

Exhibit 10

EXHIBIT 10 – U.S. PATENT 8,593,358

Plaintiff asserts that at least the following products (“Accused Instrumentalities”) infringe the Asserted Claims of U.S. Patent No. 8,593,358:

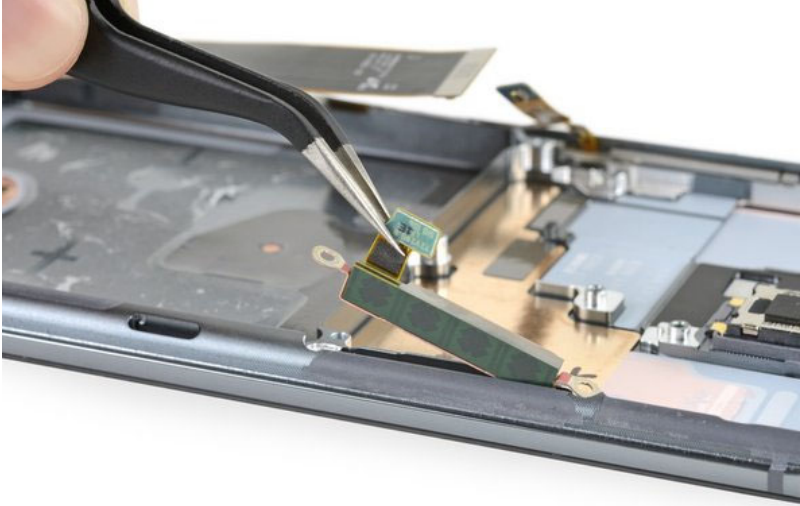
i) Smartphones:

Galaxy S20 (SM-G980, SM-G981); Galaxy S20+ (SM-G985, SM-G986); Galaxy S20 Ultra (SM-G988); Galaxy S20 FE (SM-G780, SM-G781); Galaxy S21 (SM-G991); Galaxy S21+ (SM-G996); Galaxy S21 Ultra (SM-G998); Galaxy S21 FE (SM-G990); Galaxy S22 (SM-S901); Galaxy S22+ (SM-S906); Galaxy S22 Ultra (SM-S908); Galaxy S23 (SM-S911); Galaxy S23+ (SM-S916); Galaxy S23 Ultra (SM-S918); Galaxy S23 FE (SM-S711); Galaxy S24 (SM-S921); Galaxy S24+ (SM-S926); Galaxy S24 Ultra (SM-S928); Galaxy S24 FE (SM-S821); Galaxy S25 (SM-S931); Galaxy S25+ (SM-S936); Galaxy S25 Ultra (SM-S938); Galaxy S25 Edge (SM-S935); Galaxy Z Flip 3 (SM-F711); Galaxy Z Flip 4 (SM-F721); Galaxy Z Flip 5 (SM-F731); Galaxy Z Flip 6 (SM-F741); Galaxy Z Fold 3 (SM-F926); Galaxy Z Fold 4 (SM-F936); Galaxy Z Fold 5 (SM-F946); Galaxy Z Fold 6 (SM-F956); Galaxy Note 20 (SM-N980x, SM-N981x); Galaxy Note 20 Ultra (SM-N985x, SM-N986x); Galaxy A51 (SM-A515U); Galaxy A71 (SM-A715x, SM-A716x); Galaxy A42 (SM-A426U); Galaxy A53 (SM-A536)

ii) Tablets

Galaxy Tab S7 (SM-T870, SM-T875, SM-T878U); Galaxy Tab S7+ (SM-T970, SM-T976); Galaxy Tab S7 FE (SM-T730, SM-T736B); Galaxy Tab S8 (SM-X700, SM-X706); Galaxy Tab S8+ (SM-X800, SM-X806); Galaxy Tab S8 Ultra (SM-X900, SM-X906); Galaxy Tab S9 (SM-X710, SM-X716); Galaxy Tab S9+ (SM-X810, SM-X816); Galaxy Tab S9 Ultra (SM-X910, SM-X916); Galaxy Tab S10 FE (SM-X520, SM-X526); Galaxy Tab S10 FE+ (SM-X620); Galaxy Tab S10+ (SM-X826); Galaxy Tab S10 Ultra (SM-X920)

The list of Accused Instrumentalities is a representative list to provide reasonable notice of the accused products. Plaintiff reserves the right to amend the list of accused products based on the same of similar product functionality.

Claim 1	Correspondence in Accused Instrumentalities ¹
[1Pre] A wireless device, comprising:	The Accused Instrumentalities, which include smartphones and tablets, are wireless devices at least because they transmit and receive wireless signals via WiFi, LTE or 5G communication protocols.
[1A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or more antennas forming an antenna array; and	The Accused Instrumentalities include one or more antennas for each of its wireless communication modalities, including but not limited to one or more antennas for cellular communication, Wi-Fi and Bluetooth (BT) communication. Below is an image from a teardown of a Galaxy S20 Ultra model smartphone showing a mmWave antenna. See www.ifixit.com/Teardown/Samsung+Galaxy+S20+Ultra+Teardown/131607 

¹ Unless indicated otherwise, the evidence cited in this table is representative of the operation of the Accused Instrumentalities and upon information and belief, the Accused Instrumentalities function in a substantially similar manner for purposes of this chart, unless indicated otherwise.

	The Accused Instrumentalities include one or more antennas that form an antenna array. For example, the FCC Operational Description for the Galaxy A53 5G (SM-A536V) (fccid.io/A3LSMA536V/Operational-Description/A3LSMA536V-Operational-Description-Main-Part-R4-5651659.pdf) (“A53 Operational Description”) explains that the device supports 4×4 MIMO on multiple LTE and NR bands. 4×4 MIMO requires at least four antenna elements configured and operated together as an array. In addition, the filing identifies Qorvo RF front-end modules (QM77098, QM78078) with multiple PA/LNA paths, distribution switches, and antenna switches, which drive multiple antenna elements. Likewise, for Samsung devices incorporating Snapdragon 5G modem-RF systems, Qualcomm itself confirms the presence of phased-array antenna modules. Qualcomm’s description of its X50 modem-RF system explains that it is “backed by the Qualcomm® QTM052 mmWave antenna module” which includes a phased-antenna array to focus mmWave signals for beamforming. These phased-array antenna modules are used in Samsung’s flagship Galaxy S and Note series and in certain A-series models (e.g., A71 5G UW). In addition, the accused antenna arrays are composed of multiple elements or sub-elements. The A53 Operational Description confirms that each mmWave phased-array module (S5640) includes 20 separate antenna ports, with 10 ports for the 28 GHz band and 10 ports for the 39 GHz band. Each of these ports corresponds to a distinct antenna element within the array, which are combined under electronic control to form steerable beams. Similarly, Qualcomm’s documentation for the QTM052/QTM525 phased-array antenna modules used in Samsung smartphones explains that the modules integrate a grid of radiating elements that function together as an antenna array for beamforming. These radiating elements are the “sub-elements” of the antenna module, explicitly satisfying the claim requirement that the antenna “includes one or more elements or sub-elements.” Accordingly, the Accused Instrumentalities not only include antennas that form arrays, but those arrays are themselves composed of multiple antenna elements or sub-elements that operate together to provide steerable, multi-band performance.
[1B] a plurality of transmitters, receivers or transceivers that	The different wireless communication modalities in the Accused Instrumentalities operate on different frequency bands. For example, Wi-Fi and 5G have multiple frequency bands. For example, WiFi 2.5 (802.11 b/g/n) has a 2.4 GHz band and WiFi 5 (802.11 a/n) has a 5 GHz band. The numerous bands for 4G and 5G cellular are described, for example, in “A guide to 4G and 5G frequency bands,” antenna.com

operate in one or more frequency bands,

(blog.antenova.com/hubfs/4g-5g-frequency-bands.pdf). This document identifies various bands by different carriers in the U.S. as follows:

America

CARRIER	4G LTE BANDS	5G BANDS
AT&T	2, 4, 66, 5, 12/17, 14, 29, 30	n5 (low band) n260 (mmWave)
Verizon	2, 4, 13	n40
T-Mobile	2, 4, 5, 12, 66, 71	n41 (mid band, sub-6GHz) n260 (mmWave)

See also <https://www.rfpage.com/4g-and-5g-nr-frequency-bands-explained> (identifying 4G LTE and 5G bands) and <https://www.droid-life.com/2024/10/30/us-wireless-carrier-bands-gsm-cdma-wcdma-lte-verizon-att-sprint-tmobile/> (identifying 4G LTE and 5G bands used by US carriers).

The Accused Instrumentalities comprise a plurality of transmitters, receivers or transceivers that operate in the various frequency bands.

The Qualcomm Snapdragon 5G solutions, which are included in some Accused Instrumentalities, include multiple transceivers that operate in one or more frequency bands, including one or more sub-6 GHz frequency bands and/or one or more mmWave frequency bands. See

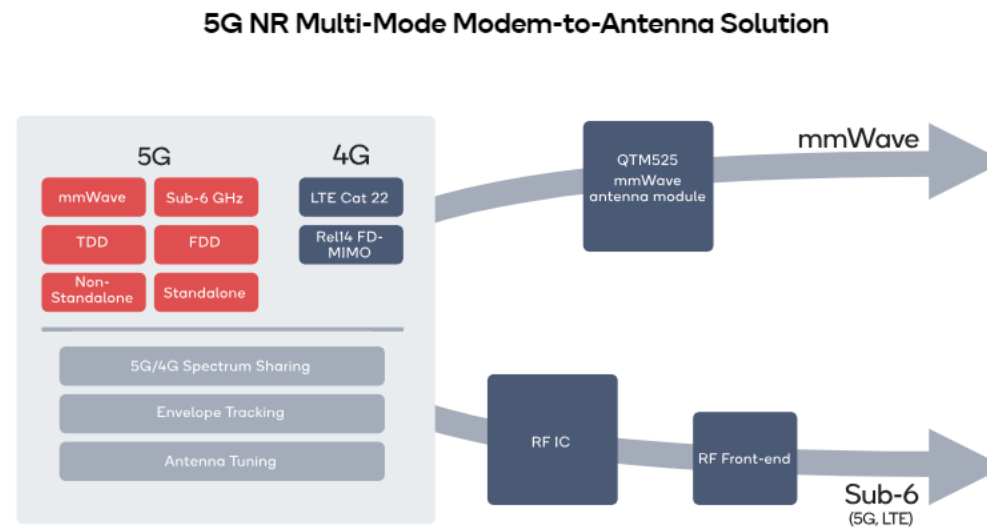
<https://www.qualcomm.com/developer/blog/2021/05/riding-wave-5g-millimeter-time> (“Our first 5G product, the Snapdragon® X50 5G Modem-RF System introduced in 2016, is backed by the Qualcomm® QTM052 mmWave antenna module. The system also combines 5G transceivers, power management, and RF front-end components, including power amplification and a phased-antenna array to focus mmWave signals for beamforming.”). Other RF front-end (RFFE) components in the Accused Instrumentalities, such as MediaTek Dimensity 9300+ and Qorvo tuning ICs, include multiple transceivers that operate in one or more frequency bands, including one or more sub-6 GHz frequency bands and/or one or more mmWave frequency bands.

In addition, FCC filings for Accused Samsung devices confirm that they comprise multiple transmitters and receivers that operate across numerous frequency bands. For example, the A53 Operational Description lists support for GSM, WCDMA, LTE, and 5G NR frequency bands, including LTE Bands 2, 4, 5, 7, 12, 13, 46, 48, and 66, and 5G NR Bands n2, n5, n66, and n77 (sub-6 GHz), as well as mmWave Bands n260 and n261. The filing further identifies integrated RF front-end modules such as the Qorvo

	QM77098 and Qorvo QM78078, each of which incorporates power amplifiers, low-noise amplifiers, filters, distribution switches, and antenna switches for multi-band coverage. 1.2 OMH LPAMiD : QM77098 1) General Description The Qorvo® QM77098 is a highly integrated Mid and High Band L-PAMiD compliant to 2G(MB), 3G, 4G and 5G standards targeted for complex flagship and premium TDD and FDD smartphones and data devices. The high efficiency L-PAMiD module consists of separate Mid and High Band PA paths, six LNA paths, distribution switches, filters, and antenna switches for multi-band coverage. The QM77098 supports Average Power Tracking (APT) for application versatility combined with higher system efficiency across a wide range of power levels. The QM77098 is packaged in a RoHS-compliant, compact 56-pin, 6.2 x 7.4 x 0.7 (max) mm surface-mount leadless package. 1.3 N77 PAM : QM78078 1) General Description The Qorvo® QM78078 is a highly integrated Sub-6GHz UHB L-PAMiD compliant to both 4G-LTE and 5G-NR standards targeted for advanced RF devices including flagship/premium smartphones and data devices. The module consists of Ultra-High Band PA, LNA, Filter, directional coupler and TxRx Switch for TDD operation. QM78078 supports Envelope Tracking (ET) as well as Average Power Tracking (APT). An integrated LNA provides low noise figure, high linearity, and optimal system sensitivity with support for high order carrier aggregation. The QM78078 is packaged in a RoHS-compliant, 5mm x 3mm package. These modules enable the transmitters and receivers within the device to operate in multiple frequency bands, including both legacy cellular bands and 5G NR sub-6 GHz bands.
[1C] wherein at least one antenna of said antenna array is used by said plurality of transmitters, receivers or transceivers in a plurality of different bands,	The Accused Instrumentalities incorporate multi-band antenna arrays that allow a single physical antenna element, or a group of elements, to operate efficiently across multiple frequency bands. In particular, these devices include at least one cellular antenna array in which antenna elements are actively tuned or switched to cover a wide range of LTE and 5G sub-6 GHz frequency bands, with separate phased-array antenna modules used for 5G mmWave operation. In addition, they include at least one Wi-Fi/Bluetooth antenna array that is designed to cover multiple WLAN frequency bands (e.g., 2.4 GHz and 5 GHz) within a single antenna structure. Together, these multi-band antenna arrays enable the accused devices to support

	simultaneous operation across numerous wireless standards while minimizing the number of discrete antennas required. The A53 Operational Description confirms that the device incorporates such multi-band antenna arrays. On the cellular side, the filing identifies the Qorvo QM77098 L-PAMiD module as a “highly integrated Mid and High Band” front-end that includes “separate Mid and High Band PA paths, six LNA paths, distribution switches, filters, and antenna switches for multi-band coverage.” The same filing also describes the Qorvo QM78078 as a sub-6 GHz ultra-high-band module that integrates a power amplifier, low-noise amplifier, filters, and a Tx/Rx switch for TDD operation. These modules are expressly designed to feed multiple antenna elements of a cellular array across multiple LTE and 5G NR frequency bands, with antenna switching used to configure the path depending on the band of operation. The filing also confirms that the Galaxy A53 supports 4×4 MIMO operation, which necessarily requires an antenna array of at least four elements, with at least one element tuned to operate across multiple LTE and NR bands. In addition, the filing confirms that the device includes a dedicated mmWave phased-array antenna module (SGB5640X01-M040) for NR FR2 bands (n257/n258/n260/n261), indicating that the sub-6 GHz subsystem uses a shared multi-band antenna array while mmWave uses a separate phased array. The FCC filing also confirms the presence of a Wi-Fi/BT subsystem supporting WLAN 2.4 GHz (802.11 b/g/n), WLAN 5 GHz (802.11 a/n/ac), and Bluetooth 5.1. These radios are described separately from the cellular RF front-end modules, reflecting that they operate over a distinct Wi-Fi/BT antenna array. Because both 2.4 GHz and 5 GHz WLAN bands are supported, that antenna array is necessarily multi-band, providing efficient transmission and reception across multiple WLAN frequencies. The FCC filings therefore establish that modern Samsung smartphones, including the Galaxy A53 5G, employ (i) a cellular antenna array that operates across multiple LTE and 5G sub-6 GHz bands with tunable and switchable front-end modules, (ii) a separate mmWave phased-array antenna module for NR FR2 bands, and (iii) a multi-band Wi-Fi/BT antenna array that covers both 2.4 GHz and 5 GHz. These disclosures demonstrate that the accused devices practice the claimed feature of “at least one antenna of said antenna array ... used by said plurality of transmitters, receivers, or transceivers in a plurality of different bands.” Teardowns and technical disclosures for Samsung’s flagship smartphones and tablets confirm the same design approach across multiple product families. For example, an iFixit teardown (see image below) of the Galaxy S20 Ultra (www.ifixit.com/Teardown/Samsung+Galaxy+S20+Ultra+Teardown/131607) identifies a Qualcomm SDX55M 5G modem, which is part of the Snapdragon X55 Modem-RF System. Qualcomm documentation explains that this system integrates 5G transceivers, RF front-end components,
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and adaptive antenna tuners (including the QAT3555 impedance tuner) capable of tuning a single antenna across a wide range of sub-6 GHz frequency bands, such as n71 (600 MHz), n5 (850 MHz), n41 (2.5 GHz), and n78 (3.5 GHz). These tuners are expressly designed to drive multi-band antenna arrays across multiple bands. The same Qualcomm documentation further confirms the use of dedicated phased-array antenna modules (e.g., QTM525) for NR FR2 bands, each of which is itself an antenna array used for beamforming. Similarly, subsequent Samsung devices including the Galaxy S21 and S22 series smartphones and Galaxy Tab S8 and S9 tablets incorporate Snapdragon X60 or X65 modems, which likewise employ adaptive antenna tuning across sub-6 GHz bands such as n71, n41, n5, n2, n66, and n77 while supporting mmWave phased arrays. See below diagram of SDX55 5G Modem-RF System from www.qualcomm.com/products/technology/modems/snapdragon-x55-5g-modem



See also www.qualcomm.com/content/dam/qcomm-martech/dm-assets/documents/x55_9_final.pdf

Other Accused Instrumentalities employ different chipsets but the same architecture. For instance, the Galaxy Tab S10 and S10 Ultra tablets include a MediaTek Dimensity 9300+ platform, which supports adaptive antenna tuning across multiple sub-6 GHz bands (e.g., n71, n41, n77). These tuners likewise control antenna arrays that include elements configured for operation in multiple bands. Still other Galaxy models include Qorvo antenna tuning ICs, which provide adaptive control of cellular antenna arrays across multiple bands. Collectively, these disclosures demonstrate that across Snapdragon-based, MediaTek-

	based, and Exynos/Qorvo-based platforms, modern Samsung devices uniformly employ antenna arrays in which at least one antenna is used by multiple transmitters, receivers, or transceivers in a plurality of different bands.
[1D] wherein said at least one antenna is one or more of a) an actively tuned antenna, and b) is tuned by one or more passive elements which are selected or interconnected using electronic control.	The Accused Instrumentalities incorporate one or more antennas that are each used by a plurality of transmitters, receivers or transceivers in multiple frequency bands, where the antenna(s)is(are) tuned to operate at a selected frequency band. This is explained, for example, in “Criticality of 5G Modem to RF Integration; A look inside Samsung Galaxy S20 Ultra,” April 2020 (omdia.tech.informa.com/om006104/criticality-of-5g-modem-to-rf-integration-a-look-inside-samsung-galaxy-s20-ultra, hereinafter “Omdia”), which explains that with all of the higher 5G frequencies, the solution is “antenna tuners.” With all these different higher 5G frequencies requiring 4x4 MIMO, antenna design becomes much more daunting in modern 5G devices. A typical LTE device may have upwards of 6 cellular antennas. Some high-end devices exhibit more due to the higher number of frequencies supported. However, the volume inside a device like the smartphone is still finite and designers can only fit in so many physically tuned antennas. The solution for that are antenna tuners. Antenna tuners are vital to 5G as higher frequencies and 4x4 MIMO requirements drive up need for more antennas. In the case of the Galaxy S20 Ultra design, Samsung is using up to five Qualcomm antenna tuners in the design. The Qualcomm Snapdragon (SN) modems, which are in at least some of the Accused Advanced Antenna Mobile Devices, include “antenna modules” with “adaptive antenna tuning.” See https://www.qualcomm.com/products/technology/modems/rf.

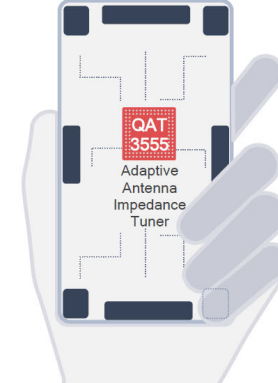
	Antenna tuning solutions Our comprehensive multi-tier portfolio of antenna performance enhancement technologies includes Qualcomm® AI-Enhanced Signal Boost, the world's first AI antenna tuning technology that intelligently detects hand grips around the phone and keeps 5G multimode devices fine-tuned for fewer dropped calls, better coverage, and longer battery life. Advanced tunability allows OEMs to design sleek smartphones and tablets with high signal performance, wide frequency range, and extensive band support. See also Snapdragon X55 and 5G RF datasheet. device.report/m/1cde5ac9c829a48d5afe8d9aadb0d0c993271ff7e3247850068f17979106bfad
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World's First Announced

5G NR Adaptive Antenna Tuning solution

Qualcomm® QAT3555

- Better indoor coverage¹
- Longer battery life¹
- Faster, more consistent data speeds¹
- Fast time-to-certification and launch for OEMs



Qualcomm® Signal Boost 5G
adaptive antenna tuning solution

Support for growing antenna count in 5G
600 MHz - 6 GHz antenna frequency support
25% reduced package height for sleek devices²

www.slideshare.net/slideshow/powerpointpresentationmaking5gnrrealityfebruary2020webpdf/252983614

See also “Qualcomm Announces Second Generation 5G RF Front-End Solutions for Sleeker, More Efficient 5G Multimode Mobile Devices,” Feb. 2019

(www.qualcomm.com/news/releases/2019/02/qualcomm-announces-second-generation-5g-rf-front-end-solutions-sleeker-more), which describes that its Snapdragon 5G modems include an “adaptive antenna tuner” for “extending adaptive tuning technology to 5G bands up to 6 GHz ...”

To help OEMs address the growing number of antennas and frequency range support required in mobile devices, Qualcomm Technologies has also introduced the QAT3555 Signal Boost adaptive antenna tuner, extending adaptive antenna tuning technology to 5G bands up to 6 GHz, while featuring a 25% reduced package height, and lower loss compared to the previous generation.

A Qorvo White Paper, “Aperture Tuning: An Essential Technology in 5G Smartphones”

(www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-paper)

explains that to accommodate the multiple antennas needed for 5G, but in small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on

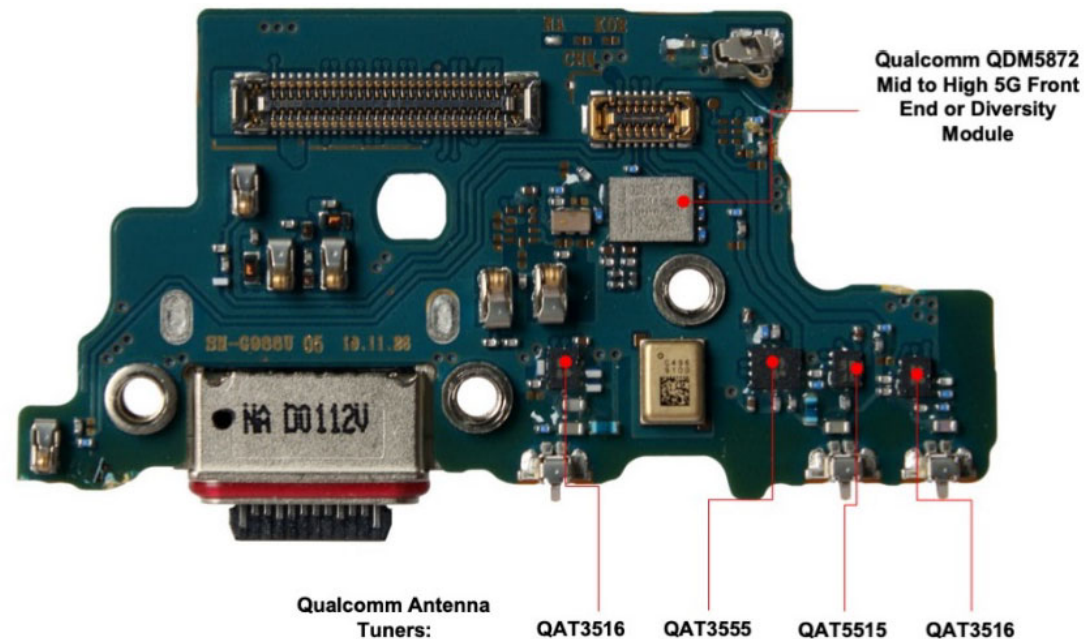
multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation.

Antenna aperture tuning is essential to enable smartphones to operate efficiently over the ever-increasing range of RF frequency bands and support the transition to 5G. Smartphones need more antennas to support growing RF requirements such as new 5G bands, MIMO, and carrier aggregation (CA), but there is less space for these antennas due to changes in smartphone industrial design. As a result, antennas are becoming smaller, potentially reducing antenna efficiency and bandwidth. Aperture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands and increasing Tx and Rx performance by 3 dB or more. Aperture tuning is implemented with switches combined with other tuning components; switches with low RON and low COFF are critical to maximize efficiency. Aperture tuning also lets antennas communicate on multiple bands simultaneously to support CA. Implementing aperture tuning requires in-depth knowledge of how to apply the technology for each application.

This paper explains that aperture tuning utilizes a switch along with a capacitor and/or inductor as tuning components. This is an example of tuning by one or more passive elements that are selected or interconnected using electronic control (i.e., part (b) of this claim element).

Samsung uses Qorvo’s RF solutions for its Galaxy platform. See www.qorvo.com/newsroom/news/2021/qorvo-recognized-by-samsung-for-best-quality-in-mobile; www.techinsights.com/blog/deep-dive-teardown-samsung-galaxy-s24-sm-s921bds-smartphone.

Below is an image from teardown of a Galaxy S20 Ultra showing 4 antenna tuners. See Omdia.



The FCC filing for the Samsung Galaxy A53 5G (see above) provides further direct evidence that the Accused Instrumentalities satisfy this limitation. The A53 Operational Description identifies the Qorvo QM77098 L-PAMiD as including “separate Mid and High Band PA paths, six LNA paths, distribution switches, filters, and antenna switches for multi-band coverage.” The same filing describes the Qorvo QM78078 as a sub-6 GHz ultra-high-band module consisting of “Ultra-High Band PA, LNA, Filter, directional coupler and Tx/Rx switch for TDD operation.” These descriptions confirm that the accused devices employ passive elements (filters, switches, distribution paths) that are selected or interconnected using electronic control (via MIPI RFFE) to tune a single antenna system across multiple LTE and 5G NR frequency bands.

The FCC filing also separately lists support for WLAN 2.4 GHz, WLAN 5 GHz, and Bluetooth 5.1, which are implemented through a distinct Wi-Fi/Bluetooth antenna subsystem that is likewise multi-band. In addition, the filing identifies a dedicated mmWave phased-array antenna module (SGB5640X01-M040)

	for NR FR2 operation, confirming that Samsung devices contain multiple antenna systems, each of which is electronically tuned across its supported frequency bands. Accordingly, the FCC record corroborates the industry and teardown evidence by demonstrating that Samsung smartphones use antennas tuned by passive elements that are electronically controlled, thereby meeting at least part (b) of this claim element.
Claim 3	Correspondence in Accused Instrumentalities
[3] The wireless device of claim 1 wherein said at least one antenna is used for transmitting, receiving, or transmitting and receiving simultaneously in said plurality of different bands.	The Accused Instrumentalities satisfy the limitation that “at least one antenna is used for transmitting, receiving, or transmitting and receiving simultaneously in said plurality of different bands.” Qualcomm Snapdragon modem-RF systems integrated into Samsung smartphones support carrier aggregation, in which the same antenna system is configured to transmit and/or receive across two or more LTE or 5G NR bands simultaneously. As Qualcomm and Qorvo explain, antenna tuners are essential in this context because handset real estate limits the number of discrete antennas, and therefore individual antennas must be tuned to operate efficiently on multiple bands at once. Qorvo’s white paper (see below) confirms CA involves a single antenna communicating on two bands simultaneously. See www.qorvo.com/design-hub/blog/4-things-to-know-about-antenna-tuning-in-4g-5g-smartphones CA combines two or more LTE carriers, often in different frequency bands, to deliver increased bandwidth and higher data rates. Due to the limited total number of antennas in handsets, this often means that a single antenna must communicate on two bands simultaneously. See also www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-paper, which explains that to accommodate the multiple antennas needed for 5G, but in a small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation. The FCC filing for the Samsung Galaxy A53 5G (see above) provides further confirmation that the accused devices support simultaneous multi-band operation. The A53 Operational Description identifies Qorvo front-end modules (e.g., QM77098, QM78078) with “antenna switches for multi-band coverage” and notes that these modules support MIMO and carrier aggregation across multiple LTE and 5G NR bands. By definition, carrier aggregation allows the device to transmit and/or receive on two or more carriers in different frequency bands at the same time. Likewise, the FCC filing lists both LTE bands and

	5G NR bands with aggregation capability, confirming that at least one cellular antenna in the device is tuned for concurrent operation across multiple bands.
Claim 4	Correspondence in Accused Instrumentalities
[4Pre] The wireless device of claim 1 further comprising	See claim 1 above.
[4A] one or more tuners associated with one or more transmitters, receivers or transceivers of said plurality of transmitters, receivers or transceivers; and	The Accused Instrumentalities include one or more tuners associated with one or more transmitters, receivers, or transceivers. For example, Galaxy S20 Ultra smartphones and Galaxy Tab S7+ 5G tablets include a Qualcomm Snapdragon X55 modem, which incorporates a QAT3555 adaptive antenna impedance tuner. The QAT3555 is electronically controlled to adjust antenna impedance for transmit and receive paths across multiple sub-6 GHz bands, such as n71 (600 MHz), n5 (850 MHz), n41 (2.5 GHz), and n78 (3.5 GHz), and thus operates in direct association with the device's transceiver chains. Likewise, Galaxy S21 and S22 Series smartphones and Galaxy Tab S8+ and S9+ tablets include Snapdragon X60 or X65 modems with adaptive impedance tuners configured to operate with transmitters and receivers on bands including n71, n41, n5, n2, n66, and n77, spanning frequencies from 600 MHz to 6 GHz. In addition, the A53 Operational Description for the Galaxy A53 5G identifies Qorvo RF modules (e.g., QM77098) that include “separate Mid and High Band PA paths, six LNA paths, distribution switches, filters, and antenna switches for multi-band coverage,” further confirming that tuners in Samsung devices are implemented in association with transmit and receive paths of the accused devices.
[4B] a controller for controlling tuning of the tuner for said at least one antenna to operate in said plurality of different bands.	The Accused Instrumentalities include a controller for controlling tuning of the tuner for the antenna(s) that operate a multiple bands. For example, the Snapdragon X55, X60 and X65 modem-RF systems integrate dynamic control logic that dynamically adjusts antenna tuning across multiple cellular bands. These modem-RF systems use the standardized MIPI RFFE control interface to drive antenna tuner ICs (such as the Qualcomm QAT3555), enabling adaptive impedance matching and efficient operation in both sub-6 GHz and mmWave frequency ranges. This constitutes a controller that controls the tuning of the tuner for the antenna. Likewise, Qorvo's integrated antenna tuning ICs are marketed as antenna control solutions that deliver impedance and aperture tuning across multiple antenna apertures and frequency bands. By design, these

	ICs implement electronic control logic to configure passive tuning elements (capacitor banks, switches, filters), thereby serving as controllers that control tuning of the tuner for the antenna. In addition, FCC filings for the Samsung Galaxy A53 5G describe Qorvo modules such as the QM77098, which are “programmable via MIPI RFFE.” This demonstrates that the tuner is controlled by an electronic controller over a standardized interface, further confirming the presence of a controller for controlling tuning of the tuner for the antenna across multiple bands.
Claim 6	Correspondence in Accused Instrumentalities
The wireless device of claim 1 wherein said antenna array is configured for use and implemented in a multiple input multiple output (MIMO) system.	The Accused Instrumentalities employ antenna arrays configured for use in multiple input multiple output (MIMO) systems. For example, the A53 Operational Description for the Samsung Galaxy A53 5G confirms that the device supports 4×4 MIMO on multiple LTE and NR frequency bands. 4×4 MIMO necessarily requires at least four separate antenna elements working together as an antenna array, with multiple transmit and receive chains driven by the Qorvo QM77098 and QM78078 front-end modules. The filing thus establishes that the A53 implements its antenna array in a MIMO configuration. Samsung’s own marketing and specifications likewise confirm MIMO implementation across its product families. For instance, the Galaxy S20 series spec sheet describes support for Enhanced 4×4 MIMO on LTE and 5G sub-6 GHz bands, which by definition requires multi-element antenna arrays operating in a MIMO system. See https://www.samsungmobilepress.com/media-assets/galaxy_s20?tab=specs. AT&T’s support page for the Galaxy S20 FE also lists “4×4 MIMO” under LTE and “5G Evolution,” corroborating that the accused devices implement multi-antenna arrays for MIMO. https://www.att.com/device-support/article-modal/wireless/KM1405218/Samsung/SamsungSMG781U. Regulatory filings further confirm that Samsung devices are evaluated as MIMO devices. For example, FCC records for Galaxy S9 (FCC ID: A3LSMG960U) explicitly designate the device as a “Multiple Input Multiple Output (MIMO) device,” confirming that its RF hardware employs antenna arrays in a MIMO configuration. See https://fccid.io/A3LSMG960U.
Claim 7	Correspondence in Accused Instrumentalities
The wireless device of claim 1 wherein said	The Accused Instrumentalities include beam-switchable antenna arrays. In particular, Samsung smartphones and tablets equipped with 5G mmWave capability implement phased-array antenna modules

antenna array is configured for use and implemented in a beam switchable array.	that provide electronically selectable beams. Beam-switchable arrays are required for mmWave operation because high path loss at these frequencies necessitates directional gain and electronically steerable beams that can be switched toward the serving base station. Samsung’s FCC filings confirm this design. For example, FCC test reports for Samsung mmWave devices (e.g., FCC ID A3LSMA536V, corresponding to the Galaxy A53 5G) identify beamforming operation and multiple beam states for NR FR2 bands (n257/n258/n260/n261). These disclosures demonstrate that the mmWave antenna modules are not fixed single-beam antennas, but rather beam-switchable phased arrays capable of selecting among multiple beams to maintain robust connectivity. Samsung’s own flagship Galaxy S-series (e.g., Galaxy S20+ 5G and later), Note-series, and Fold/Flip “UW” models are likewise equipped with Qualcomm QTM-series mmWave antenna modules (e.g., QTM052, QTM525). Qualcomm describes these modules as phased-antenna arrays that generate multiple discrete beams, which the device can dynamically select or switch among during operation. https://www.qualcomm.com/developer/blog/2019/11/5g-modems-rf-and-antennas-getting-mmwave-data-device; https://www.qualcomm.com/news/onq/2019/09/qualcomm-qtm527-5g-extended-range-mmwave-antenna-module-revolutionaizes-fixed. By incorporating such modules, the Accused Instrumentalities employ beam-switchable arrays for mmWave connectivity.
Claim 8	Correspondence in Accused Instrumentalities
[8Pre] A wireless device, comprising:	See element [1Pre] above.
[8A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or more antennas forming an antenna array; and	See element [1A] above.

[8B] at least one multiband transmitter, receiver or transceiver;	See element [1B] above.
[8C] a tuner associated with said at least one multiband transmitter, receiver, or transceiver; and	As described above for element [1D] and element 4[A], the Accused Instrumentalities include a tuner for actively tuning the antenna.
[8D] a controller for controlling tuning of the tuner to a plurality of different bands,	See element [4B] above.
[8E] wherein at least one antenna of said antennas antenna array is used by said at least one multiband transmitter, receiver or transceiver in a plurality of different bands,	See element [1C] above (establishing that at least one antenna is tunable and used across multiple LTE and 5G bands).
[8F] wherein said at least one antenna is one or more of a) an actively tuned antenna, and b) is tuned by one or more passive elements which are selected or	See element [1D] above.

interconnected using electronic control.	
Claim 9	Correspondence in Accused Instrumentalities
[9] The wireless device of claim 8 said at least one antenna is used for transmitting, receiving, or transmitting and receiving simultaneously in said plurality of different bands.	See claim [3] above.
Claim 12	Correspondence in Accused Instrumentalities
The wireless device of claim 8 wherein said antenna array is configured for use and implemented in a multiple input multiple output (MIMO) system.	See claim 6.
Claim 13	Correspondence in Accused Instrumentalities
The wireless device of claim 8 wherein said antenna array is configured for use and	See claim 7.

implemented in a beam switchable array.	
Claim 14	Correspondence in Accused Instrumentalities
[14Pre] A wireless device, comprising:	See element [1Pre] above.
[14A] at least one multiband antenna which includes one or more elements or sub-elements and which is configured to form an antenna array;	See elements [1A] and [1C] above.
[14B] at least one multiband transmitter, receiver or transceiver; and	See element [1B] above.
[14C] a tuner associated with said at least one multiband transmitter, receiver, or transceiver, said tuner matching said at least one multiband antenna to said at least one multiband transmitter, receiver or transceiver in a	See elements [1D] and [4A] above, and claim 3 above. The Accused Instrumentalities satisfy this limitation because they include tuners associated with multiband transmitters, receivers, or transceivers that match a multiband antenna to the transceiver across multiple frequency bands simultaneously. As Qorvo explains in its white paper, aperture tuning is used in 5G smartphones to allow one antenna to efficiently operate on multiple bands simultaneously by compensating for impedance mismatch across frequency ranges. See www.qorvo.com/design-hub/blog/4-things-to-know-about-antenna-tuning-in-4g-5g-smartphones CA combines two or more LTE carriers, often in different frequency bands, to deliver increased bandwidth and higher data rates. Due to the limited total number of antennas in handsets, this often means that a single antenna must communicate on two bands simultaneously. See also www.qorvo.com/resources/d/qorvo-antenna-tuning-essential-technology-5g-smartphones-white-

plurality of different bands simultaneously.	paper, which explains that to accommodate the multiple antennas needed for 5G, but in a small phone form factor, “[a]perture tuning compensates for this problem by allowing antennas to be tuned to operate efficiently on multiple bands ...” and that “[a]perture tuning also lets antennas communicate on multiple bands simultaneously to support” carrier aggregation. Accordingly, the Accused Instrumentalities include tuners — including aperture tuning circuits and front-end impedance matching components — that match multiband antennas to multiband transceivers across multiple frequency bands simultaneously. This is confirmed by Qualcomm’s Snapdragon modem-RF documentation, Qorvo’s antenna tuning disclosures, and FCC filings for the Galaxy A53 identifying specific Qorvo modules with multi-band tuning functionality. Snapdragon X55 Modem-RF System: World’s most advanced commercial 5G modem (www.qualcomm.com/content/dam/qcomm-martech/dm-assets/documents/x55_9_final.pdf) The A35 Operational Description for the Galaxy A53 5G identifies Qorvo RF front-end modules (e.g., QM77098, QM78078) that incorporate antenna switches and tuning circuits for multi-band coverage. These modules necessarily provide impedance matching between the multiband antennas and transceivers to enable operation across LTE and 5G NR bands concurrently. A35 Operational Description at § 1.2, § 1.3. Accordingly, the Accused Instrumentalities include tuners that match multiband antennas to multiband transceivers across multiple frequency bands simultaneously, literally meeting the limitation.
Claim 15	Correspondence in Accused Instrumentalities
The mobile device of claim 14 wherein said at least one antenna is used for transmitting, receiving, or transmitting and receiving simultaneously in said plurality of different bands.	See claim 3 above.

Claim 17	Correspondence in Accused Instrumentalities
The wireless device of claim 14 wherein said antenna array is configured for use and implemented in a multiple input multiple output (MIMO) system.	See claim 6 above.
Claim 18	Correspondence in Accused Instrumentalities
The wireless device of claim 14 wherein said antenna array is configured for use and implemented in a beam switchable array.	See claim 7 above.
Claim 19	Correspondence in Accused Instrumentalities
[19Pre] A wireless portable device, comprising:	See element [1Pre] above. The Accused Instrumentalities are portable at least because they are handheld, wireless devices.
[19A] one or more antennas wherein at least one of said one or more antennas includes one or more elements or sub-elements, said one or	See elements [1A] and [1C] above.

more antennas forming an antenna array, said one or more antennas radiating or receiving electromagnetic energy at particular frequency bands, at least one of said one or more antennas radiating or receiving electromagnetic energy at a plurality of particular frequency bands;	
[19B] one or more components selected from the group consisting of receivers, transmitters and transceivers, said one or more components connected to said at least one of said one or more antennas, whereby	See element [1B] above.
[19C] at least one of said one or more components transmits or receives electromagnetic energy simultaneously	See elements [1D] and 4[A] above, and claim 3 above.

at two or more of said plurality of particular frequency bands, or two or more components transmit or receive electromagnetic energy simultaneously at two or more of said plurality of particular frequency bands.	
Claim 21	Correspondence in Accused Instrumentalities
The wireless portable device of claim 19 further comprising one or more tuners which match electromagnetic energy at a particular frequency band to only one of said one or more components.	See elements 4[A] and 4[B] above. The purpose of an antenna tuner in a radio frequency front end is to match the impedance of the transmitter, receiver, or transceiver to the antenna at a given operating frequency, thereby maximizing the transfer of electromagnetic energy. By dynamically adjusting antenna impedance across multiple bands, the tuner ensures efficient operation of the wireless device in both transmit and receive modes.
Claim 22	Correspondence in Accused Instrumentalities
The wireless portable device of claim 19 further comprising isolation means for isolating said one or more components from more than one	The Accused Instrumentalities satisfy this limitation because they include structural isolation means that isolate components from more than one particular frequency band of the plurality of frequency bands supported by the devices. The A53 Operational Description shows that the device supports multiple frequency bands, including LTE, NR sub-6 GHz, and FR2 mmWave bands (n261 at 28 GHz and n260/n262 at 39 GHz). To operate across this plurality of bands, the device incorporates isolation structures such as diplexers, band-pass filters, low-pass filters, and T/R switches that ensure components handling one band are isolated from signals in other

particular frequency band of said plurality of frequency bands.	bands. For example, the FCC report explains that the intermediate frequency (IF) signal from the phased array chip passes through a diplexer and a T/R switch before reaching the receiver chain, thereby separating signals for the intended frequency band and preventing leakage of other bands into that chain. See A53 Operational Description at §1.10.2. In addition, the RF front-end implements band-selective filtering, which further isolates components from out-of-band signals and ensures that only the correct frequency band is delivered to each module. These switches, filters (including LC trap circuits), and tuned amplifier circuits together constitute the claimed “isolation means,” isolating one or more components of the device from more than one particular frequency band of the plurality of supported bands.
Claim 23	Correspondence in Accused Instrumentalities
The wireless portable device of claim 19 wherein said antenna array is configured for use and implemented in a multiple input multiple output (MIMO) system.	See claim 6 above.
Claim 24	Correspondence in Accused Instrumentalities
The wireless portable device of claim 19 wherein said antenna array is configured for use and implemented in a beam switchable array.	See claim 7 above.