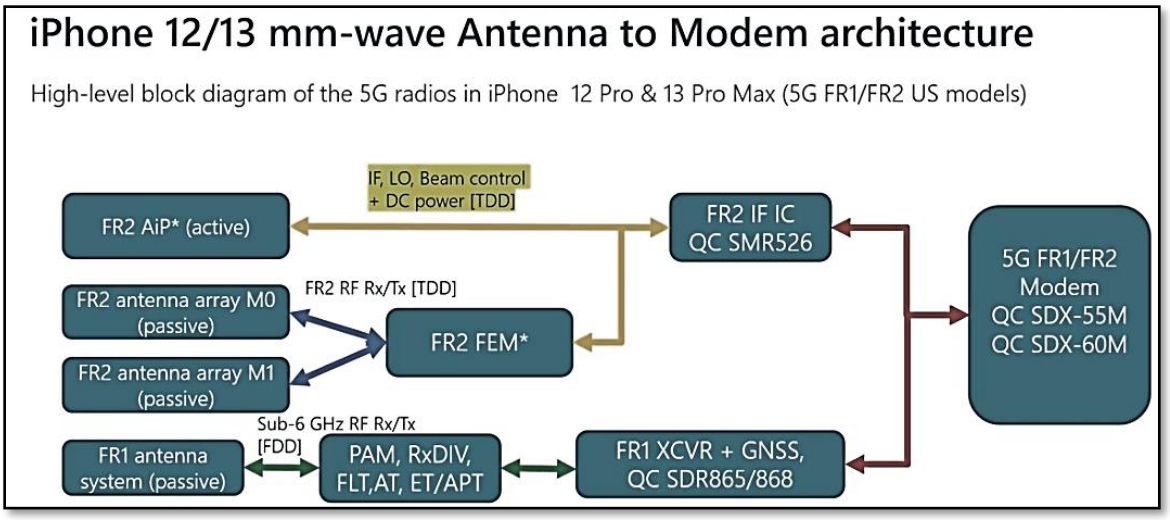
IPHONE 12 PRO (A2341) TEARDOWN – HISTOGRAM IMAGE (The horizontal ("H") and vertical ("V") probe feeds for the driven patch in the antenna array are identified and the transmission lines that connect the patch antennas to the RF FEM and transceiver are identified in the bottom image.) (annotation added).

63. The Apple '854 Products include MIMO sensor arrays that are coupled to one or more analog-to-digital converter units. For example, in the iPhone 13 Pro Max the M1 array is connected to an analog-to-digital converter unit that is located in the SDR868 shown in green below.



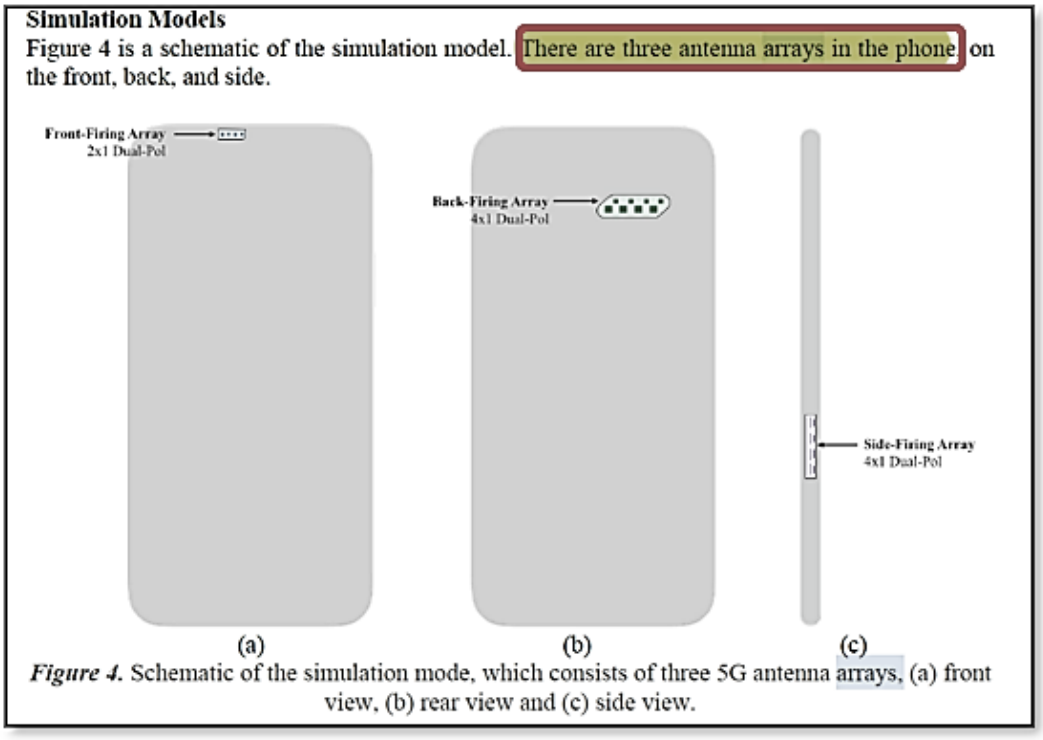
IPHONE 13 PRO MAX (A2484) TEARDOWN IMAGE (annotation added).

64. The following analysis of the iPhone 12 and iPhone 13 "Antenna to Modem Architecture" shows at a high-level how several of the MIMO wireless sensor nodes are connected to the SDR865/SDR868 transceiver and SDX-55M/SDX-60M Modem.



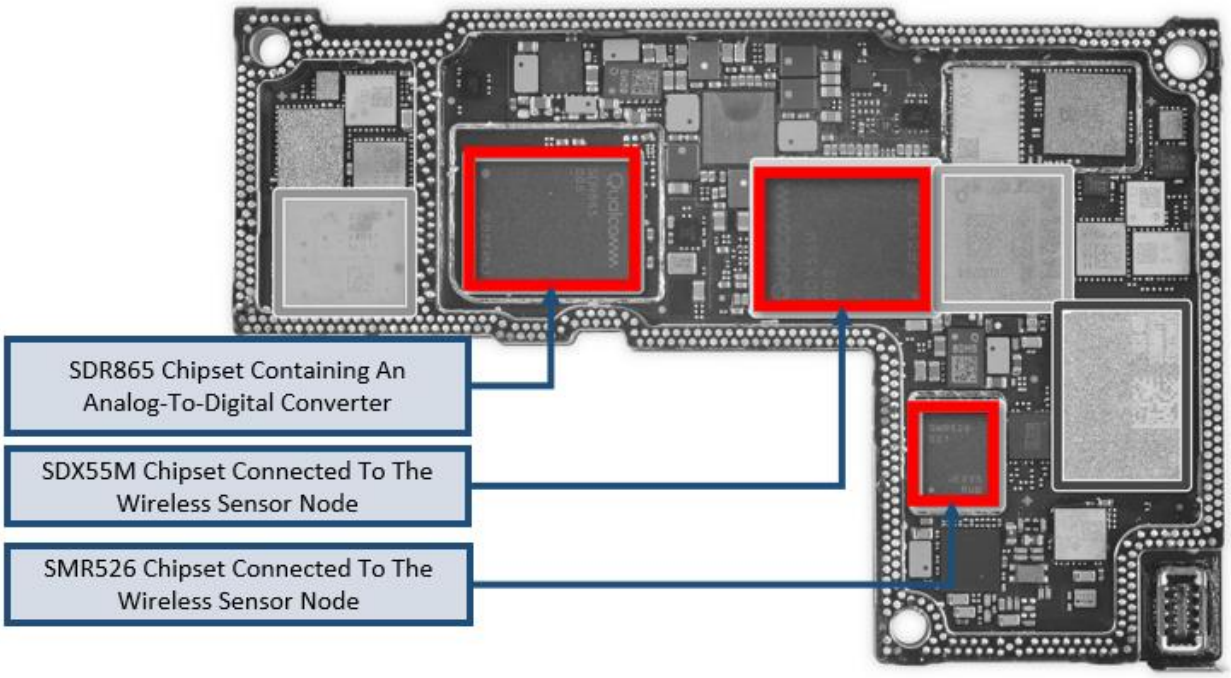
TECHINSIGHTS REPORT - ANTENNA MODULE IMPLEMENTATION IN THE IPHONE 12/13 (2022).

65. There are multiple sensor arrays on the Apple '854 Products including a front-firing array, back firing array and side firing array as shown in the below excerpt from Apple's submission to the Federal Communications Commission.



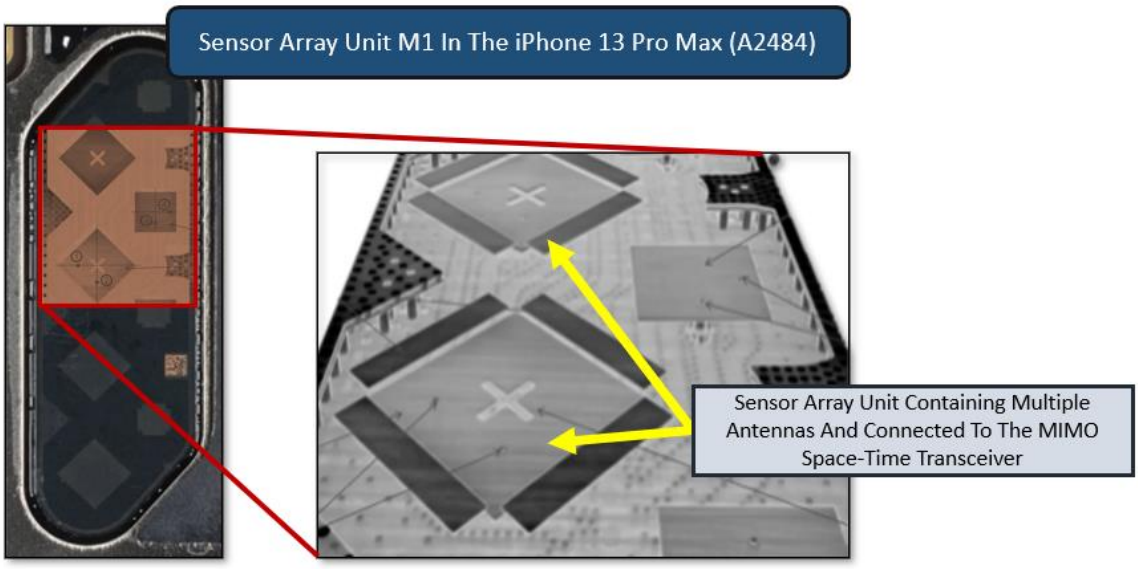
A2342 5G Product mmWave MPE Simulation Report v1.1, FEDERAL COMMUNICATIONS COMMISSION SUBMISSION at 5 (October 3, 2020) (emphasis added).

66. The Apple '854 Products comprise technology for an analog-to-digital converter unit coupled to a signal processing and data computing unit. For example, the Apple '854 Products contain integrated circuits that perform signal processing and data computing. These integrated circuits are connected to the transmission systems of the Apple '854 Products that comprise technology to convert signals from analog to digital signals.



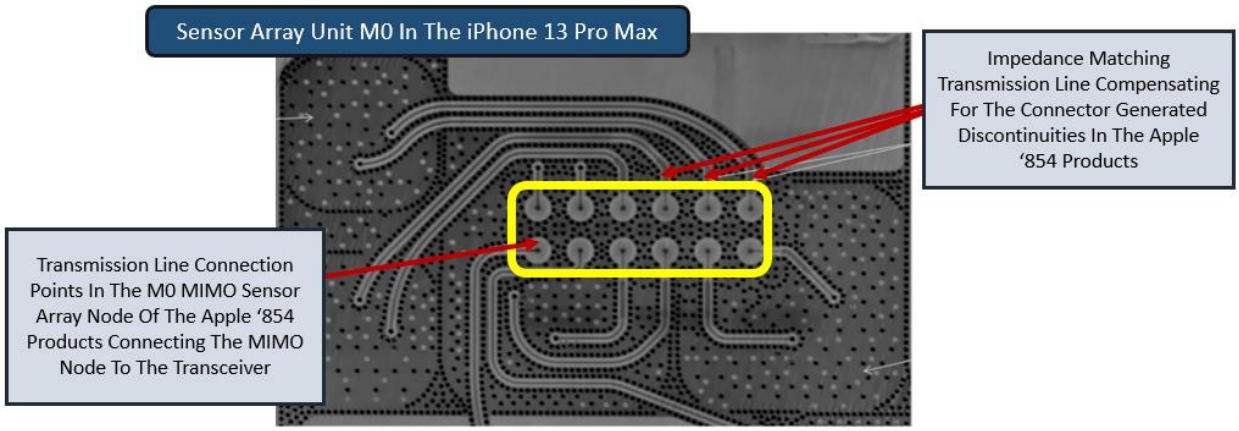
IPHONE 12 PRO (A2341) TEARDOWN IMAGE (annotation added).

67. The Apple '854 Products include a signal processing and data computing unit that is coupled to a multiple-input multiple-output space-time transceiver that is connected to 2 or more antennas.



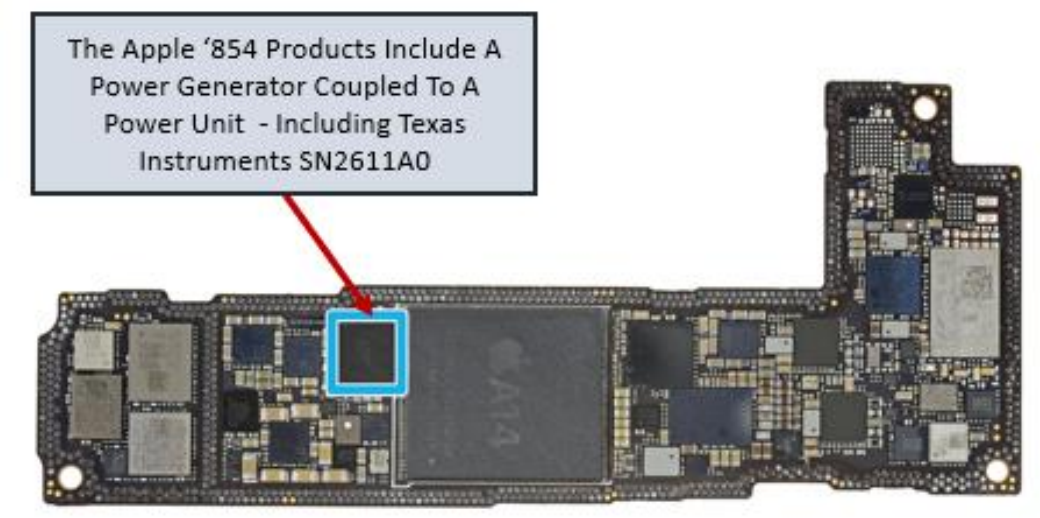
IPHONE 13 PRO MAX (A2484) TEARDOWN IMAGE (annotation added).

68. The below diagram shows one example of the infringing functionality wherein Wi-Fi antennas are coupled to the signal processing and data computing unit through transmission lines in the M0 sensor array.



IPHONE 13 PRO MAX (A2484) TEARDOWN IMAGE (annotation added).

69. The Apple '854 Products include a power generator coupled to a power unit. Specifically, Apple documentation for the infringing products shows a power regulator connected to the power unit (supply voltages).



IPHONE 12 PRO (A2341) TEARDOWN IMAGE (annotation added)

70. The Apple '854 Products include a power unit that is connected to the sensor array unit, the analog-to-digital converter unit, the signal processing and data computing unit, and the multiple-input multiple-output space-time transceiver.

71. Apple has directly infringed and continues to directly infringe the '854 patent by, among other things, making, using, offering for sale, and/or selling technology for MIMO wireless sensor networks, including but not limited to the Apple '854 Products.

72. The Apple '854 Products are available to businesses and individuals throughout the United States.

73. The Apple '854 Products are provided to businesses and individuals located in the Western District of Texas.

74. By making, using, testing, offering for sale, and/or selling products and services that comprise a MIMO wireless sensor, including but not limited to the Apple '854 Products, Apple has injured Plaintiff and is liable to Plaintiff for directly infringing one or more claims of the '854 patent, including at least claim 15 pursuant to 35 U.S.C. § 271(a).

75. To the extent applicable, the requirements of 35 U.S.C. § 287(a) have been met with respect to the '854 patent.

76. As a result of Apple's infringement of the '854 patent, Plaintiff has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Apple's infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple together with interest and costs as fixed by the Court.

COUNT II
INFRINGEMENT OF U.S. PATENT NO. 7,046,716

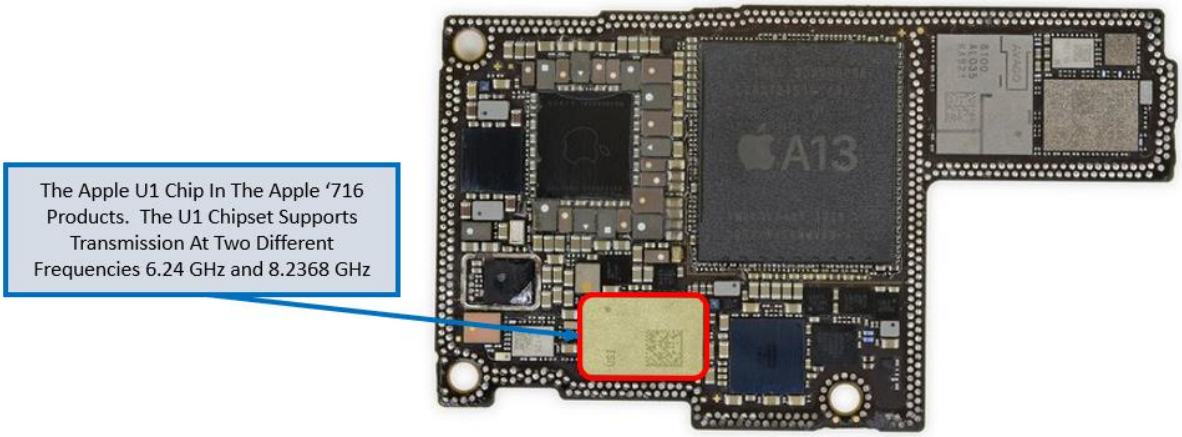
77. Plaintiff references and incorporates by reference the preceding paragraphs of this Complaint as if fully set forth herein.

78. Apple designs, makes, uses, sells, and/or offers for sale in the United States products comprising a dual-mode ultra-wideband and wireless local area network transceiver.

79. Apple designs, makes, sells, offers to sell, imports, and/or uses the following products: iPhone 11 Pro Max (A2161), iPhone 11 Pro (A2160), iPhone 11 (A2111), iPhone 12 Pro Max (A2342), iPhone 12 Pro (A2341), iPhone 12 (A2172), iPhone 12 mini (A2176), iPhone 13 Pro Max (A2484), iPhone 13 Pro (A2483), iPhone 13 (A2482), and iPhone 13 mini (A2481) (the "Apple '716 Product(s)").

80. One or more Apple subsidiaries and/or affiliates use the Apple '716 Products in regular business operations.

81. The Apple '716 Products are a dual-mode UWB and wireless local area network transceiver. Specifically, the Apple '716 Products contain multichannel ultra-wideband functionality enabled by Apple's U1 chipset. The following image shows the Apple UWB module in the Apple iPhone 11.

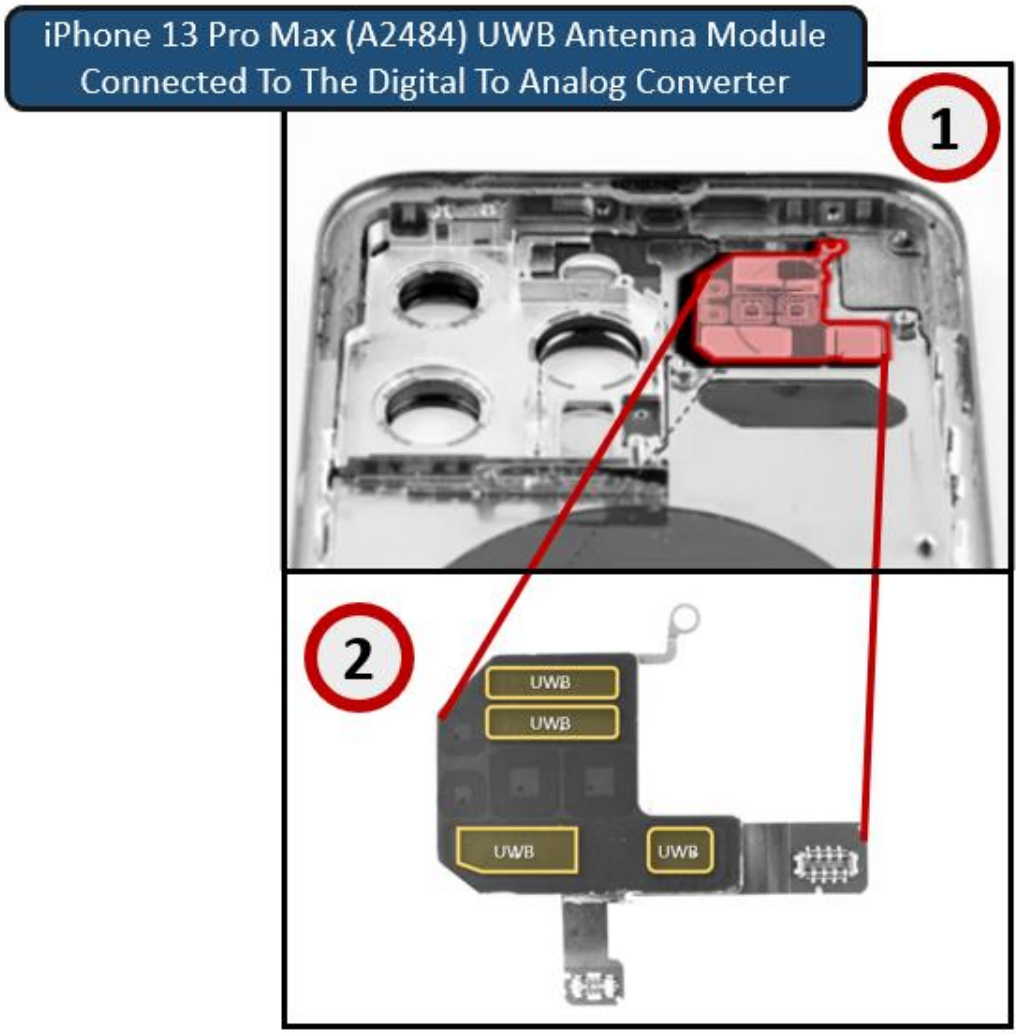


APPLE IPHONE 11 (A2111) TEARDOWN IMAGE (annotation added).

82. The Apple '716 Products contain an UWB module that is compliant with the 802.15.4z standard. *See* IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs), Documents 15-20-0325-00-wng0 at 2 (November 2020).

83. The Apple '716 Products contain an UWB commuter unit which contains a UWB switch. Specifically, the Apple '716 Products including the iPhone 12 (A2172) contain connections on the UWB USI module identified as UWB_ANT2_6G and UWB_ANT2_8G at pins 125 and 149.

84. The Apple '716 Products contain UWB antennas that are connected to a digital to analog converter ("DAC") and digital lowpass shaping filter system. The below image shows one of the UWB antenna modules that is connected to Apple U1 UWB module.

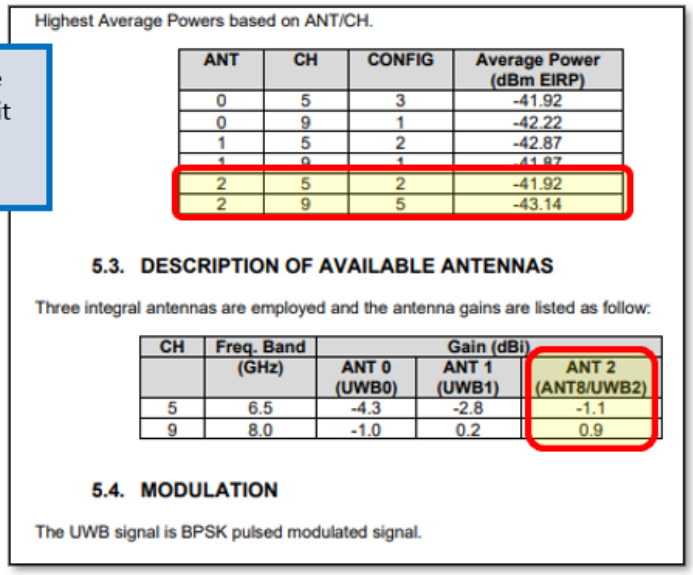


IPHONE 13 PRO MAX (A2484) TEARDOWN (showing (1) the interior of the device and (2) one of the UWB antenna modules).

85. The Apple '716 Products contain integrated circuits that comprise switches including the SKY53807, SKY53813, SKY55504, and SKY58245 switches.

86. The Apple '716 Products contain a UWB Module that is connected to an antenna that operates in two frequencies and the signal is modulated using Binary Phase Shift Keying. The following excerpt from documentation submitted to the Federal Communication Commission shows that the UWB module can operate in multiple frequencies.

The iPhone '716 Products Comprise UWB Functionality That Can Transmit Over The 6.5 GHz and 8.0 GHz Frequency.



Highest Average Powers based on ANT/CH.

ANT	CH	CONFIG	Average Power (dBm EIRP)
0	5	3	-41.92
0	9	1	-42.22
1	5	2	-42.87
1	9	1	-41.87
2	5	2	-41.92
2	9	5	-43.14

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Three integral antennas are employed and the antenna gains are listed as follow:

CH	Freq. Band (GHz)	Gain (dBi)		
		ANT 0 (UWB0)	ANT 1 (UWB1)	ANT 2 (ANT8/UWB2)
5	6.5	-4.3	-2.8	-1.1
9	8.0	-1.0	0.2	0.9

5.4. MODULATION

The UWB signal is BPSK pulsed modulated signal.

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 133335182-E21V2 at 8 (September 26, 2020) (annotations added).

87. The Apple '716 Products comprise structures for ultra-wideband selectable multicarrier frequencies connected to the ultra-wideband commuter unit. For example, the Apple '716 Products enable a dual-frequency modulation scheme where each symbol is modulated by means of PBFSK modulation wherein the signal is shifted from the center frequency of the UWB pulse carrier. This functionality is described in the IEEE 802.15.4z standard.

In the dual-frequency modulation scheme(s), each symbol is modulated by means of PBFSK modulation. The PBFSK modulation carrying binary values zero and one encodes them by shifting the center frequency of the UWB pulse carrier as described in Table 18-4a.

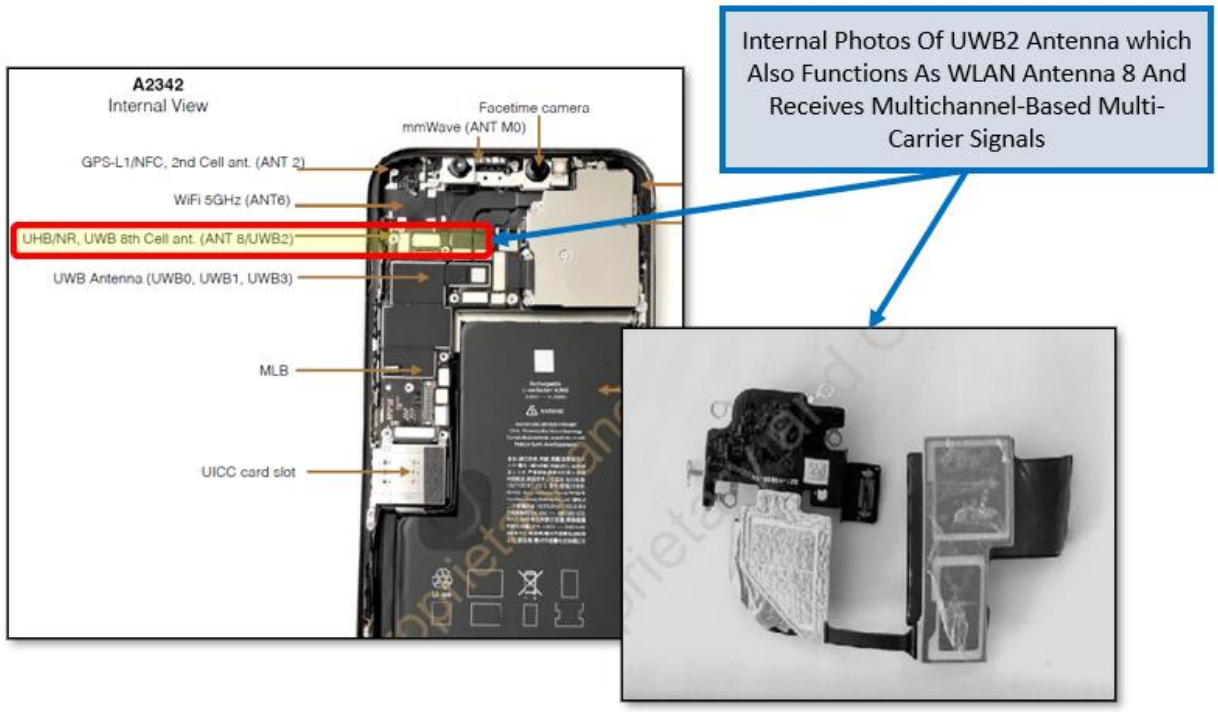
Table 18-4a—PBFSK pulse frequency encoding

Binary value being encoded	Transmitted pulse center frequency
0	The RF carrier of the pulse is shifted by $-f_{dev}$
1	The RF carrier of the pulse is shifted by $+f_{dev}$

The value of parameter f_{dev} is specified in 18.2.5.1.

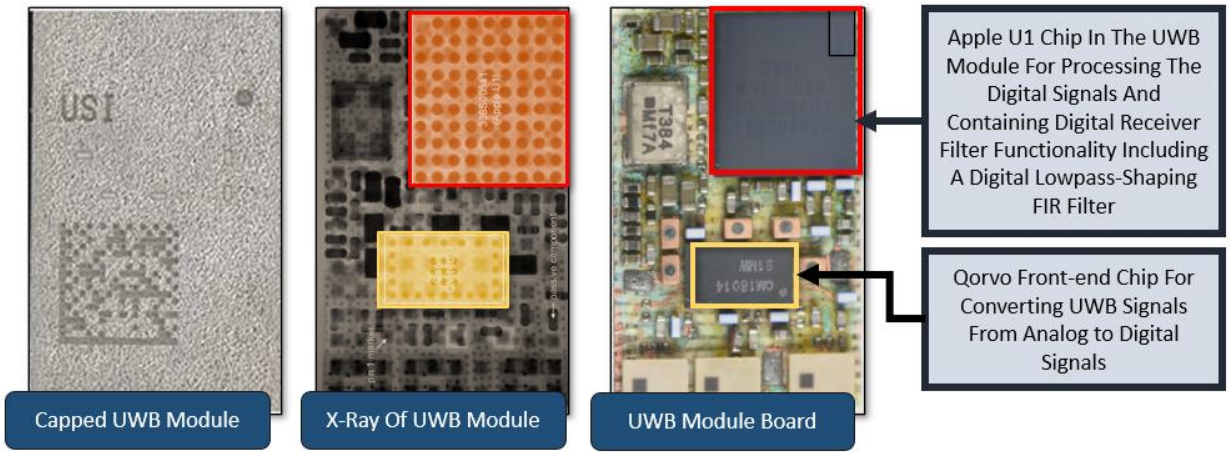
IEEE STD. 802.15.4z-2020 at § 18.2.5 (June 4, 2020).

88. The Apple '716 Products contain UWB functionality that utilizes multiple antennas including an antenna module that functions to transmit UWB signals and WLAN signals.



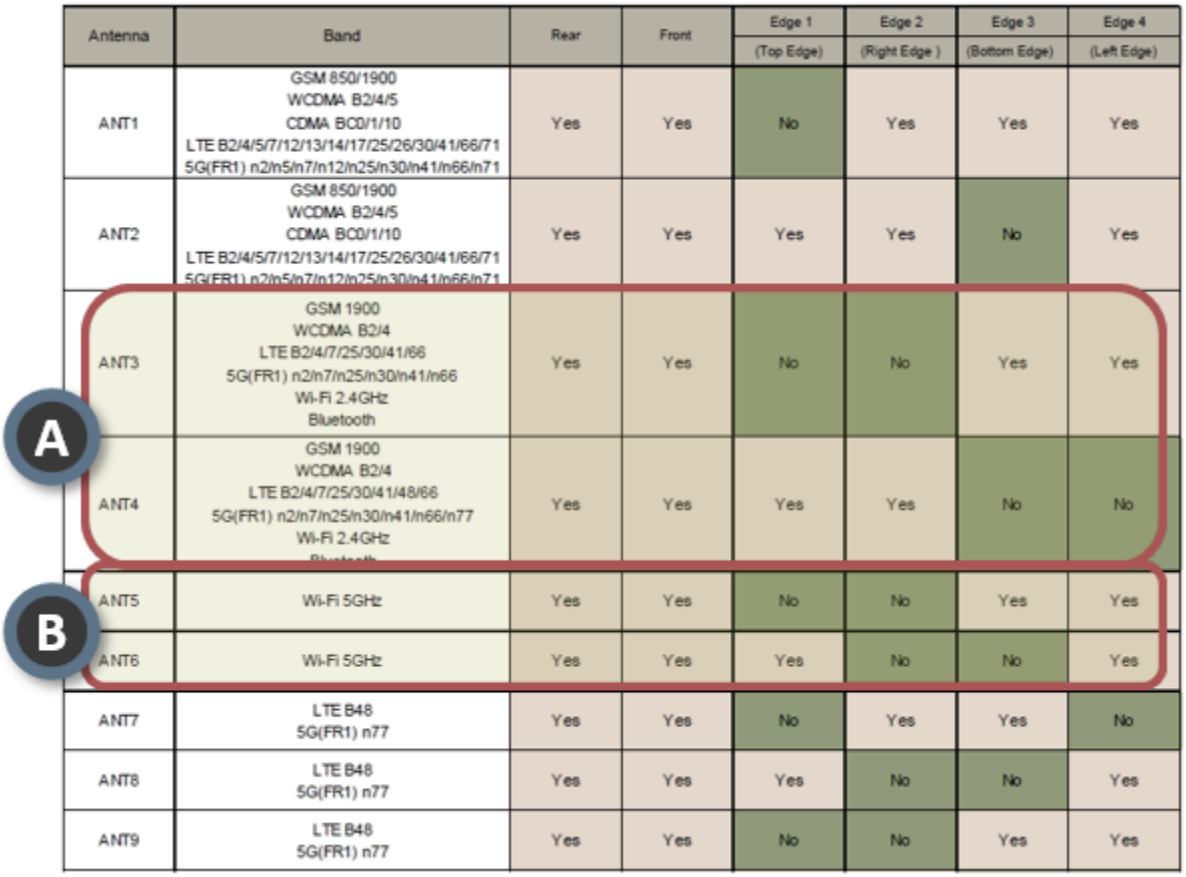
Apple iPhone 12 Pro Internal Photos, FEDERAL COMMUNICATIONS COMMISSION SUBMISSION at 4 and 18 (October 2020) (annotation added).

89. The Apple '716 Products comprise a digital lowpass-shaping finite impulse response filter system coupled to an ultra-wideband multichannel pseudorandom noise sequence mapping or a wireless local area network inverse fast Fourier transform and in-phase/quadrature modulation.



APPLE '716 PRODUCTS TEARDOWN IMAGE OF U1 MODULE (338S00541) (annotation added).

90. The Apple '716 Products contain functionality for selecting a lower band and upper band mode for wireless local area network signal processing using multicarrier frequencies. For example, the Apple '716 Products contain functionality for transmitting at two bands using QPSK and OFDM modulation.

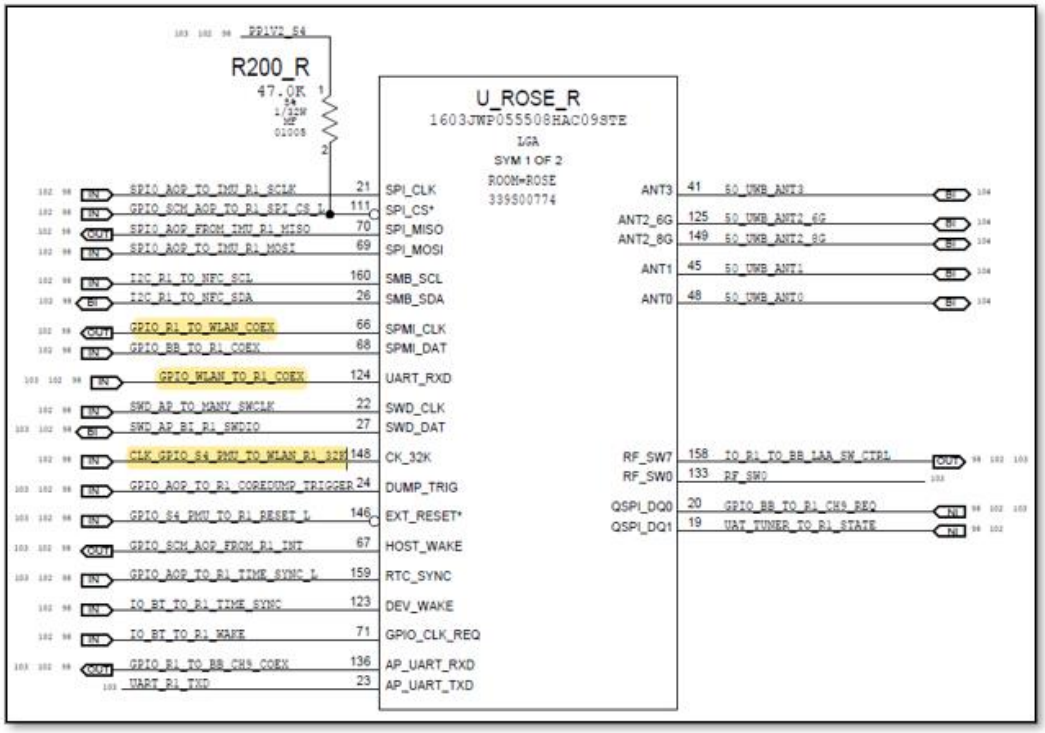


Antenna	Band	Rear	Front	Edge 1 (Top Edge)	Edge 2 (Right Edge)	Edge 3 (Bottom Edge)	Edge 4 (Left Edge)
ANT1	GSM 850/1900 WCDMA B2/4/5 CDMA BC0/1/10 LTE B2/4/5/7/12/13/14/17/25/26/30/41/66/71 5G(FR1) n2/n5/n7/n12/n25/n30/n41/n66/n71	Yes	Yes	No	Yes	Yes	Yes
ANT2	GSM 850/1900 WCDMA B2/4/5 CDMA BC0/1/10 LTE B2/4/5/7/12/13/14/17/25/26/30/41/66/71 5G(FR1) n2/n5/n7/n12/n25/n30/n41/n66/n71	Yes	Yes	Yes	Yes	No	Yes
ANT3	GSM 1900 WCDMA B2/4 LTE B2/4/7/25/30/41/66 5G(FR1) n2/n7/n25/n30/n41/n66 Wi-Fi 2.4GHz Bluetooth	Yes	Yes	No	No	Yes	Yes
ANT4	GSM 1900 WCDMA B2/4 LTE B2/4/7/25/30/41/48/66 5G(FR1) n2/n7/n25/n30/n41/n66/n77 Wi-Fi 2.4GHz	Yes	Yes	Yes	Yes	No	No
ANT5	Wi-Fi 5GHz	Yes	Yes	No	No	Yes	Yes
ANT6	Wi-Fi 5GHz	Yes	Yes	Yes	No	No	Yes
ANT7	LTE B48 5G(FR1) n77	Yes	Yes	No	Yes	Yes	No
ANT8	LTE B48 5G(FR1) n77	Yes	Yes	Yes	No	No	Yes
ANT9	LTE B48 5G(FR1) n77	Yes	Yes	No	No	Yes	Yes

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13573771-S1V4 at 28 (September 13, 2021) (annotation showing that in system will support (a) Wi-Fi 2.4 GHz and (b) Wi-Fi 5 GHz).

91. The Apple '716 Products include technology for a dual-mode sampling frequency rate coupled to a digital-to-analog converter.

92. The Apple '716 Products contain connections between the UWB Module, and the WLAN module as shown in the below excerpt from a schematic of the iPhone 12 (A2172).



IPHONE 12 (A2172) SCHEMATIC FOR UWB MODULE (March 28, 2020) (showing the UWB Module internal name U_ROSE_R) (emphasis added).

93. The Apple '716 Products comprise a digital lowpass shaping filter system coupled to a digital to analog converter.

94. The Apple '716 Products include a switch that connects the ultra-wideband multichannel pseudorandom noise sequence mapping, or the wireless local area network inverse fast Fourier transform and in-phase/quadrature modulation to the digital lowpass-shaping filter system.

95. Apple has directly infringed and continues to directly infringe the '716 patent by, among other things, making, using, offering for sale, and/or selling technology comprising a dual-mode ultra-wideband and wireless local area network transceiver, including but not limited to the Apple '716 Products.

96. The Apple '716 Products are available to businesses and individuals throughout the United States.

97. The Apple '716 Products are provided to businesses and individuals located in the Western District of Texas.

98. By making, using, testing, offering for sale, and/or selling products and services comprising a dual-mode ultra-wideband and wireless local area network transceiver, including but not limited to the Apple '716 Products, Apple has injured Plaintiff and is liable to Plaintiff for directly infringing one or more claims of the '716 patent, including at least claim 1 pursuant to 35 U.S.C. § 271(a).

99. To the extent applicable, the requirements of 35 U.S.C. § 287(a) have been met with respect to the '716 patent.

100. As a result of Apple's infringement of the '716 patent, Plaintiff has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Apple's infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple together with interest and costs as fixed by the Court.

COUNT III
INFRINGEMENT OF U.S. PATENT NO. 7,133,646

101. Plaintiff references and incorporates by reference the preceding paragraphs of this Complaint as if fully set forth herein.

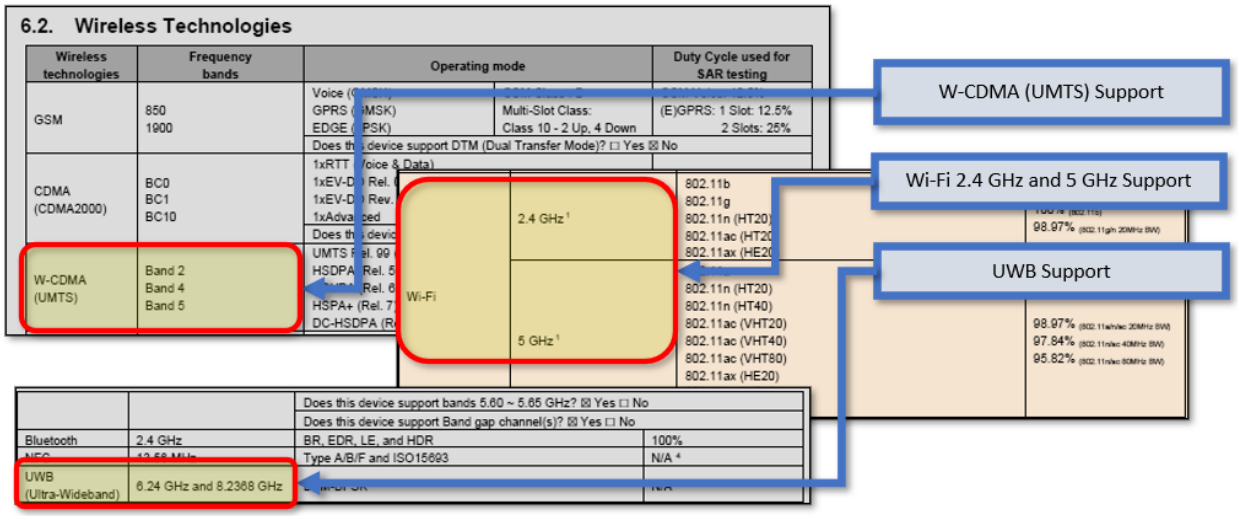
102. Apple designs, makes, uses, sells, and/or offers for sale in the United States products for receiving Wideband Code Division Multiple Access (W-CDMA), Wireless Local Area Network (WLAN), and Ultra-Wideband (UWB) Communications.

103. Apple designs, makes, sells, offers to sell, imports, and/or uses the following products: iPhone 11 Pro Max (A2161), iPhone 11 Pro (A2160), iPhone 11 (A2111), iPhone 12 Pro Max (A2342), iPhone 12 Pro (A2341), iPhone 12 (A2172), iPhone 12 mini (A2176), iPhone 13

Pro Max (A2484), iPhone 13 Pro (A2483), iPhone 13 (A2482), and iPhone 13 mini (A2481) (the "Apple '646 Product(s)").

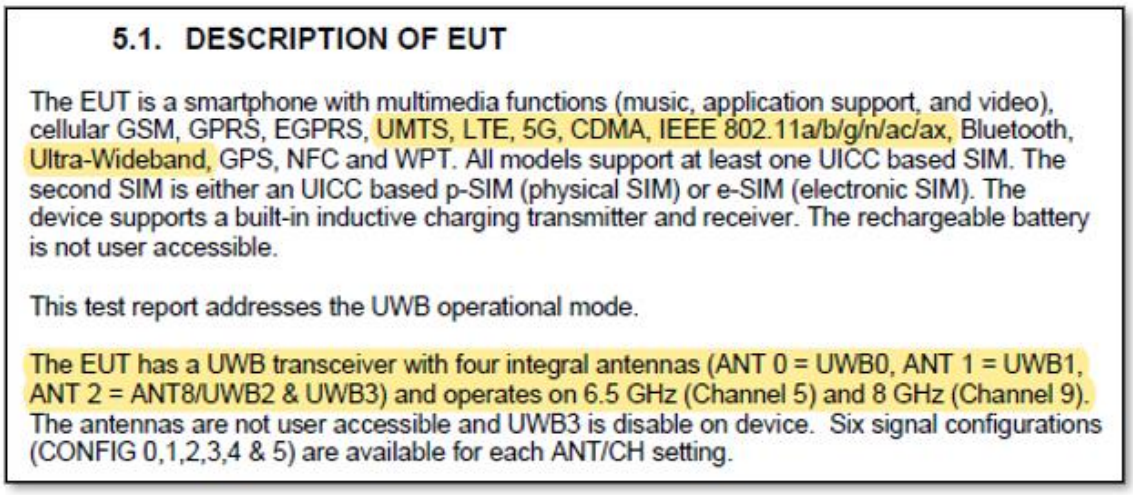
104. One or more Apple subsidiaries and/or affiliates use the Apple '646 Products in regular business operations.

105. The Apple '646 Products perform the method of multimode communication based on a set of instructions adapted to be executed on a processor-based system. The following excerpt from Apple documentation shows the Apple '646 Products perform multimode communication on a processor-based system. The Apple '646 Products receive and transmit W-CDMA, WLAN, and UWB signals.



FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13179116-S1V5 at 16-17 (September 28, 2020) (annotation added).

106. The Apple '646 Products perform the step of setting the processor-based system in a receiver mode depending on whether received signals belong to W-CDMA, WLAN or UWB.



5.1. DESCRIPTION OF EUT

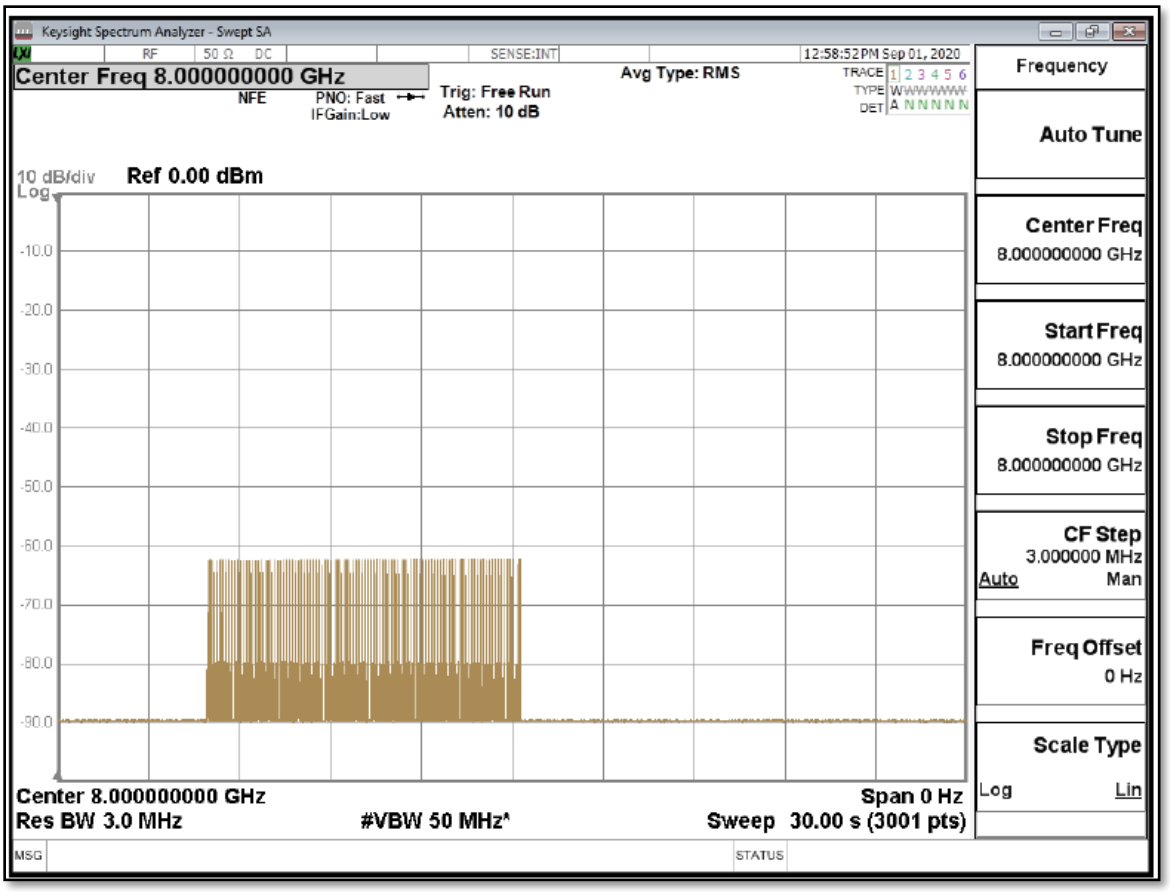
The EUT is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and WPT. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM). The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible.

This test report addresses the UWB operational mode.

The EUT has a UWB transceiver with four integral antennas (ANT 0 = UWB0, ANT 1 = UWB1, ANT 2 = ANT8/UWB2 & UWB3) and operates on 6.5 GHz (Channel 5) and 8 GHz (Channel 9). The antennas are not user accessible and UWB3 is disable on device. Six signal configurations (CONFIG 0,1,2,3,4 & 5) are available for each ANT/CH setting.

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13335182-E21V2 at 7 (September 26, 2020) (emphasis added).

107. The Apple '646 Products perform the step of setting the processor-based system to perform a W-CDMA function and to turn off WLAN and UWB functions during W-CDMA mode. Specifically, the Apple '646 Products enable W-CDMA functionality and disable WLAN and UWB functionality. The below excerpt from Apple's submission to the Federal Communications Commission shows that when no UWB signal is received the UWB functionality is turned off. Specifically, the UWB intentional radiator in the Apple '646 Products ceases transmission within 10 seconds unless it receives an acknowledgement from an associated receiver that its transmission is being received. An acknowledgement of reception must continue to be received by the Apple '646 Products at least every 10 seconds or the Apple '646 Products will cease transmitting using UWB functionality.



FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13335182-E21V2 at 27 (September 26, 2020) (emphasis added).

108. The Apple '646 Products perform the step of setting the processor-based system to perform the WLAN function and to turn off the W-CDMA and the UWB functions during WLAN mode. Specifically, the Apple '646 Products perform the step of turning off the W-CDMA and UWB functions. The below reports filed with the Federal Communications Commission shows configurations including with the cellular antennas off (e.g., W-CDMA).

The simultaneous transmission possibilities for this device are listed as below.

RF Exposure Condition	Item		Capable Transmit Configurations		
Head Body Worn Accessory Hotspot	1	WWAN & 5G OFF (CELLULAR ANTENNAS OFF)	+ (ANT5) Wi-Fi 5 GHz SISO	+	(ANT3) Bluetooth (P_{High})
	2		+ (ANT6) Wi-Fi 5 GHz SISO	+	(ANT3) Bluetooth (P_{High})
	3		+ Wi-Fi 5 GHz MIMO	+	(ANT3) Bluetooth (P_{High})
	4		+ (ANT5) Wi-Fi 5 GHz SISO	+	(ANT4) Bluetooth (P_{High})
	5		+ (ANT6) Wi-Fi 5 GHz SISO	+	(ANT4) Bluetooth (P_{High})
	6		+ Wi-Fi 5 GHz MIMO	+	(ANT4) Bluetooth (P_{High})
	7	WWAN & 5G ON (CELLULAR ANTENNAS ON)	+ (ANT3) Wi-Fi 2.4 GHz SISO		
	8		+ (ANT4) Wi-Fi 2.4 GHz SISO		
	9		+ Wi-Fi 2.4 GHz MIMO		
	10			+	(ANT3) Bluetooth (P_{High})
	11			+	(ANT4) Bluetooth (P_{High})
	12		+ (ANT5) Wi-Fi 5 GHz SISO		
	13		+ (ANT6) Wi-Fi 5 GHz SISO		
	14		+ Wi-Fi 5 GHz MIMO		
	15		+ (ANT5) Wi-Fi 5 GHz SISO	+	(ANT3) Bluetooth (P_{low})
	16		+ (ANT6) Wi-Fi 5 GHz SISO	+	(ANT3) Bluetooth (P_{low})
	17		+ Wi-Fi 5 GHz MIMO	+	(ANT3) Bluetooth (P_{low})
	18		+ (ANT5) Wi-Fi 5 GHz SISO	+	(ANT4) Bluetooth (P_{low})
	19		+ (ANT6) Wi-Fi 5 GHz SISO	+	(ANT4) Bluetooth (P_{low})
	20		+ Wi-Fi 5 GHz MIMO	+	(ANT4) Bluetooth (P_{low})

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13259315-S1V3 at 259 (September 25, 2020).

109. The Apple '646 Products perform the step of setting the processor-based system to perform the UWB function and to turn off the W-CDMA and the WLAN functions during UWB mode.

110. Apple has directly infringed and continues to directly infringe the '646 patent by, among other things, making, using, offering for sale, and/or selling technology for Wideband Code Division Multiple Access (W-CDMA), Wireless Local Area Network (WLAN), and Ultra-Wideband (UWB) Communications, including but not limited to the Apple '646 Products.

111. The Apple '646 Products are available to businesses and individuals throughout the United States.

112. The Apple '646 Products are provided to businesses and individuals located in the Western District of Texas.

113. By making, using, testing, offering for sale, and/or selling products and services for Wideband Code Division Multiple Access (W-CDMA), Wireless Local Area Network (WLAN),

and Ultra-Wideband (UWB) Communications, including but not limited to the Apple '646 Products, Apple has injured Plaintiff and is liable to Plaintiff for directly infringing one or more claims of the '646 patent, including at least claim 16 pursuant to 35 U.S.C. § 271(a).

114. To the extent applicable, the requirements of 35 U.S.C. § 287(a) have been met with respect to the '646 patent.

115. As a result of Apple's infringement of the '646 patent, Plaintiff has suffered monetary damages, and seek recovery in an amount adequate to compensate for Apple's infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple together with interest and costs as fixed by the Court.

COUNT IV
INFRINGEMENT OF U.S. PATENT NO. 7,305,057

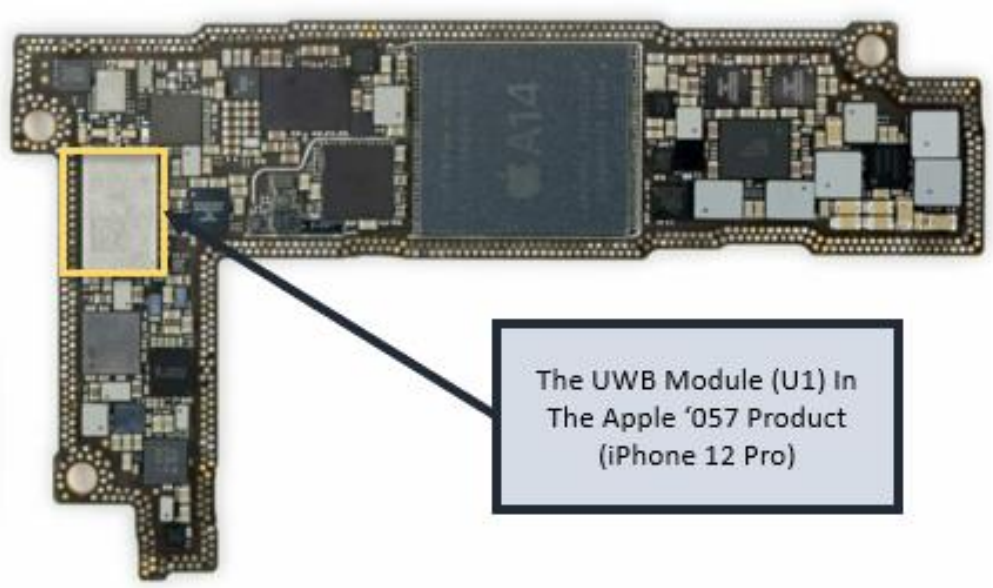
116. Plaintiff references and incorporates by reference the preceding paragraphs of this Complaint as if fully set forth herein.

117. Apple designs, makes, uses, sells, and/or offers for sale in the United States products comprising a multichannel filter-based handheld ultra-Wideband (UWB) communication transmitter.

118. Apple designs, makes, sells, offers to sell, imports, and/or uses the following products: iPhone 11 Pro Max (A2161), iPhone 11 Pro (A2160), iPhone 11 (A2111), iPhone 12 Pro Max (A2342), iPhone 12 Pro (A2341), iPhone 12 (A2172), iPhone 12 mini (A2176), iPhone 13 Pro Max (A2484), iPhone 13 Pro (A2483), iPhone 13 (A2482), and iPhone 13 mini (A2481) (the "Apple '057 Product(s)").

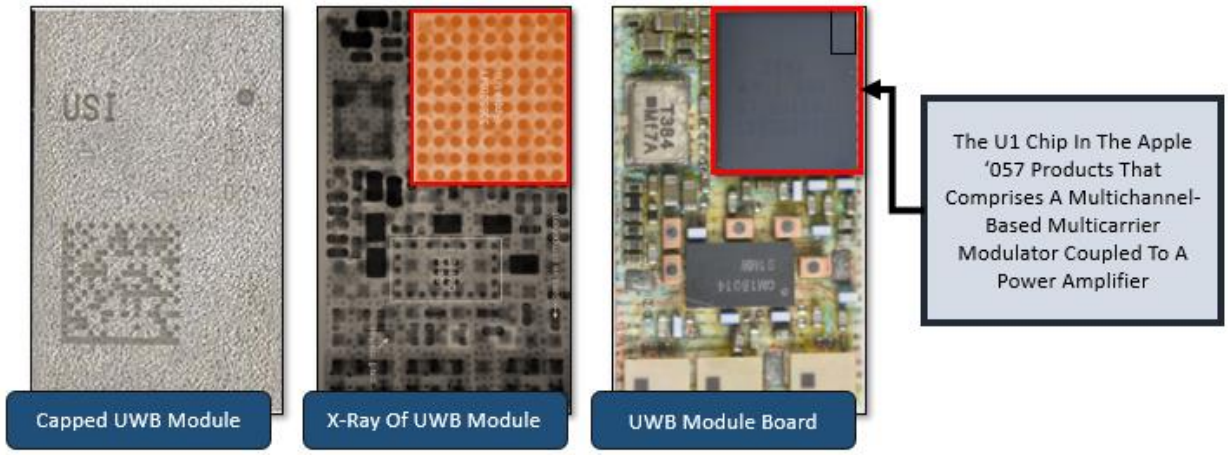
119. One or more Apple subsidiaries and/or affiliates use the Apple '057 Products in regular business operations.

120. The Apple '057 Products comprise a UWB transmitter. Specifically, the Apple '057 Products include UWB antennas and a UWB Module which includes the Apple U1 UWB chip.



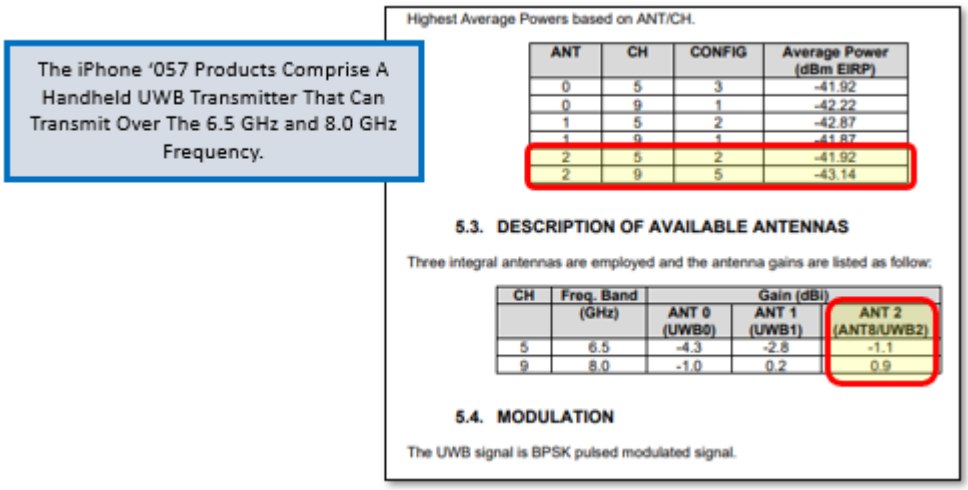
APPLE IPHONE 12 PRO (A2341) TEARDOWN IMAGE (annotation added).

121. The Apple '057 Products include a multichannel-based multicarrier modulator coupled to a power amplifier.



APPLE '057 PRODUCTS TEARDOWN IMAGE OF U1 MODULE (338S00541) (annotation added).

122. The Apple '057 Products comprise a multichannel filter based handheld UWB transmitter. Specifically, the Apple '057 Products utilize multiple channels for precise UWB localization including channel 5 (6.5 GHz) and channel 9 (8.0 GHz).



FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 133335182-E21V2 at 8 (September 26, 2020) (annotations added).

123. The Apple '057 Products contain functionality that is compliant with the 802.15.4z standard.

TABLE II
OVERVIEW OF UWB RADIO MANUFACTURERS OR DESIGNERS, THEIR CHIPS AND THE STANDARDS SUPPORTED BY EACH CHIP AND COMPANY.

Manufacturer or designer	Chip	HRP Standard	LRP standard	Standardization memberships
Apple	U1 [23]	IEEE 802.15.4z		CCC FiRa consortium Apple Nearby Interaction

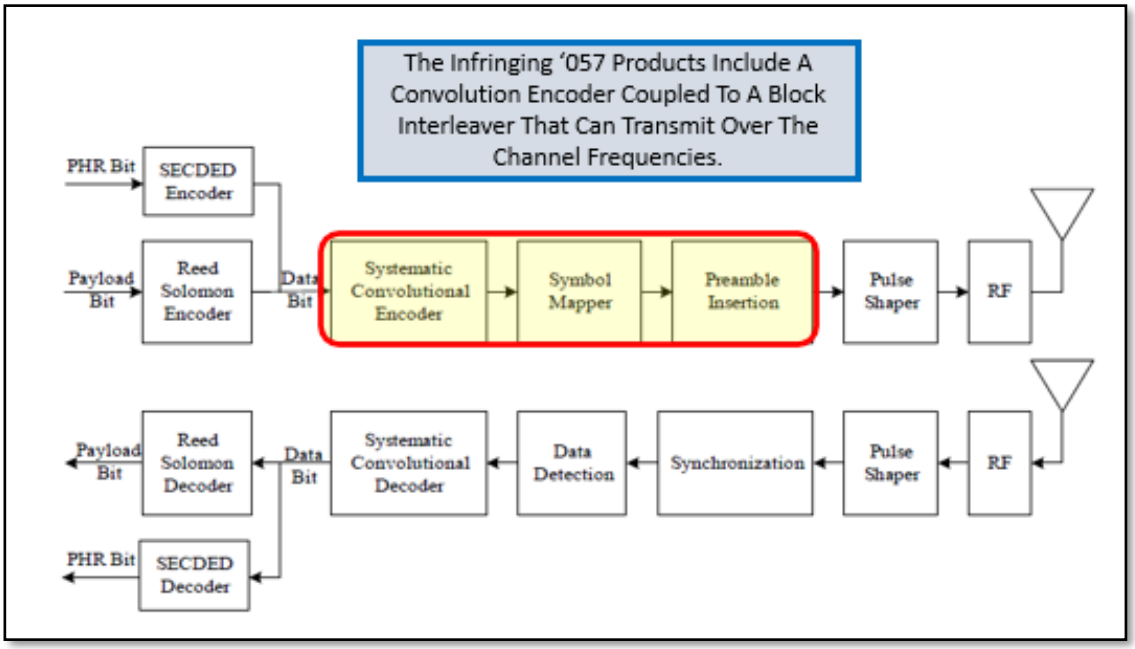
Coppens, Dieter, *et al*., *An Overview of Ultra-WideBand (UWB) Standards (IEEE 802.15. 4, FiRa, Apple): Interoperability Aspects and Future Research Directions*, ARXIV PREPRINT ARXIV:2202.02190 at 5 (2022).

124. The Apple '057 Products include a convolution encoder coupled to a block interleaver. Specifically, the forward error correction (FEC) "used by the HRP UWB PHY is a concatenated code consisting of an outer Reed-Solomon systematic block code and an inner half-rate systematic convolutional code." IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS 802.15.4-2020 § 15.3.3.1 (2020).

> Data bits, as used in the PHY Header (PHR) and the PHY Service Data Unit (PSDU), are encoded using either a SECDED (PHR) or Reed-Solomon (PSDU) code, followed by convolutional encoding, after which the coded bits are mapped via Burst Position Modulation (BPM) and BPSK onto sets of multiple pulses called "bursts". The pulses within a burst are transmitted back-to-back, meaning without gaps on the 499.2 MHz chip grid. The (BPSK) polarities of the pulses, as well as the (BPM) burst timings, are scrambled using a linear feedback shift register (LFSR), in order to whiten the spectrum, so as not to cause spectral peaks which would degrade the allowable transmitted integrated band power. Scrambling also increases orthogonality between different transmitted signals, which may provide benefits in (co-channel) interference scenarios.

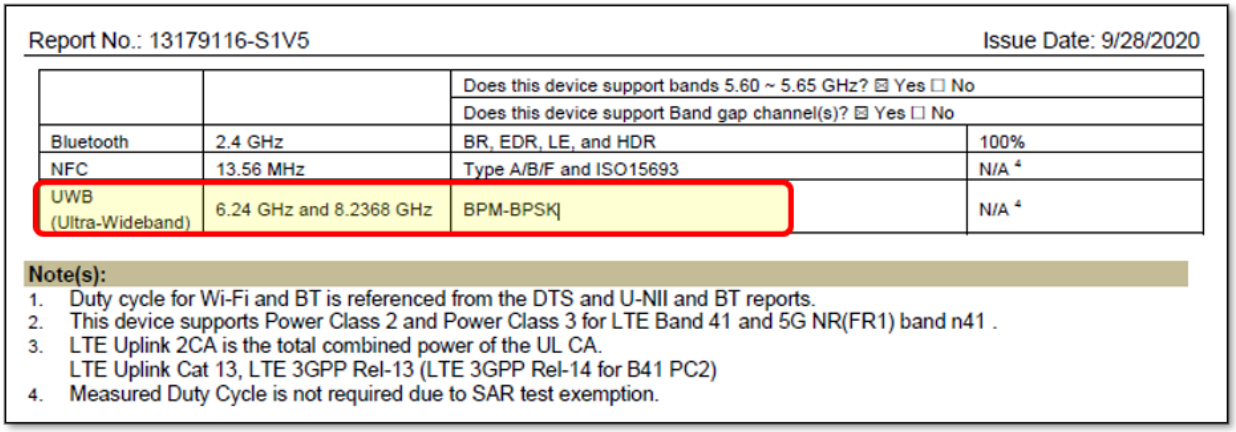
Frank Leong and Hans-Juergen Pirch, *Introduction to Impulse Radio UWB Seamless Access Systems*, FIRA WHITE PAPER at 9 (2020) (emphasis added).

125. The Apple '057 Products utilize a combination of BPM and BPSK to transmit and receive UWB signals over multiple channels. The combined BPM-BPSK is used to modulate symbols with each symbol composed of an active burst of UWB pulses. The following figure shows the sequence of processing steps used to create and modulate an HRP UWB PPDU by the Apple '057 Products.



IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS 802.15.4-2020 § 15.1 (2020) (annotation added).

126. The Apple '057 Products transmit and receive an ultra-wideband signal that is a binary phase shift keying (BPSK) pulsed modulated signal.



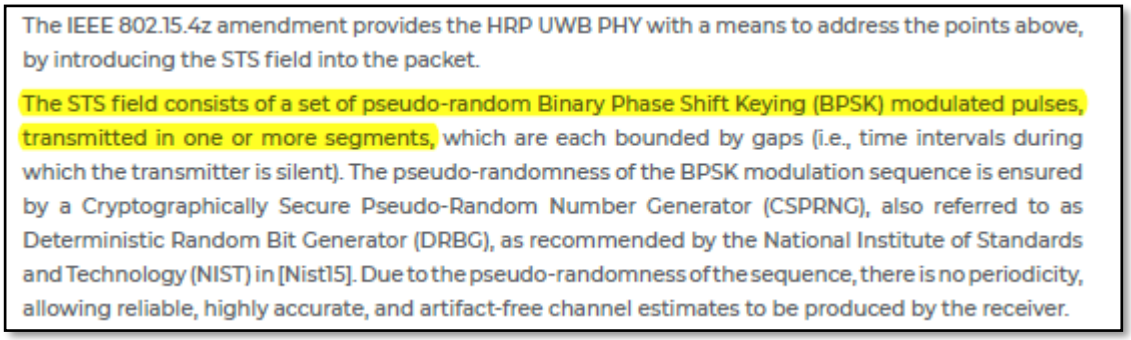
Report No.: 13179116-S1V5 Issue Date: 9/28/2020

		Does this device support bands 5.60 ~ 5.65 GHz? ☒ Yes ☐ No Does this device support Band gap channel(s)? ☒ Yes ☐ No	
Bluetooth	2.4 GHz	BR, EDR, LE, and HDR	100%
NFC	13.56 MHz	Type A/B/F and ISO15693	N/A [4]
UWB (Ultra-Wideband)	6.24 GHz and 8.2368 GHz	BPM-BPSK	N/A [4]

Note(s):
1. Duty cycle for Wi-Fi and BT is referenced from the DTS and U-NII and BT reports.
2. This device supports Power Class 2 and Power Class 3 for LTE Band 41 and 5G NR(FR1) band n41 .
3. LTE Uplink 2CA is the total combined power of the UL CA.
   LTE Uplink Cat 13, LTE 3GPP Rel-13 (LTE 3GPP Rel-14 for B41 PC2)
4. Measured Duty Cycle is not required due to SAR test exemption.

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13179116-S1V5 at 17 (September 28, 2020) (emphasis added).

127. The Apple '057 Products include a block interleaver coupled to a multichannel pseudorandom (PN) sequence mapping. Specifically, the Apple '057 Products utilize a Cryptographically Secure Pseudo-Random Number Generator (CSPRNP), also referred to as a Deterministic Random Bit Generator (DRBG).



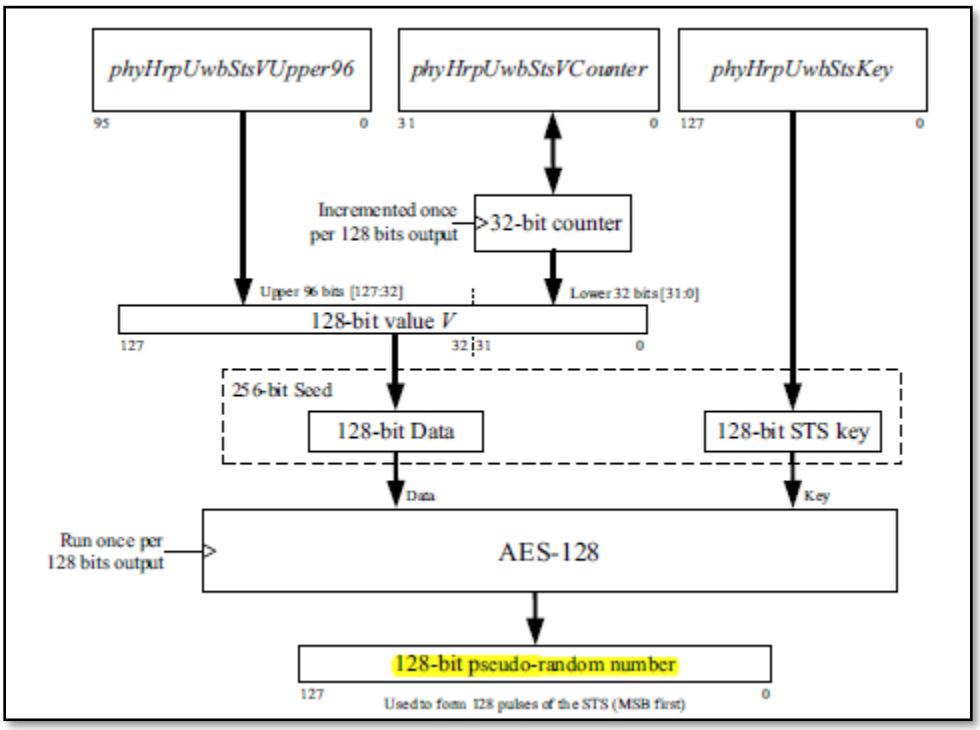
The IEEE 802.15.4z amendment provides the HRP UWB PHY with a means to address the points above, by introducing the STS field into the packet.

The STS field consists of a set of pseudo-random Binary Phase Shift Keying (BPSK) modulated pulses, transmitted in one or more segments, which are each bounded by gaps (i.e., time intervals during which the transmitter is silent). The pseudo-randomness of the BPSK modulation sequence is ensured by a Cryptographically Secure Pseudo-Random Number Generator (CSPRNG), also referred to as Deterministic Random Bit Generator (DRBG), as recommended by the National Institute of Standards and Technology (NIST) in [Nist15]. Due to the pseudo-randomness of the sequence, there is no periodicity, allowing reliable, highly accurate, and artifact-free channel estimates to be produced by the receiver.

Frank Leong and Hans-Juergen Pirch, *Introduction to Impulse Radio UWB Seamless Access Systems*, FIRA WHITE PAPER at 8 (2020) (emphasis added).

128. The Apple '057 Products comprise a multichannel PN sequence mapping coupled to a digital UWB transmitter filter system. Each iteration of the CSPRNG/DRBG produces a 128-bit pseudo-random number. This transmits the most significant bit first, where each bit of value zero produces a positive polarity pulse and each bit of value one produces a negative polarity pulse.

These pulses are spread and transmitted. The creation of the PM sequence mapping is shown in the below diagram.



IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS - AMENDMENT 1: ENHANCED ULTRA WIDEBAND (UWB) PHYSICAL LAYERS (PHYS) AND ASSOCIATED RANGING TECHNIQUES 802.15.4z-2020 § 15.2.9.1 (2020) (emphasis added).

129. The Apple '057 Products include a pseudorandom sequence look-up table coupled to a multichannel pseudorandom sequence mapping component.

130. The Apple '057 Products include a multichannel control coupled to the multichannel pseudorandom sequence mapping and coupled to the multichannel-based multicarrier modulator.

131. The Apple '057 Products include a digital UWB transmitter filter system coupled to a digital-to-analog converter.

132. The Apple '057 Products comprise a digital-to-analog converter (DAC) connected to a multichannel-based multicarrier modulator.

133. The Apple '057 Products include a DAC that is connected to a modulator that transmits and receives UWB signals that have a center frequency of 6.489 MHz, 7.987 MHz. Each UWB channel has a minimum bandwidth of 500 MHz.

ANT	CH	CONFIG	Payload	EUT Orientation	Meas. Ant Polarity	FM (GHz)	FL (GHz)	FH (GHz)	FC (GHz)	OBW (MHz)	Min. OBW (MHz)	OBW Margin (MHz)	OBW Pass/Fail
0	5	0	125	Portrait	H	6.729	6.227	6.753	6.490	526.132	500	26.132	P
0	5	1	125	Portrait	H	6.251	6.226	6.753	6.489	526.632	500	26.632	P
0	5	2	125	Portrait	H	6.729	6.228	6.751	6.489	523.631	500	23.631	P
0	5	3	125	Portrait	H	6.729	6.228	6.751	6.490	523.131	500	23.131	P
0	5	4	0	Portrait	H	6.251	6.226	6.753	6.489	526.632	500	26.632	P
0	5	5	0	Portrait	H	6.251	6.225	6.754	6.489	528.632	500	28.632	P
0	9	0	125	Portrait	H	8.226	7.724	8.250	7.987	526.132	500	26.132	P
0	9	1	125	Portrait	H	8.226	7.724	8.250	7.987	526.132	500	26.132	P
0	9	2	125	Portrait	H	8.226	7.725	8.249	7.987	524.131	500	24.131	P
0	9	3	125	Portrait	H	8.227	7.726	8.249	7.987	523.131	500	23.131	P
0	9	4	0	Portrait	H	8.226	7.724	8.250	7.987	526.132	500	26.132	P
0	9	5	0	Portrait	H	8.226	7.723	8.251	7.987	528.132	500	28.132	P
1	5	0	125	Portrait	H	6.729	6.227	6.753	6.490	525.631	500	25.631	P
1	5	1	125	Portrait	H	6.729	6.227	6.753	6.490	525.631	500	25.631	P
1	5	2	125	Portrait	H	6.729	6.228	6.751	6.489	523.631	500	23.631	P
1	5	3	125	Portrait	H	6.729	6.229	6.751	6.490	522.131	500	22.131	P
1	5	4	0	Portrait	H	6.729	6.227	6.753	6.490	525.631	500	25.631	P
1	5	5	0	Portrait	H	6.728	6.227	6.754	6.490	527.132	500	27.132	P
1	9	0	125	Portrait	H	7.748	7.724	8.250	7.987	525.631	500	25.631	P
1	9	1	125	Portrait	H	7.748	7.724	8.250	7.987	525.631	500	25.631	P
1	9	2	125	Portrait	H	7.748	7.725	8.249	7.987	523.631	500	23.631	P
1	9	3	125	Portrait	H	7.748	7.726	8.248	7.987	521.630	500	21.63	P
1	9	4	0	Portrait	H	7.748	7.724	8.250	7.987	525.631	500	25.631	P
1	9	5	0	Portrait	H	7.748	7.723	8.251	7.987	527.632	500	27.632	P
2	5	0	125	Flatbed	H	6.729	6.227	6.753	6.490	526.132	500	26.132	P
2	5	1	125	Flatbed	H	6.729	6.227	6.753	6.490	526.132	500	26.132	P
2	5	2	125	Flatbed	H	6.729	6.228	6.752	6.490	524.131	500	24.131	P
2	5	3	125	Flatbed	H	6.729	6.229	6.751	6.490	522.131	500	22.131	P
2	5	4	0	Flatbed	H	6.729	6.227	6.753	6.490	526.132	500	26.132	P
2	5	5	0	Flatbed	H	6.728	6.226	6.754	6.490	528.132	500	28.132	P
2	9	0	125	Landscape	H	8.226	7.726	8.250	7.988	524.131	500	24.131	P
2	9	1	125	Landscape	H	8.226	7.726	8.250	7.988	524.631	500	24.631	P
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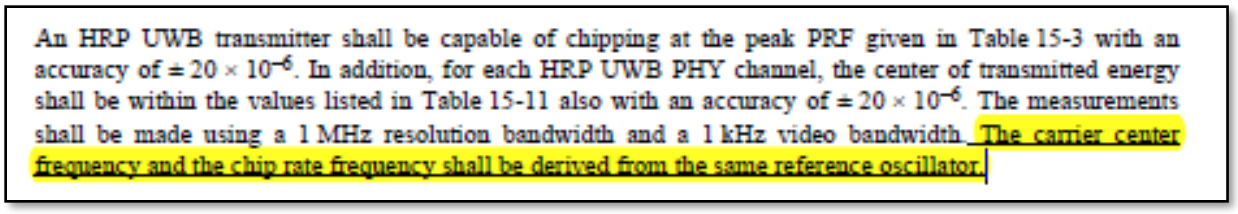
2	9	4	0	Landscape	H	8.227	7.726	8.251	7.988	525.131	500	25.131	P
2	9	5	0	Landscape	H	8.226	7.725	8.252	7.988	526.632	500	26.632	P

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13179116-S21V3 at 16 (September 28, 2020).

134. The Apple '057 Products comprise a clock control coupled to the digital UWB transmitter filter system, the digital-to-analog converter, and the multichannel-based multicarrier modulator.


An HRP UWB transmitter shall be capable of chipping at the peak PRF given in Table 15-3 with an accuracy of $\pm 20 \times 10^{-6}$. In addition, for each HRP UWB PHY channel, the center of transmitted energy shall be within the values listed in Table 15-11 also with an accuracy of $\pm 20 \times 10^{-6}$. The measurements shall be made using a 1 MHz resolution bandwidth and a 1 kHz video bandwidth. The carrier center frequency and the chip rate frequency shall be derived from the same reference oscillator.

IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS - AMENDMENT 1: ENHANCED ULTRA WIDEBAND (UWB) PHYSICAL LAYERS (PHYS) AND ASSOCIATED RANGING TECHNIQUES 802.15.4z-2020 § 15.4.6 (2020) (emphasis added).

135. Apple has directly infringed and continues to directly infringe the '057 patent by, among other things, making, using, offering for sale, and/or selling technology comprising a multichannel filter-based handheld ultra-wideband (UWB) communication transmitter, including but not limited to the Apple '057 Products.

136. The Apple '057 Products are available to businesses and individuals throughout the United States.

137. The Apple '057 Products are provided to businesses and individuals located in the Western District of Texas.

138. By making, using, testing, offering for sale, and/or selling products and services comprising a multichannel filter-based handheld ultra-wideband (UWB) communication transmitter, including but not limited to the Apple '057 Products, Apple has injured Plaintiff and is liable to Plaintiff for directly infringing one or more claims of the '057 patent, including at least claim 1 pursuant to 35 U.S.C. § 271(a).

139. To the extent applicable, the requirements of 35 U.S.C. § 287(a) have been met with respect to the '057 patent.

140. As a result of Apple's infringement of the '057 patent, Plaintiff has suffered monetary damages, and seek recovery in an amount adequate to compensate for Apple's

infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple together with interest and costs as fixed by the Court.

COUNT V
INFRINGEMENT OF U.S. PATENT NO. 7,433,382

141. Plaintiff references and incorporates by reference the preceding paragraphs of this Complaint as if fully set forth herein.

142. Apple designs, makes, uses, sells, and/or offers for sale in the United States products comprising a multichannel modulation Ultra-Wideband (UWB) communication transceiver.

143. Apple designs, makes, sells, offers to sell, imports, and/or uses the following products: iPhone 11 Pro Max (A2161), iPhone 11 Pro (A2160), iPhone 11 (A2111), iPhone 12 Pro Max (A2342), iPhone 12 Pro (A2341), iPhone 12 (A2172), iPhone 12 mini (A2176), iPhone 13 Pro Max (A2484), iPhone 13 Pro (A2483), iPhone 13 (A2482), and iPhone 13 mini (A2481) (the "Apple '382 Product(s)").

144. One or more Apple subsidiaries and/or affiliates use the Apple '382 Products in regular business operations.

145. The Apple '382 Products comprise a spread spectrum based multichannel modulation UWB communication transceiver. Specifically, the Apple '382 Products utilize a multichannel modulator in supporting UWB channels with a center frequency of 6.489 GHz, 7.987 GHz. Each UWB channel has a minimum bandwidth of 500 MHz.

ANT	CH	CONFIG	Payload	EUT Orientation	Meas. Ant Polarity	FM (GHz)	FL (GHz)	FH (GHz)	FC (GHz)	OBW (MHz)	Min. OBW (MHz)	OBW Margin (MHz)	OBW Pass/Fail
0	5	0	125	Portrait	H	6.729	6.227	6.753	6.490	526.132	500	26.132	P
0	5	1	125	Portrait	H	6.251	6.226	6.753	6.489	526.632	500	26.632	P
0	5	2	125	Portrait	H	6.729	6.228	6.751	6.489	523.631	500	23.631	P
0	5	3	125	Portrait	H	6.729	6.228	6.751	6.490	523.131	500	23.131	P
0	5	4	0	Portrait	H	6.251	6.226	6.753	6.489	526.632	500	26.632	P
0	5	5	0	Portrait	H	6.251	6.225	6.754	6.489	528.632	500	28.632	P
0	9	0	125	Portrait	H	8.226	7.724	8.250	7.987	526.132	500	26.132	P
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1	5	5	0	Portrait	H	6.728	6.227	6.754	6.490	527.132	500	27.132	P
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1	9	1	125	Portrait	H	7.748	7.724	8.250	7.987	525.631	500	25.631	P
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2	5	5	0	Flatbed	H	6.728	6.226	6.754	6.490	528.132	500	28.132	P
2	9	0	125	Landscape	H	8.226	7.726	8.250	7.988	524.131	500	24.131	P
2	9	1	125	Landscape	H	8.226	7.726	8.250	7.988	524.631	500	24.631	P
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2	9	5	0	Landscape	H	8.226	7.725	8.252	7.988	526.632	500	26.632	P

FEDERAL COMMUNICATIONS COMMISSION REPORT NO. 13179116-S21V3 at 16 (September 28, 2020).

146. The Apple '382 Products comprise a spread spectrum physical layer (PHY). Specifically, the Apple '382 Products enable what is "essentially a spread-spectrum PHY. Preamble symbols are repeated by the transmitter such that energy can be accumulated in the receiver and data symbols are spread across multiple pulses." Frank Leong and Hans-Juergen Pirch, *Introduction to Impulse Radio UWB Seamless Access Systems*, FIRA WHITE PAPER at 9 (2020).

147. The Apple '382 Products contain a spread-spectrum PHY wherein the encoded block is spread and modulated using BPM-BPSK modulation such that the transmit waveform during the *k*th symbol interval may be expressed as follows:

$$x^{(k)}(t) = [1-2g_1^{(k)}] \sum_{n=1}^{N_{cpb}} [1-2s_{n+kN_{cpb}}] \times p(t-g_0^{(k)}T_{BPM}-h^{(k)}T_{burst}-nT_c)$$

IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS 802.15.4-2020 § 15.3.1 (2020).

148. The Apple '382 Products use the spreading sequence to improve the interference rejection capabilities of the UWB PHY.

> Data bits, as used in the PHY Header (PHR) and the PHY Service Data Unit (PSDU), are encoded using either a SECDED (PHR) or Reed-Solomon (PSDU) code, followed by convolutional encoding, after which the coded bits are mapped via Burst Position Modulation (BPM) and BPSK onto sets of multiple pulses called "bursts". The pulses within a burst are transmitted back-to-back, meaning without gaps on the 499.2 MHz chip grid. The (BPSK) polarities of the pulses, as well as the (BPM) burst timings, are scrambled using a linear feedback shift register (LFSR), in order to whiten the spectrum, so as not to cause spectral peaks which would degrade the allowable transmitted integrated band power. Scrambling also increases orthogonality between different transmitted signals, which may provide benefits in (co-channel) interference scenarios.

Frank Leong and Hans-Juergen Pirch, *Introduction to Impulse Radio UWB Seamless Access Systems*, FIRA WHITE PAPER at 8 (2020).

149. The Apple '382 Products contain a pseudorandom noise sequence look-up table coupled to a multichannel pseudorandom noise sequence mapping.

> [T]he BPSK modulated STS sequence is used for enabling secure ranging in HRP mode of IEEE 802.15.4. In absence of multi-path and receiver noise, HRP with STS can be used to implement a secure ranging system. In such a scenario the receiver might be able to decode most of the individual pulses of the STS sequence and can require high correlation of the received and template STS. Since an adversary is unable to predict the pseudo-randomly generated sequence it will not be able to generate a high enough correlation peak that satisfies the checks applied at the receiver.

M. Singh, *et al.*, *Security Analysis of IEEE 802.15.4z/HRP UWB Time-of-Flight Distance Measurement*, PROCEEDINGS OF THE 14TH ACM CONFERENCE ON SECURITY AND PRIVACY IN WIRELESS AND MOBILE NETWORKS at 4 (June 28, 2021).

150. The Apple '382 Products comprise a multichannel pseudorandom noise sequence mapping coupled to a digital lowpass finite impulse response shaping filter. Specifically, the

Apple '382 Products use a pulse shaper to ensure compliance to the specified transmit mask and avoid distortion of other channels.

> In order to match the UWB signal to the 500 MHz bandwidth of [Ieee15], the pulse shape needs to be chosen carefully to ensure compliance to the [Ieee15] specified transmit spectrum mask and avoid distortion of adjacent channels. Additionally, stringent regulatory transmit limits must be respected. Figure 2 shows the [Ieee15] Root Raised Cosine (RRC) HRP UWB reference pulse with a center frequency that corresponds to channel 9, as well as an upconverted 8th order Butterworth low pass pulse with a -3 dB bandwidth of 500 MHz and a center frequency that corresponds to channel 5. Both of these pulses would meet the requirements specified in [Ieee15] to be used for IR-UWB radios.

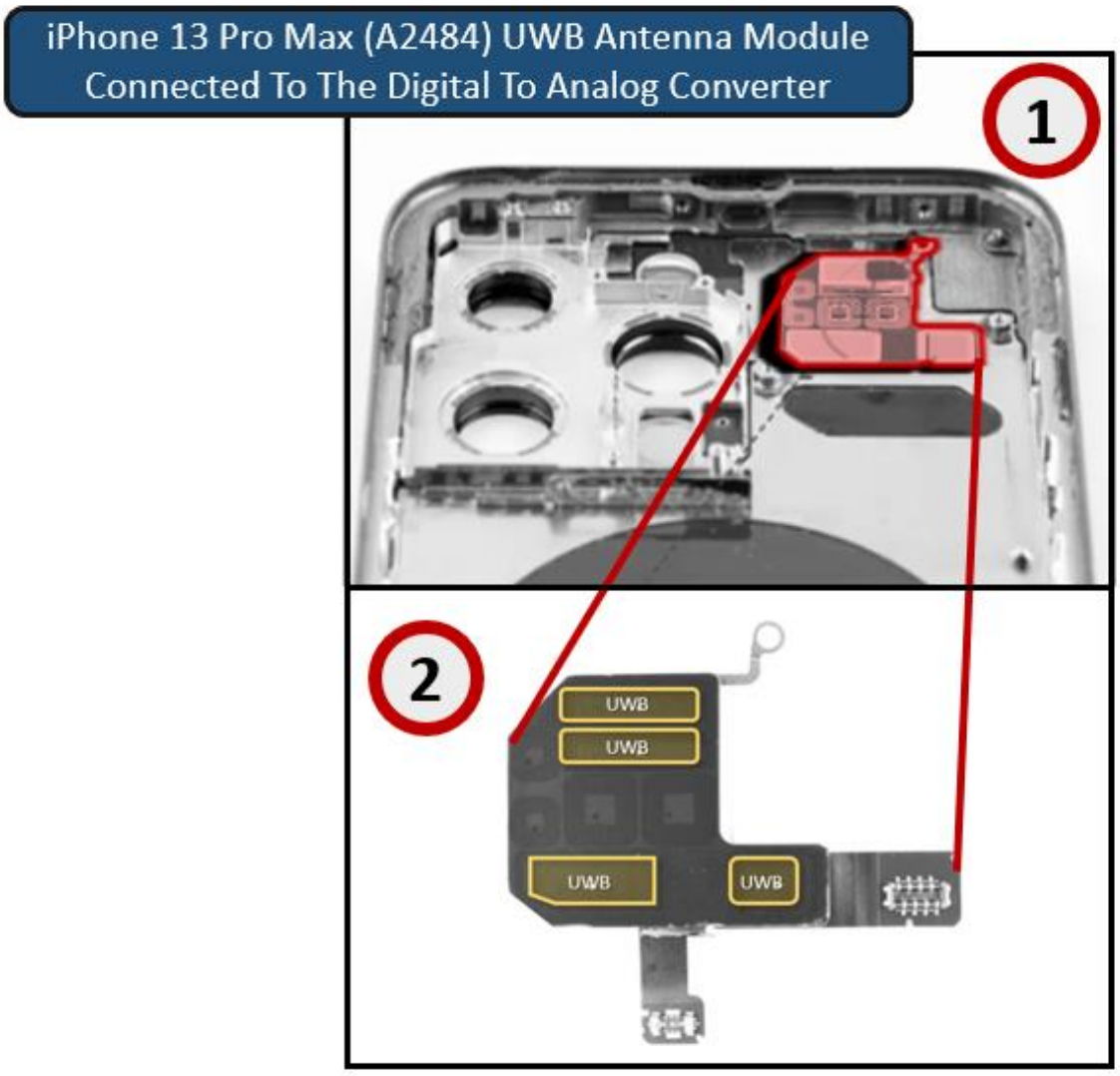
Frank Leong and Hans-Juergen Pirch, *Introduction to Impulse Radio UWB Seamless Access Systems*, FIRA WHITE PAPER at 3 (2020) (emphasis added)

151. Further, the Apple '382 Products use the multichannel PN sequence mapping to ensure compliance with the IEEE 802.15.4z standard.

> In other words, some systematic redundancy is added into the data in order to recover the correct data at the receiver in the presence of errors. Then, the coded data is mapped onto specific symbols for modulation purposes. As an example, the coded data can be mapped onto binary phase shift keying (BPSK) symbols, which take values from the set $\{-1,+1\}$.

Sinan Gezici and H. Vincent Poor, *Position Estimation via Ultra-Wideband Signals*, PROCEEDINGS OF THE IEEE 97.2 at 25 (2009).

152. The Apple '382 Products comprise a digital lowpass finite impulse response shaping filter coupled to a digital-to-analog converter. Specifically, the Apple '382 Products comprise UWB antenna modules that are connected to a digital lowpass FIR filter that is coupled to a digital-to-analog converter (DAC).



APPLE IPHONE 13 PRO MAX (A2484) TEARDOWN (showing (1) the interior of the device and (2) one of the UWB antenna modules) (annotation added).

153. The Apple '382 Products contain a multichannel pseudorandom noise sequence mapping wherein two or more I delay units are coupled to two or more down sampling units followed by two or more Exclusive OR (XOR) units in parallel and said two or more XOR units are connected to a pseudorandom noise sequence look-up table.

Table 15-1 and Table 15-2 show how the PHR field, $H_0 – H_{18}$, PHY Payload field, $D_0 – D_{N-1}$, and Tail field, $T_0 – T_1$, are mapped onto the symbols. In these tables, the polarity bit column operation is an XOR. The tables also show when the transition from the header bit rate to the data bit rate takes place. Note that the delay line of the convolutional code is initialized to zero. For this reason, the position bit of Symbol 0 shall always be zero..

Table 15-1—Mapping of PHR field bits, PHY Payload field bits, and Tail field bits onto symbols with Viterbi rate 0.5

Symbol #	Input data	Position bit	Polarity bit	
0	H_0	0	H_0	21 symbols of PHY header at 850 kb/s or 110 kb/s
1	H_1	H_0	H_1	
2	H_2	H_1	$H_0 \oplus H_2$	
3	H_3	H_2	$H_1 \oplus H_3$	
…	…	…	…	
16	H_{16}	H_{15}	$H_{14} \oplus H_{16}$	
17	H_{17}	H_{16}	$H_{15} \oplus H_{17}$	
18	H_{18}	H_{17}	$H_{16} \oplus H_{18}$	
19	D_0	H_{18}	$H_{17} \oplus D_0$	
20	D_1	D_0	$H_{18} \oplus D_1$	
21	D_2	D_1	$D_0 \oplus D_2$	N symbols of data at data rate, e.g., 6.8 Mb/s
…	…	…	…	
N+17	D_{N-2}	D_{N-3}	$D_{N-4} \oplus D_{N-2}$	
N+18	D_{N-1}	D_{N-2}	$D_{N-3} \oplus D_{N-1}$	
N+19	T_0	D_{N-1}	$D_{N-2} \oplus T_0$	
N+20	T_1	T_0	$D_{N-1} \oplus T_1$	

IEEE STANDARD FOR LOW-RATE WIRELESS NETWORKS 802.15.4-2020 § 15.2.2 (2020) (emphasis added).

154. Apple has directly infringed and continues to directly infringe the ‘382 patent by, among other things, making, using, offering for sale, and/or selling technology for a multichannel modulation Ultra-Wideband (UWB) communication transceiver, including but not limited to the Apple ‘382 Products.

155. The Apple ‘382 Products are available to businesses and individuals throughout the United States.

156. The Apple ‘382 Products are provided to businesses and individuals located in the Western District of Texas.

157. By making, using, testing, offering for sale, and/or selling products and services for a multichannel modulation Ultra-Wideband (UWB) communication transceiver, including but not limited to the Apple '382 Products, Apple has injured Plaintiff and is liable to Plaintiff for directly infringing one or more claims of the '382 patent, including at least claim 1 pursuant to 35 U.S.C. § 271(a).

158. To the extent applicable, the requirements of 35 U.S.C. § 287(a) have been met with respect to the '382 patent.

159. As a result of Apple's infringement of the '382 patent, Plaintiff has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Apple's infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple together with interest and costs as fixed by the Court.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff MIMO Research, LLC respectfully requests that this Court enter:

A. A judgment in favor of Plaintiff that Apple has infringed, either literally and/or under the doctrine of equivalents, the '854, '716, '646, '057, and '382 patents;

B. An award of damages resulting from Apple's acts of infringement in accordance with 35 U.S.C. § 284;

C. A judgment and order finding that Apple's infringement was willful, wanton, malicious, bad-faith, deliberate, consciously wrongful, flagrant, or characteristic of a pirate within the meaning of 35 U.S.C. § 284 and awarding to Plaintiff enhanced damages.

D. A judgment and order finding that this is an exceptional case within the meaning of 35 U.S.C. § 285 and awarding to Plaintiff reasonable attorneys' fees against Apple.

E. Any and all other relief to which Plaintiff may show themselves to be entitled.

JURY TRIAL DEMANDED

Pursuant to Rule 38 of the Federal Rules of Civil Procedure, Plaintiff MIMO Research, LLC requests a trial by jury of any issues so triable by right.

Dated: June 14, 2022

Respectfully submitted,

/s/ Daniel P. Hipskind

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