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UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

GENGHISCOMM HOLDINGS, LLC, Plaintiff, v. LG ELECTRONICS U.S.A., INC., LG ELECTRONICS MOBILECOMM U.S.A., INC., and LG ELECTRONICS MOBILE RESEARCH U.S.A., LLC, Defendants.	Case No. '23CV1363 BEN AHG COMPLAINT FOR PATENT INFRINGEMENT AND JURY TRIAL DEMANDED

This is an action for patent infringement arising under the patent laws of the United States, Title 35 of the United States Code, against Defendant LG Electronics U.S.A., Inc., LG Electronics Mobilecomm U.S.A., Inc., and LG Electronics Mobile Research U.S.A., LLC (collectively, "LG" or "Defendants") that relates to eight U.S. patents owned by GenghisComm: U.S. Patent Nos. 9,768,842 (the "'842 Patent"), 10,200,227 (the "'227 Patent"), 10,389,568 (the "'568 Patent"), 11,075,786 (the "'786 Patent"), 11,223,508 (the "'508 Patent"), 11,252,005 (the "'005 Patent"), 11,381,285 (the "'285 Patent"), and 11,424,792 (the "'792 Patent") (collectively, the "Patents-in-Suit").

THE PARTIES

1. Plaintiff GenghisComm Holdings, LLC ("GenghisComm") is a Colorado limited liability company with an address at 942 Broadway Street, Suite 314c, Boulder, CO 80302.

2. Steve Shattil, Director of GenghisComm, is the named inventor on the patents and holds advanced degrees in physics and electrical engineering. He invented technologies which are essential parts of cellular and wireless standards.

3. Defendant LG Electronics U.S.A., Inc. is a corporation duly organized and existing under the laws of Delaware, with a place of business at 1000 Sylvan Avenue, Englewood Cliffs, New Jersey 07632. LG Electronics U.S.A., Inc. can be served with process through its registered agent, Corporation Service Company (d/b/a CSC-Lawyers Incorporating Service), 2710 Gateway Oaks Drive, Suite 150N, Sacramento, CA 95833.

4. Defendant LG Electronics MobileComm U.S.A., Inc. is a corporation duly organized and existing under the laws of California, with a place of business at 10101 Old Grove Road, San Diego, California 92131. LG Electronics MobileComm U.S.A., Inc. can be served with process through its registered agent, Corporation Service Company (d/b/a CSC-Lawyers Incorporating Service), 2710 Gateway Oaks Drive, Suite 150N, Sacramento, CA 95833.

5. Defendant LG Electronics Mobile Research U.S.A., LLC is a company duly organized and existing under the laws of California, with a place of business at 10225 Willow Creek Road, San Diego, California, 92131. LG Electronics Mobile Research U.S.A., LLC can be served with process through its registered agent, Corporation Service Company (d/b/a CSC-Lawyers Incorporating Service), 2710 Gateway Oaks Drive, Suite 150N, Sacramento, CA 95833.

6. LG makes, uses, imports, sells and offers for sale wireless mobile devices including smartphones and tablets), devices for providing cellular connectivity to vehicles, and related applications and services.

JURISDICTION AND VENUE

7. This Complaint states causes of action for patent infringement arising under the patent laws of the United States, 35 U.S.C. § 1 *et seq.,* and, more particularly 35 U.S.C. § 271.

8. This Court has subject matter jurisdiction of this action under 28 U.S.C. §§ 1331 and 1338(a) in which the district courts have original and exclusive jurisdiction of any civil action for patent infringement.

9. Each LG Defendant is subject to this Court's general personal jurisdiction pursuant to due process and/or California Long Arm Statute, Cal. Code Civ. Proc. § 410.10, due at least to its substantial business conducted in this District, including: (i) having solicited business in the State of California, transacted business within the State of California and attempted to derive financial benefit from residents of the State of California in this District, including benefits directly related to the instant patent infringement causes of action set forth herein; (ii) having placed its products and services into the stream of commerce throughout the United States and having been actively engaged in transacting business in California and in this District, and (iii) having committed the complained of tortious acts in California and in this District.

10. LG, directly and/or through subsidiaries and agents (including distributors, retailers, and others), makes, imports, ships, distributes, offers for sale, sells, uses, and advertises (including offering products and services through its website, http://www.lg.com/us, as well as other retailers) its products and/or services in the United States, the State of California and the Southern District of California.

11. LG, directly and/or through its subsidiaries and agents (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 they will be purchased and used by consumers in the Southern District of California. These infringing products and/or services have been and continue to be purchased and used by consumers in the Southern District of California. LG has committed acts of patent infringement within the State of California and, more

particularly, within the Southern District of California. For example, LG Electronics MobileComm U.S.A., Inc. is a California corporation. LG Electronics Mobile Research U.S.A., LLC is organized under the laws of the State of California. Both have regular and established places of business in San Diego, California. LG Electronics U.S.A., Inc. is also registered with the California Secretary of State to conduct business in the State of California.

12. This Court's exercise of personal jurisdiction over LG is consistent with the California Long Arm Statute, Cal. Code Civ. Proc § 410.10, and traditional notions of fair play and substantial justice.

13. Venue is proper in this District under §1400 (b), which provides that "Any civil action for patent infringement may be brought in the judicial district where the defendant resides, or where the defendant has committed acts of infringement and has a regular and established place of business." Venue is proper as to Defendant LG Electronics MobileComm U.S.A., Inc., which resides in California, because it is incorporated in California and it also has a regular and established place of business in this District at 10101 Old Grove Rd., San Diego, California 92131. Venue is proper as to Defendant LG Electronics Mobile Research U.S.A., LLC because it is a company organized under the laws of the State of California and it also has a regular and established place of business in this District at 10225 Willow Creek Road, San Diego, California, 92131. Venue is proper as to Defendant LG Electronics U.S.A., Inc. which, upon information and belief, maintains a regular and established place of business in this District through its corporate relationship with LG Electronics MobileComm U.S.A., Inc. and/or Defendant LG Electronics Mobile Research U.S.A., LLC.

BACKGROUND FACTS REGARDING THE GENGHISCOMM PATENTS

14. GenghisComm is the owner of record and assignee of each of the Patents-in-Suit.

15. GenghisComm has the exclusive right to sue and the exclusive right to recover damages for infringement of the Patents-in-Suit during all relevant time periods.

16. On September 19, 2017, the '842 Patent entitled "Pre-coding in multi-user MIMO" was duly and legally issued by the USPTO. The '842 Patent (at 1:5-22) notes that:

> This application is a Continuation of U.S. patent application Ser. No. 14/967,633, filed Dec. 14, 2015, which is a Continuation-in-Part of U.S. patent application Ser. No. 14/168,466 filed Jan. 30, 2014, which is a Continuation-in-Part of U.S. patent application

> Ser. No. 11/187,107 filed Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to Provisional Appl. No. 60/598,187, filed Aug. 2, 2004, and which is a Continuation-in-Part of U.S. patent application Ser. No. 10/145,854, filed May 14, 2002. The patent applications, U.S. patent application Ser. No. 13/116,984, filed May 26, 2011, U.S. patent application Ser. No. 12/328,917, filed Dec. 5, 2008, now U.S. Pat. No. 7,965,761, U.S. patent application Ser. No. 11/621,014 filed Jan. 8, 2007, now U.S. Pat. No. 7,593,449, U.S. patent application Ser. No. 10/131,163 filed Apr. 24, 2002, now U.S. Pat. No. 7,430,257, and U.S. Provisional Application 60/286,850, filed Apr. 26, 2001 are expressly incorporated by reference in their entireties.

The '842 Patent, at 30:53-55, further notes that the 10/145,854 application is incorporated by reference as well.

17. On February 5, 2019, the '227 Patent entitled "Pre-coding in multi-user MIMO" was duly and legally issued by the USPTO. The '227 Patent (at 1:5-22) notes that:

> This application is a Continuation-in-Part of U.S. patent application Ser. No. 14/168,466 filed Jan. 30, 2014, which is a Continuation-in-Part of U.S. patent application Ser. No. 11/187,107 filed Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to Provisional Appl. No. 60/598,187, filed Aug. 2, 2004, and which is a Continuation-in-Part of U.S. patent application Ser. No. 10/145,854, filed May 14, 2002, each of which is expressly incorporated by reference in its entirety. The patent applications, U.S. patent application Ser. No. 15/149,382, filed May 9, 2016; U.S. patent application Ser. No. 13/116,984, filed May 26, 2011; U.S. patent application Ser. No. 12/328,917, filed Dec. 5, 2008, now U.S. Pat. No. 7,965,761; U.S. patent application Ser. No. 11/621,014, filed Jan. 8, 2007, now U.S. Pat. No. 7,593,449; U.S. patent application Ser. No. 10/131,163, filed Apr. 24, 2002, now U.S. Pat. No. 7,430,257; and U.S. Provisional Application 60/286,850, filed Apr. 26, 2001 are expressly incorporated by reference in their entireties.

18. On August 20, 2019, the '568 Patent entitled "Single carrier frequency division multiple access baseband signal generation" was duly and legally issued by the USPTO. The '568 Patent (at 1:5-23) notes that:

> This application is a continuation of U.S. patent application Ser. No. 15/489,664 filed on Apr. 17, 2017, which is a continuation of U.S. patent application Ser. No. 15/149,382, filed on May 9, 2016, now U.S. Pat. No. 9,628,231, which is a continuation in part of U.S. patent application Ser. No. 14/727,769 filed Jun. 1, 2015, which is a continuation of U.S. patent application Ser. No. 14/276,309 filed May 13, 2014, now U.S. Pat. No. 9,048,897, which is a continuation U.S. patent application Ser. No. 12/545,572, filed Aug. 21, 2009, now U.S. Pat. No. 9,042,333, which is a division of U.S. patent application Ser. No. 11/187,107 filed on Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to U.S. Provisional Patent Application No. 60/598,187 filed Aug. 2, 2004 and is a continuation in part of U.S. patent application Ser. No. 10/145,854 filed on May 14, 2002, all of which are hereby incorporated by reference in their entireties and all

> of which this application claims priority under at least 60 U.S.C. 120 and/or any other applicable provision in Title 60 of the United States Code.

19. On July 27, 2021, the '786 Patent entitled "Multicarrier sub-layer for direct sequence channel and multiple-access coding" was duly and legally issued by the USPTO. The '786 Patent (at 1:8-29) notes that:

> This application is a Continuation of U.S. patent application Ser. No. 16/199,221, filed Nov. 26, 2018, now U.S. Pat. No. 10,644,916, which is a Continuation of U.S. patent application Ser. No. 16/027,191, filed Jul. 3, 2018, now U.S. patent Ser. No. 10/574,497, which is a Continuation of U.S. patent application Ser. No. 15/489,664, filed Apr. 17, 2017, now U.S. Pat. No. 9,800,448, which is a Continuation of U.S. patent application Ser. No. 15/149,382, filed May 9, 2016, now U.S. Pat. No. 9,628,231, which is a Continuation-in-Part of U.S. patent application Ser. No. 14/727,769, filed Jun. 1, 2015, which is a Continuation of U.S. patent application Ser. No. 14/276,309, filed May 13, 2014, now U.S. Pat. No. 9,048,897, which is a Continuation of U.S. patent application Ser. No. 12/545,572, filed Aug. 21, 2009, now U.S. Pat. No. 9,042,333, which is a Divisional of U.S. patent application Ser. No. 11/187,107, filed on Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to Provisional Appl. No. 60/598,187, filed Aug. 2, 2004, all of which are hereby incorporated by reference in their entireties and all of which this application claims priority under at least 35 U.S.C. 120 and/or any other applicable provision in Title 35 of the United States Code.

20. On September 19, 2017, the '508 Patent entitled "Wireless communications using flexible channel bandwidth" was duly and legally issued by the USPTO. The '508 Patent (at 1:6-28) notes that:

> This application is a continuation of U.S. patent application Ser. No. 16/426,240, filed on May 30, 2019, which is a continuation of U.S. patent application Ser. No. 15/786,270, filed on Oct. 17, 2017, now U.S. Pat. No. 10,389,568, which is a continuation of U.S. patent application Ser. No. 15/489,664, filed on Apr. 17, 2017, now U.S. Pat. No. 9,800,448, which is a continuation of U.S. patent application Ser. No. 15/149,382, filed on May 9, 2016, now U.S. Pat. No. 9,628,231, which is a continuation-in-part of U.S. patent application Ser. No. 14/727,769, filed Jun. 1, 2015, which is a continuation of U.S. patent application Ser. No. 14/276,309, filed May 13, 2014, now U.S. Pat. No. 9,048,897, which is a continuation U.S. patent application Ser. No. 12/545,572, filed Aug. 21, 2009, now U.S. Pat. No. 8,670,390, which is a division of U.S. patent application Ser. No. 11/187,107, filed on Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to U.S. Provisional Patent Application No. 60/598,187, filed Aug. 2, 2004, all of which are hereby incorporated by reference in their entireties and all of which this application claims priority under at least 35 U.S.C. 120 and/or any other applicable provision in Title 35 of the United States Code.

21. On February 15, 2022, the '005 Patent entitled "Spreading and precoding in OFDM" was duly and legally issued by the USPTO. The '005 Patent (at 1:5-19) notes that:

> This application is a Continuation-in-Part of U.S. patent application Ser. No. 14/727,769, entitled "Cooperative Wireless Networks," filed Jun. 1, 2015, which is a Continuation of U.S. patent application Ser. No. 14/276,309, entitled "Cooperative Wireless Networks," filed May 13, 2014, now U.S. Pat. No. 9,048,897, which is a Continuation of U.S. patent application Ser. No. 12/545,572, entitled "Cooperative Wireless Networks," filed Aug. 21, 2009, now U.S. Pat. No. 8,750,264, which is a Divisional of U.S. patent application Ser. No. 11/187,107, entitled "Cooperative Beam-Forming in Wireless Networks," filed on Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to Provisional Appl. No. 60/598,187, filed Aug. 2, 2004, all of which are incorporated by reference in their entireties.

22. On July 5, 2022, the '285 Patent entitled "Transmit pre-coding" was duly and legally issued by the USPTO. The '285 Patent (at 1:5-15) notes that:

> This application is a Continuation of U.S. patent application Ser. No. 14/727,769, filed Jun. 1, 2015, which is a Continuation of U.S. patent application Ser. No. 14/276,309, filed May 13, 2014, now U.S. Pat. No. 9,048,897, which is a Continuation of U.S. patent application Ser. No. 12/545,572, filed Aug. 21, 2009, now U.S. Pat. No. 8,750,264, which is a Divisional of U.S. patent application Ser. No. 11/187,107, filed on Jul. 22, 2005, now U.S. Pat. No. 8,670,390, which claims priority to Provisional Appl. No. 60/598,187, filed Aug. 2, 2004, all of which are incorporated by reference in their entireties.

23. On August 23, 2022, the '792 Patent entitled "Coordinated multipoint systems" was duly and legally issued by the USPTO. The '792 Patent (at 1:5-16) notes that:

> This application is a Continuation of U.S. patent application Ser. No. 16/575,713, filed on Sep. 19, 2019, now U.S. Pat. No. 10,931,338, which is a Continuation of U.S. patent application Ser. No. 14/733,013, filed Jun. 8, 2015, now U.S. Pat. No. 10,425,135, which is a Continuation-in-Part of U.S. patent application Ser. No. 13/116,984, filed May 26, 2011, now U.S. Pat. No. 10,014,882, which is a Continuation-in-Part of U.S. patent application Ser. No. 12/328,917, filed Dec. 5, 2008, now U.S. Pat. No. 7,965,761, which is a Divisional of U.S. patent application Ser. No. 11/621,014 filed Jan. 8, 2007, now U.S. Pat. No. 7,593,449, all of which are expressly incorporated by reference in their entireties.

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DEFENDANTS' INFRINGING PRODUCTS

24. Defendants have been, and now is, directly infringing claims of the Patents-in-Suit under 35 U.S.C. § 271(a) by making, using, offering for sale, selling, and/or importing the below accused smartphones, tablets, and other mobile wireless devices in this District and elsewhere in the United States that include the apparatuses claimed in the Patents-in-Suit.

25. Defendants' infringing products include its mobile devices that have LTE network connectivity and that adhere to the LTE standards, including, but not limited to, its K22, K30, K31, K51, K8X, G8X ThinQ, Stylo 6, Xpression, Aristo 5, and Tribute Monarch smart phones. Defendants' infringing LTE products further include components (e.g., C-V2X transceiver module) used to provide cellular network connectivity to vehicles. Defendants' infringing LTE products are collectively referred to as the "Accused LG LTE Devices."

26. Defendants' infringing products further include its mobile devices that have 5G network connectivity and that adhere to the 5G wireless standards, including, but not limited to, its Wing, K92, Velvet, V50 ThinQ, and V60 ThinQ mobile phones. Defendants' infringing 5G products are collectively referred to as the "Accused LG 5G Devices."

DEFENDANTS' KNOWLEDGE OF THE PATENTS-IN-SUIT AND CONTINUED INFRINGEMENT DESPITE THAT KNOWLEDGE

27. On November 2, 2020, counsel for GenghisComm sent a letter to Mr. Jongho (Matthew) Soh, Manage of Patent Transactions for LG Electronics ("LGE"), and Mr. Chang Kim, General Counsel for LG Electronics, informing Defendant LG Electronics of GenghisComm's patents, and how Defendant LGE infringed GenghisComm's patents. UPS confirmed that the letters were delivered. Defendant LGE has been aware of at least the '842, '227 and '568 Patents since at least November 2, 2020. With the claim charts, the letter was 105 pages. LGE did not respond.

28. LGE did not enter into a license agreement with GenghisComm.

29. On December 21, 2022, counsel for GenghisComm sent another letter to LGE informing them of infringement of three additional GenghisComm patents: the '005 Patent, the '285 Patent, and the '792 Patent. LGE did not respond.

30. Defendants have not agreed to enter into a licensing agreement with GenghisComm.

31. This Complaint serves as additional notice to Defendants for each of the Patents-in-Suit and the manner in which the Patents-in-Suit are infringed.

32. Despite knowledge of the Patents-in-Suit and knowledge of the manner in which the Patents-in-Suit are infringed as demonstrated in the provided claim charts, Defendants have continued to infringe, and/or induce the infringement of, the Patents-in-Suit.

COUNT I: INFRINGEMENT OF U.S. PATENT '842 CLAIM 1

33. Genghiscomm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

34. Claim 1 of the '842 Patent provides:

Claim 1 Preamble	An OFDM transmitter, comprising:
Element A	an OFDM spreader configured to spread a plurality of data symbols with Fourier coefficients to generate a discrete Fourier Transform (DFT)-spread data signal;
Element B	a mapper configured to map the DFT-spread data signal to a plurality of OFDM subcarriers; and
Element C	an OFDM modulator configured to modulate the DFT-spread data signal onto the plurality of OFDM subcarriers to produce an OFDM transmission signal comprising a superposition of the OFDM subcarriers, wherein the OFDM spreader is configured to provide the superposition with a reduced peak-to-average power ratio.

35. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 4G LTE networks and that comply with the 4G LTE wireless standards (e.g., 3GPP TS 36.211 version 8.7.0 Release 8; the "LTE Specification") and its requirements for uplink physical channel communications. These communications are sent from Accused LG LTE Devices to eNodeB receivers located at cell sites.

36. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 1 of the '842 Patent.

37. The Accused LG LTE Devices include a transmitter used for LTE network connectivity and communications. For example, the LG Velvet uses the Qualcomm SM7250 Snapdragon 765G system-on-a-chip, with the chip including LTE connectivity using its transmitter.

38. LTE network uplink physical channel transmissions rely on single-carrier frequency-division multiple access (SC-FDMA), and downlink physical channel transmission rely on orthogonal frequency-division multiplexing (OFDM). An SC-FDMA signal is a modulated OFDM signal, and is derived from the OFDM signal sent to the Accused LG LTE Devices.

39. The transmitter in Accused LG LTE Devices includes an OFDM spreader that is used to spread data symbols onto subcarriers using the LTE Specification's Transform Precoding method according to the equation below:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$$

$$l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}}\cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\leq N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The LTE Transform Precoding method uses a discrete Fourier transform (highlighted in the above equation) to generate a spread data signal. The transform precoding step is a complex-matrix multiply that spreads each data symbol across multiple subcarriers. One feature resulting from transform precoding is that the superposition of subcarriers has a lower peak-to-average power ratio (PAPR) compared to downlink OFDM signals.

40. The transmitter in Accused LG LTE Devices includes a mapper that is used to map the spread data signals onto subcarriers consistent with the LTE Specification section 5.4.3 (Mapping to Physical Resources). The LTE specification requires a resource element mapper for mapping the spread data signals to physical resource elements (subcarriers).

41. The transmitter in Accused LG LTE Devices include an OFDM modulator that is used to modulate the mapped and spread data symbols onto the physical resource elements (subcarriers) consistent with the LTE Specification section 5.6 (SC-FDMA baseband signal generation):

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil -1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f (t - N_{CP,l} T_s)}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1} (N_{CP,l'} + N) T_s$ within the slot.

Table 5.6-1lists the values of $N_{CP,l}$ that shall be used. Note that different SC-FDMA symbols within a slot may have different cyclic prefix lengths.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

This process entails modulating the mapped and spread data signals onto OFDM subcarriers for each uplink slot to generate a time-domain OFDM signal. The process of SC-FDMA baseband signal generation results in a signal that consists of a superposition of subcarrier signals that mimic a single carrier signal.

42. LG directly infringes claim 1 of the ’842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

43. LG has had knowledge of the ’842 Patent since November 2, 2020.

44. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 1 of the ’842 Patent under 35 U.S.C. § 271(a) directly.

45. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT II: INFRINGEMENT OF U.S. PATENT '842 CLAIM 2

46. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

47. Claim 2 of the '842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, wherein the OFDM spreader comprises an N-point DFT and the OFDM modulator comprises an M-point inverse discrete Fourier Transform, wherein M>N.

48. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 2 of the '842 Patent.

49. The transmitter in Accused LG LTE Devices performs SC-FDMA baseband signal generation consistent with the LTE Specification sections 5.5.3 (transform precoding) and 5.6 (SC-FDMA signal generation).

50. The transform precoding step spreads data symbols to cause the superposition of modulated subcarriers to mimic a single carrier, while the signal generation step modulates the spread signals onto scheduled subcarrier signals for uplink transmission. There are fewer data symbols (N) than the total number of subcarriers in the uplink bandwidth (M) because the number of scheduled subcarriers is less than the total number of subcarriers in the uplink bandwidth.

51. The transform precoding step utilizes an N-point discrete Fourier transform (DFT), as shown in the highlighted portion of the equation below:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\mathrm{symb}}-1)$ is divided into $M_{\mathrm{symb}}/M_{\mathrm{sc}}^{\mathrm{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+k)=\frac{1}{\sqrt{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}\sum_{i=0}^{M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1} d(l \cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}$$

$$k=0,...,M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$$
$$l=0,...,M_{\mathrm{symb}}/M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\mathrm{symb}}-1)$. The variable $M_{\mathrm{sc}}^{\mathrm{PUSCH}}=M_{\mathrm{RB}}^{\mathrm{PUSCH}} \cdot N_{\mathrm{sc}}^{\mathrm{RB}}$, where $M_{\mathrm{RB}}^{\mathrm{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\mathrm{RB}}^{\mathrm{PUSCH}}=2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \le N_{\mathrm{RB}}^{\mathrm{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The N-point DFT transforms data symbols from the time domain into the frequency domain.

52. The SC-FDMA signal generation step utilizes an M-point inverse DFT, as shown in the highlighted portion of the equation below:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f (t - N_{CP,l} T_s)}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1} (N_{CP,l'} + N) T_s$ within the slot.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The M-point inverse DFT is used to generate time-domain symbols from the frequency-domain transform symbols generated during transform precoding.

53. LG directly infringes claim 2 of the '842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

54. LG has had knowledge of the '842 Patent since November 2, 2020.

55. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 2 of the '842 Patent under 35 U.S.C. § 271(a) directly.

56. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT III: INFRINGEMENT OF U.S. PATENT '842 CLAIM 3

57. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

58. Claim 3 of the '842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, wherein the OFDM modulator comprises an inverse fast Fourier transform.

59. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 3 of the '842 Patent.

60. The transmitter in Accused LG LTE Devices performs SC-FDMA baseband signal generation consistent with the LTE Specification section 5.6. LTE Specification section 5.6 utilizes an inverse fast Fourier transform to produce the time-continuous signal:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t)=\sum_{k=-\left\lfloor N_{RB}^{UL}N_{sc}^{RB}/2\right\rfloor}^{\left\lceil N_{RB}^{UL}N_{sc}^{RB}/2\right\rceil-1} a_{k^{(-)},l}\cdot e^{j2\pi(k+1/2)\Delta f\left(t-N_{CP,l}T_s\right)}$$

for $0\le t<\left(N_{CP,l}+N\right)\times T_s$ where $k^{(-)}=k+\left\lfloor N_{RB}^{UL}N_{sc}^{RB}/2\right\rfloor$, $N=2048$, $\Delta f=15\text{ kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

Source: 3GPP TS 36.211 version 8.7.0 Release 8

61. LG directly infringes claim 3 of the '842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

62. LG has had knowledge of the '842 Patent since November 2, 2020.

63. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 3 of the '842 Patent under 35 U.S.C. § 271(a) directly.

64. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT IV: INFRINGEMENT OF U.S. PATENT '842 CLAIM 4

65. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

66. Claim 4 of the '842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, wherein the data symbols comprise reference-signal symbols, which comprise at least one of known training symbols and synchronization symbols.

67. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 4 of the ’842 Patent.

68. A later release of the LTE Specification, release 15, introduced requirements (Section 5.5.2.1 and 5.5.3 in release 15) for reference signals used in the physical channel uplink. These reference signal requirements specify that at least one of the data symbols be a reference signal used for demodulation and synchronization. The Accused LG LTE Devices comply with this release 15 of the LTE Specification.

69. Demodulation reference signals are used for channel estimation, while synchronization reference signals are used for signal-quality estimation. Both channel estimation and signal-quality estimation are types of training symbols.

70. LG directly infringes claim 4 of the ’842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

71. LG has had knowledge of the ’842 Patent since November 2, 2020.

72. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 4 of the ’842 Patent under 35 U.S.C. § 271(a) directly.

73. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT V: INFRINGEMENT OF U.S. PATENT ’842 CLAIM 7

74. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

75. Claim 7 of the ’842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, further comprising a cyclic prefix appender configured to append at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal.

76. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 7 of the ’842 Patent.

77. During SC-FDMA baseband signal generation, the inverse DFT used to modulate data symbols onto subcarriers also appends the cyclic prefix, as shown in the highlighted portion of the equation below:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f \underline{(t - N_{CP,l} T_s)}}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1} (N_{CP,l'} + N) T_s$ within the slot.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

78. LG directly infringes claim 7 of the '842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

79. LG has had knowledge of the '842 Patent since November 2, 2020.

80. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 7 of the '842 Patent under 35 U.S.C. § 271(a) directly.

81. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT VI: INFRINGEMENT OF U.S. PATENT '842 CLAIM 8

82. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

83. Claim 8 of the '842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, wherein the OFDM spreader is configured to provide channel precoding.

84. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 8 of the ’842 Patent.

85. During uplink processing, Accused LG LTE Devices employ transform precoding in accordance with the LTE Specification:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The highlighted portion of the above equation corresponds to a DFT used to spread data symbols using spreading codes. The transform precoding DFT precodes data symbols to be used in transmission.

86. LG directly infringes claim 8 of the ’842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

87. LG has had knowledge of the ’842 Patent since November 2, 2020.

88. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 8 of the ’842 Patent under 35 U.S.C. § 271(a) directly.

89. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT VII: INFRINGEMENT OF U.S. PATENT ’842 CLAIM 9

90. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

91. Claim 9 of the ’842 Patent provides:

Element A	The OFDM transmitter recited in claim 1, wherein the plurality of data symbols are at least one of time-multiplexed with reference-signal symbols, frequency-multiplexed with reference-signal symbols, and code-multiplexed with reference-signal symbols.

92. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 9 of the ’842 Patent.

93. A later release of the LTE Specification, release 15, introduced requirements (Section 5.5.2.1 and 5.5.3 in release 15) for reference signals used in the physical channel uplink. These reference signal requirements specify that at least one of the data symbols be a reference signal used for demodulation and synchronization. The Accused LG LTE Devices comply with this release 15 of the LTE Specification.

94. The reference signals are time multiplexed with other uplink transmissions from the same device, and frequency multiplexed with uplink transmissions from multiple devices.

95. LG directly infringes claim 9 of the ’842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

96. LG has had knowledge of the ’842 Patent since November 2, 2020.

97. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 9 of the ’842 Patent under 35 U.S.C. § 271(a) directly.

98. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT VIII: INFRINGEMENT OF U.S. PATENT ’227 CLAIM 22

99. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

100. Claim 22 of the ’227 Patent provides:

Claim 22 Preamble	An apparatus comprising:
Element A	a processor; and

Element B	a non-transitory memory coupled to the processor, the non-transitory memory including a set of instructions stored therein and executable by the processor to:
Element C	perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols, the invertible transform comprising complex-valued spreading codes;
Element D	map the N spread data symbols to at least N subcarriers of a plurality M of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers to generate a set of complex subcarrier amplitudes; and
Element E	perform an M-point inverse discrete Fourier transform (IDFT) on the set of complex subcarrier amplitudes to generate a time-domain sequence to be transmitted into a wireless channel, the time-domain sequence comprising a superposition of the OFDM subcarriers, wherein the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.

101. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 4G LTE networks and that comply with the 4G LTE wireless standards (e.g., 3GPP TS 36.211 version 8.7.0 Release 8; the "LTE Specification") and its requirements for uplink physical channel communications. These communications are sent from Accused LG LTE Devices to eNodeB receivers located at cell sites.

102. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 22 of the '227 Patent.

103. The Accused LG LTE Devices have processors and non-transitory memory coupled to the processor. The memory includes instructions for applying LTE physical channel processing consistent with the LTE Specification. For example, the LG Velvet uses the Qualcomm SM7250 Snapdragon 765G system-on-a-chip (including up to 12 GB LPDDR) and includes up to 8 GB of RAM.

104. The memory of Accused LG LTE Devices includes instructions for performing transform precoding on data symbols according to the LTE Specification. The transform precoding process utilizes a discrete Fourier transform (DFT) to transform OFDM data symbols (N) into spread OFDM complex-valued data symbols used during physical channel uplink communications, as shown in the highlighted portion below (Section 5.3.3 of the LTE Specification):

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \le N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The DFT is invertible.

105. One feature resulting from transform precoding using the invertible DFT of Section 5.3.3 of the LTE Specification is that it generates complex-valued data symbols that, when mapped and modulated onto physical resource subcarriers, results in a superposition of subcarriers having a lower peak-to-average power ratio (PAPR) compared to downlink OFDM signals.

106. The memory of Accused LG LTE Devices includes instructions for mapping the N spread data signals onto N subcarriers consistent with the LTE Specification section 5.4.3 (Mapping to Physical Resources):

5.3.4 Mapping to physical resources

The block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$ shall be multiplied with the amplitude scaling factor β_{PUSCH} in order to conform to the transmit power P_{PUSCH} specified in Section 5.1.1.1 in [4], and mapped in sequence starting with $z(0)$ to physical resource blocks assigned for transmission of PUSCH. The mapping to resource elements (k,l) corresponding to the physical resource blocks assigned for transmission and not used for transmission of reference signals and not reserved for possible SRS transmission shall be in increasing order of first the index k, then the index l, starting with the first slot in the subframe.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

The N spread data symbols correspond to the "*z*(0)…" complex-valued symbols described in Section 5.3.4 of the LTE Specification, and are mapped onto the same number (N) of subcarriers assigned to the UE out of the total number of subcarriers in the uplink bandwidth (M).

107. The complex valued data symbols (N spread data symbols) are multiplied by an amplitude scaling factor, and then mapped to M physical resource blocks (OFDM subcarriers) to generate complex subcarrier amplitudes used during the SC-FDMA baseband signal generation step.

108. The memory of Accused LG LTE Devices includes instructions for modulating the mapped and spread data symbols onto N physical resource elements (subcarriers) consistent with the LTE Specification section 5.6 (SC-FDMA baseband signal generation). This process entails modulating the mapped and spread data signals onto OFDM subcarriers for each uplink slot to generate a time-domain OFDM signal. The process of SC-FDMA baseband signal generation results in a signal that consists of a superposition of subcarrier signals that mimic a single carrier signal.

109. The SC-FDMA baseband signal generation step uses an M-point inverse DFT:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t)=\sum_{k=-\lfloor N_{RB}^{UL}N_{sc}^{RB}/2\rfloor}^{\lceil N_{RB}^{UL}N_{sc}^{RB}/2\rceil-1} a_{k^{(-)},l}\cdot e^{j2\pi(k+1/2)\Delta f(t-N_{CP,l}T_s)}$$

for $0\le t<(N_{CP,l}+N)\times T_s$ where $k^{(-)}=k+\lfloor N_{RB}^{UL}N_{sc}^{RB}/2\rfloor$, $N=2048$, $\Delta f=15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l=0$, where SC-FDMA symbol $l>0$ starts at time $\sum_{l'=0}^{l-1}(N_{CP,l'}+N)T_s$ within the slot.

Table 5.6-1lists the values of $N_{CP,l}$ that shall be used. Note that different SC-FDMA symbols within a slot may have different cyclic prefix lengths.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

110. N (number of subcarriers) < M (total number of subcarriers) allows for the pulse-shaping seen in SC-FDMA. That is, the subcarriers in the SC-FDMA signal combine in phase at uniformly spaced intervals in each SC-FDMA symbol duration to produce a pulse waveform in each interval,

which allows multiple subcarriers to mimic a single carrier signal. OFDM baseband signal generation typically upsamples the data being transmitted, which means that the size of the inverse DFT is larger than the number of assigned subcarriers onto which the data is modulated. This is also the case for SC-FDMA baseband signal generation (Section 5.6). DFT spreading (i.e., transform precoding, Section 5.3.3) is applied to the data before mapping to the inverse DFT, so the DFT size is smaller than the inverse DFT size. This causes the DFT to shape the output of the inverse DFT into uniformly spaced pulses in each SC-FDMA symbol duration, which causes the SC-FDMA signal to resemble a single-carrier signal.

111. LG directly infringes claim 22 of the ’227 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

112. LG has had knowledge of the ’227 Patent since November 2, 2020.

113. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 22 of the ’227 Patent under 35 U.S.C. § 271(a) directly.

114. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT IX: INFRINGEMENT OF U.S. PATENT ’227 CLAIM 24

115. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

116. Claim 24 of the ’227 Patent provides:

Element A	The apparatus recited in claim 22, configured to reside on a User Equipment.

117. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 24 of the ’227 Patent.

118. Accused LG LTE Devices are User Equipment that include the processor and memory described in paragraph 99 above.

119. LG directly infringes claim 24 of the ’842 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

120. LG has had knowledge of the ’842 Patent since November 2, 2020.

121. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 24 of the ’227 Patent under 35 U.S.C. § 271(a) directly.

122. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT X: INFRINGEMENT OF U.S. PATENT ’227 CLAIM 25

123. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

124. Claim 25 of the ’227 Patent provides:

Element A	The apparatus recited in claim 22, wherein M>N.

125. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 25 of the ’227 Patent.

126. During processing for the physical channel uplink, the number of subcarriers available for use, M, exceeds the number of data symbols and subcarriers, N, that are ultimately modulated onto those subcarriers. The number of subcarriers and data symbols actually used (N) by user equipment in the uplink is less than the overall number of subcarriers in the uplink bandwidth (M) to allow for the pulse-shaping seen in SC-FDMA.

127. N (number of subcarriers) < M (total number of subcarriers) allows for the pulse-shaping seen in SC-FDMA. That is, the subcarriers in the SC-FDMA signal combine in phase at uniformly spaced intervals in each SC-FDMA symbol duration to produce a pulse waveform in each interval, which allows multiple subcarriers to mimic a single carrier signal. OFDM baseband signal generation typically upsamples the data being transmitted, which means that the size of the inverse DFT is larger than the number of assigned subcarriers onto which the data is modulated. This is also the case for SC-FDMA baseband signal generation (Section 5.6). DFT spreading (i.e., transform precoding, Section 5.3.3) is applied to the data before mapping to the inverse DFT, so the DFT size is smaller than the inverse DFT size. This causes the DFT to shape the output of the inverse DFT into uniformly spaced

pulses in each SC-FDMA symbol duration, which causes the SC-FDMA signal to resemble a single-carrier signal.

128. LG directly infringes claim 25 of the ’227 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

129. LG has had knowledge of the ’227 Patent since November 2, 2020.

130. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 25 of the ’227 Patent under 35 U.S.C. § 271(a) directly.

131. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XI: INFRINGEMENT OF U.S. PATENT ’227 CLAIM 26

132. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

133. Claim 26 of the ’227 Patent provides:

Element A	The apparatus recited in claim 22, wherein the IDFT comprises an inverse fast Fourier transform.

134. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 26 of the ’227 Patent.

135. Accused LG LTE Devices perform SC-FDMA baseband signal generation consistent with the LTE Specification section 5.6. LTE Specification section 5.6 utilizes an inverse fast Fourier transform to produce the SC-FDMA time-continuous signal.

136. LG directly infringes claim 26 of the ’227 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

137. LG has had knowledge of the ’227 Patent since November 2, 2020.

138. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 26 of the ’227 Patent under 35 U.S.C. § 271(a) directly.

139. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XII: INFRINGEMENT OF U.S. PATENT ’227 CLAIM 28

140. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

141. Claim 28 of the ’227 Patent provides:

Element A	The apparatus recited in claim 22, wherein the non-transitory memory further comprises instructions to append at least one of a cyclic prefix, a postfix, and a guard interval to the time-domain sequence.

142. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 28 of the ’227 Patent.

143. During SC-FDMA baseband signal generation, the inverse DFT used to modulate data symbols onto subcarriers also appends the cyclic prefix, as shown in the highlighted portion of the equation below:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f \left(t - N_{CP,l} T_s\right)}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ kHz and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1} (N_{CP,l'} + N) T_s$ within the slot.

Table 5.6-1lists the values of $N_{CP,l}$ that shall be used. Note that different SC-FDMA symbols within a slot may have different cyclic prefix lengths.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

144. LG directly infringes claim 28 of the ’227 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

145. LG has had knowledge of the ’227 Patent since November 2, 2020.

146. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 28 of the ’227 Patent under 35 U.S.C. § 271(a) directly.

147. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XIII: INFRINGEMENT OF U.S. PATENT ’568 CLAIM 24

148. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

149. Claim 24 of the ’568 Patent provides:

Claim 24 Preamble	An apparatus comprising:
Element A	a processor; and
Element B	a non-transitory computer-readable memory communicatively coupled to the processor, the memory including a set of instructions stored thereon and executable by the processor for:
Element C	dividing a block of complex-valued symbols into a plurality of sets of complex-valued symbols;
Element D	transform precoding each of the plurality of sets of complex-valued symbols into a block of transform-precoded complex-valued symbols; and
Element E	generating an Orthogonal Frequency Division Multiplex (OFDM) signal comprising a plurality of OFDM subcarriers modulated by the transform-precoded complex-valued symbols, wherein the transform precoding generates a plurality of orthogonal spreading codes to provide a superposition of the plurality of OFDM subcarriers with a reduced peak-to-average-power ratio.

150. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 4G LTE networks and that comply with the 4G LTE wireless standards (e.g., 3GPP TS 36.211 version 8.7.0 Release 8; the “LTE Specification”) and its requirements for uplink physical channel communications. These communications are sent from Accused LG LTE Devices to eNodeB receivers located at cell sites.

151. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 24 of the ’568 Patent.

152. The Accused LG LTE Devices have processors and non-transitory memory coupled to the processor. The memory includes instructions for applying LTE physical channel processing consistent with the LTE Specification. For example, the LG Velvet uses the Qualcomm SM7250 Snapdragon 765G system-on-a-chip (including up to 12 GB LPDDR) and includes up to 8 GB of RAM.

153. The memory in Accused LG LTE Devices stores instructions for processing physical channel uplink (from user equipment to eNode B) and downlink (from eNode B to user equipment) consistent with the LTE Specification.

154. For the uplink, the LTE Specification employs a Transform Precoding step (section 5.3.3):

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$
$$k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$$
$$l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}}\cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\leq N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

where OFDM data symbols are divided into M_{symb}/M_{sc}^{PUSCH} sets, with each set corresponding to one SC-FDMA symbol. The division process results in multiple sets of complex-valued symbols. These complex-valued symbols are transform precoded using a discrete Fourier transform to generate blocks of transform precoded complex-valued symbols. The transform precoding step is a complex-matrix multiply that spreads the complex-valued symbols across multiple subcarriers. One feature resulting from transform precoding is that the superposition of subcarriers has a lower peak-to-average power ratio (PAPR) compared to downlink OFDM signals.

155. The block of transform precoded complex-valued symbols are then mapped to physical resources (subcarriers) consistent with LTE Specification section 5.4.3 (Mapping to Physical Resources):

5.3.4 Mapping to physical resources

The block of complex-valued symbols $z(0),...,z(M_{symb}-1)$ shall be multiplied with the amplitude scaling factor β_{PUSCH} in order to conform to the transmit power P_{PUSCH} specified in Section 5.1.1.1 in [4], and mapped in sequence starting with $z(0)$ to physical resource blocks assigned for transmission of PUSCH. The mapping to resource elements (k,l) corresponding to the physical resource blocks assigned for transmission and not used for transmission of reference signals and not reserved for possible SRS transmission shall be in increasing order of first the index k, then the index l, starting with the first slot in the subframe.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

156. Once mapped, the pre-coded complex-valued symbols are then modulated on physical resources (subcarriers) in accordance with LTE Specification 5.6 (SC-FDMA Baseband Signal Generation). The SC-FDMA Baseband Signal Generation step utilizes an inverse DFT to generate a time-domain signal, as shown in the highlighted portion below

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f(t-N_{CP,l}T_s)}$$

for $0 \leq t < (N_{CP,l}+N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l=0$, where SC-FDMA symbol $l>0$ starts at time $\sum_{l'=0}^{l-1}(N_{CP,l'}+N)T_s$ within the slot.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

157. SC-FDMA itself stands for single-carrier frequency division multiple division access, and is a modulated version of an OFDM signal that uses the same subcarriers as regular OFDM. The process of transform precoding and SC-FDMA baseband signal generation results in a transmitted signal that consists of a superposition of OFDM subcarrier signals that mimic a single carrier signal.

158. LG directly infringes claim 24 of the ’568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

159. LG has had knowledge of the ’568 Patent since November 2, 2020.

160. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 24 of the ’568 Patent under 35 U.S.C. § 271(a) directly.

161. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XIV: INFRINGEMENT OF U.S. PATENT ’568 CLAIM 25

162. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

163. Claim 25 of the ’568 Patent provides:

Element A	The apparatus of claim 24, wherein the transform precoding spreads the block of complex-valued symbols with a plurality of orthogonal spreading codes comprising complex-valued coefficients of a discrete Fourier transform (DFT) to produce the block of transform-precoded complex-valued symbols.

164. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 25 of the ’568 Patent.

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165. During transform precoding in accordance with the LTE Specification, complex-valued symbols are spread onto orthogonal spreading codes consistent with the below equation that employs a discrete Fourier transform:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$$

$$l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

In the above equation, the complex-valued coefficients correspond to the variable $e^{-j\frac{2\pi ik}{M_{SC}^{PUSCH}}}$.

166. One property of the DFT used in transform precoding is that it is an orthogonal matrix, such that symbols will be spread orthogonally.

167. The transform precoding step generates a block of transform precoded complex-valued symbols, $z(0),\ldots z(M_{\text{symb}}\text{-}1)$.

168. LG directly infringes claim 25 of the ’568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

169. LG has had knowledge of the ’568 Patent since November 2, 2020.

170. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 25 of the ’568 Patent under 35 U.S.C. § 271(a) directly.

171. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XV: INFRINGEMENT OF U.S. PATENT '568 CLAIM 26

172. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

173. Claim 26 of the '568 Patent provides:

Element A	The apparatus of claim 25, wherein the DFT is a fast Fourier transform (FFT).

174. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim26 of the '568 Patent.

175. Transform precoding in accordance with the LTE Specification employs a DFT which is a fast Fourier transform, as shown in the equation below:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\mathrm{symb}}-1)$ is divided into $M_{\mathrm{symb}}/M_{\mathrm{sc}}^{\mathrm{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l\cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+k)=\frac{1}{\sqrt{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}\sum_{i=0}^{M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1} d(l\cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}$$

$$k=0,...,M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$$

$$l=0,...,M_{\mathrm{symb}}/M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\mathrm{symb}}-1)$. The variable $M_{\mathrm{sc}}^{\mathrm{PUSCH}}=M_{\mathrm{RB}}^{\mathrm{PUSCH}}\cdot N_{\mathrm{sc}}^{\mathrm{RB}}$, where $M_{\mathrm{RB}}^{\mathrm{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\mathrm{RB}}^{\mathrm{PUSCH}}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\le N_{\mathrm{RB}}^{\mathrm{UL}}$$

where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

176. LG directly infringes claim 26 of the '568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

177. LG has had knowledge of the '568 Patent since November 2, 2020.

178. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 26 of the '568 Patent under 35 U.S.C. § 271(a) directly.

179. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XVI: INFRINGEMENT OF U.S. PATENT '568 CLAIM 29

180. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

181. Claim 29 of the '568 Patent provides:

Element A	The apparatus of claim 24, comprising instructions for: mapping the block of transform-precoded complex-valued symbols to physical resource blocks assigned for transmission of a physical uplink shared channel.

182. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 29 of the '568 Patent.

183. During signal processing for the physical channel uplink, transform-precoded complex-valued symbols $z(0),\ldots z(M_{\text{symb}}\text{-}1)$ are mapped onto physical resource blocks in accordance with section 5.3.4 of the LTE Specification:

5.3.4 Mapping to physical resources

The block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$ shall be multiplied with the amplitude scaling factor β_{PUSCH} in order to conform to the transmit power P_{PUSCH} specified in Section 5.1.1.1 in [4], and mapped in sequence starting with $z(0)$ to physical resource blocks assigned for transmission of PUSCH. The mapping to resource elements (k,l) corresponding to the physical resource blocks assigned for transmission and not used for transmission of reference signals and not reserved for possible SRS transmission shall be in increasing order of first the index k, then the index l, starting with the first slot in the subframe.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

184. The physical resource blocks are assigned to user equipment for the purpose of physical channel uplink transmissions.

185. LG directly infringes claim 29 of the '568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

186. LG has had knowledge of the '568 Patent since November 2, 2020.

187. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 29 of the ’568 Patent under 35 U.S.C. § 271(a) directly.

188. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XVII: INFRINGEMENT OF U.S. PATENT ’568 CLAIM 32

189. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

190. Claim 32 of the ’568 Patent provides:

Element A	The apparatus of claim 29, wherein the mapping is configured to select the plurality of OFDM subcarriers according to at least one of a frequency division multiple access scheme, a time division multiple access scheme, a space division multiple access scheme, a code division multiple access scheme, and a frequency-hoping scheme.

191. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 32 of the ’568 Patent.

192. During signal processing for the physical channel uplink, transform-precoded complex-valued symbols $z(0),\ldots z(M_{\text{symb}}\text{-}1)$ are mapped onto physical resource blocks in accordance with section 5.3.4 of the LTE Specification.

5.3.4 Mapping to physical resources

The block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$ shall be multiplied with the amplitude scaling factor β_{PUSCH} in order to conform to the transmit power P_{PUSCH} specified in Section 5.1.1.1 in [4], and mapped in sequence starting with $z(0)$ to physical resource blocks assigned for transmission of PUSCH. The mapping to resource elements (k,l) corresponding to the physical resource blocks assigned for transmission and not used for transmission of reference signals and not reserved for possible SRS transmission shall be in increasing order of first the index k, then the index l, starting with the first slot in the subframe.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

This mapping process further entails selecting from physical resource elements within the physical resource blocks.

193. The physical resource elements within a block correspond to OFDM subcarriers.

194. Once mapped, the complex-valued symbols are modulated onto the physical resources (OFDM subcarriers) during SC-FDMA baseband signal generation, in accordance with Section 5.6 of the LTE Specification.

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f(t - N_{CP,l} T_s)}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1}(N_{CP,l'} + N)T_s$ within the slot.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

SC-FDMA stands for single carrier frequency division multiple access. The subcarriers are selected and mapped according to at least a frequency division multiple access scheme.

195. LG directly infringes claim 32 of the ’568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

196. LG has had knowledge of the ’568 Patent since November 2, 2020.

197. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 32 of the ’568 Patent under 35 U.S.C. § 271(a) directly.

198. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XVIII: INFRINGEMENT OF U.S. PATENT ’568 CLAIM 33

199. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

200. Claim 33 of the ’568 Patent provides:

Element A	The apparatus of claim 24, comprising instructions for: scrambling a block of bits of one subframe of a physical uplink shared channel resulting in a block of scrambled bits; and

Element B	modulating the block of scrambled bits resulting in the block of complex-valued symbols.

201. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 33 of the '568 Patent.

202. During physical channel uplink signal processing, a block of bits on the physical uplink shared channel are scrambled using a scrambling sequence to generate a block of scrambled bits in accordance with Section 5.3.1 of the LTE Specification:

5.3.1 Scrambling

The block of bits $b(0),...,b(M_{\text{bit}}-1)$, where M_{bit} is the number of bits transmitted on the physical uplink shared channel in one subframe, shall be scrambled with a UE-specific scrambling sequence prior to modulation, resulting in a block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ according to the following pseudo code

Source: 3GPP TS 36.211 version 8.7.0 Release 8

203. After scrambling, the block of scrambled bits are modulated to generate a block of complex-valued symbols in accordance with Section 5.3.2 of the LTE Specification:

5.3.2 Modulation

The block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

204. LG directly infringes claim 33 of the '568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

205. LG has had knowledge of the '568 Patent since November 2, 2020.

206. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 33 of the '568 Patent under 35 U.S.C. § 271(a) directly.

207. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

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COUNT XIX: INFRINGEMENT OF U.S. PATENT '568 CLAIM 34

208. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

209. Claim 34 of the '568 Patent provides:

Element A	The apparatus of claim 33, wherein the scrambling is configured to scramble the block of bits into a block of scrambled bits with at least one pseudo-noise code.

210. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 34 of the '568 Patent.

211. The LTE Specification section 5.3.1 requires that the scrambling of the block of bits use pseudo noise code:

5.3.1 Scrambling

The block of bits $b(0),...,b(M_{\text{bit}}-1)$, where M_{bit} is the number of bits transmitted on the physical uplink shared channel in one subframe, shall be scrambled with a UE-specific scrambling sequence prior to modulation, resulting in a block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{\text{bit}}-1)$ according to the following pseudo code

Source: 3GPP TS 36.211 version 8.7.0 Release 8

212. LG directly infringes claim 34 of the '568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

213. LG has had knowledge of the '568 Patent since November 2, 2020.

214. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 34 of the '568 Patent under 35 U.S.C. § 271(a) directly.

215. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XX: INFRINGEMENT OF U.S. PATENT '568 CLAIM 44

216. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

217. Claim 44 of the ’568 Patent provides:

Element A	The method of claim 24, wherein each of the plurality of sets of complex-valued symbols is a single carrier frequency division multiple access (SC-FDMA) symbol.

218. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 44 of the ’568 Patent.

219. The LTE Specification section 5.6 (SC-FDMA baseband signal generation) defines how to generate SC-FDMA symbols of a time-continuous signal.

220. LG directly infringes claim 44 of the ’568 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

221. LG has had knowledge of the ’568 Patent since November 2, 2020.

222. LG makes, uses, and/or imports the Accused LG LTE Devices knowing that LG infringed and continues to infringe at least claim 44 of the ’568 Patent under 35 U.S.C. § 271(a) directly.

223. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

<u>COUNT XXI: INFRINGEMENT OF U.S. PATENT ’786 CLAIM 10</u>

224. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

225. Claim 10 of the ’786 Patent provides:

Claim 10 Preamble	An apparatus for communication in a wireless communication network that employs a first set of complex-valued codes to encode data symbols to be transmitted, and employs a second set of complex-valued codes to recover transmitted data symbols from a received signal, the apparatus comprising:
Element A	at least one processor; and
Element B	a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:

Element C	selecting a plurality of subcarriers to be transmitted;
Element D	encoding the data symbols with the first set of complex-valued codes to produce encoded data symbols;
Element E	applying the encoded data symbols to the plurality of subcarriers to produce a spread-Orthogonal Frequency Division Multiplexing (OFDM) signal; and
Element F	wherein the first set of complex-valued codes are complex conjugates of the second set of complex-valued codes.

226. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 4G LTE networks and that comply with the 4G LTE wireless standards (e.g., 3GPP TS 36.211 version 8.7.0 Release 8; the “LTE Specification”) and its requirements for uplink physical channel communications. These communications are sent from Accused LG LTE Devices to eNodeB receivers located at cell sites.

227. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 10 of the ’786 Patent.

228. The Accused LG LTE Devices are devices that are used in LTE wireless communication networks. The LTE radio network uses both physical channel uplink communications from the device to eNode B, and physical channel downlink communications from the eNode B to the device. The uplink relies on a single-carrier frequency division multiple access (SC-FDMA) scheme, which entails the use of transform precoding data using complex-valued codes to encode data symbols to be sent from the device. The eNode B receives the SC-FDMA signals from the device, and decodes the signals using a second set of complex-valued codes that are the inverse of the first set of complex-valued codes.

229. The Accused LG LTE Devices have processors and non-transitory memory coupled to the processor. The memory includes instructions for applying LTE physical channel processing consistent with the LTE Specification. For example, the LG Velvet uses the Qualcomm SM7250 Snapdragon 765G system-on-a-chip (including up to 12 GB LPDDR) and includes up to 8 GB of RAM.

230. The memory in Accused LG LTE Devices stores instructions for processing physical channel uplink (from user equipment to eNode B) and downlink (from eNode B to user equipment) consistent with the LTE Specification.

231. For the uplink, the LTE Specification employs a Transform Precoding step (section 5.3.3), where OFDM data symbols are divided into $M_{symb} / M_{sc}^{PUSCH}$ sets, with each set corresponding to one SC-FDMA symbol. The division process results in the first set of complex-valued symbols. These complex-valued symbols are transform precoded using a discrete Fourier transform (DFT) to generate blocks of transform precoded complex-valued symbols. The DFT includes complex-valued codes used to encode the complex-valued data symbols that are to be transmitted, as shown in the highlighted portion of the equation below:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}} / M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

232. The DFT used in transform precoding for the uplink is the inverse of the DFT used by the eNodeB to decode the transform-precoded uplink signals. Because the DFT used for transform-precoding in the uplink is a unitary matrix, its complex conjugate is also its inverse.

233. In accordance with the LTE Specification, Accused LG LTE Devices are assigned physical resource blocks to be used for uplink transmissions to base stations. Each physical resource block includes twelve subcarriers, and determine the number of inputs for SC-FDMA signal generation. Accused LG LTE Devices select subcarriers based on the number of resource blocks assigned to the device.

234. During uplink signal processing, Accused LG LTE Devices transform precoded complex valued symbols in accordance with Section 5.3.3 of the LTE Specification. The transform precoding step generates complex-valued data symbols by using the complex-valued codes of the discrete Fourier transform used in transform precoding, as shown in the highlighted portion of the equation below:

5.3.3 Transform precoding

The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to

$$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \le N_{\text{RB}}^{\text{UL}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

235. During transform precoding, complex-valued symbols $d(0),\ldots d(M_{\text{symb}} - 1)$ are encoded with the complex-valued codes to produce encoded complex-valued data symbols, $z(0),\ldots z((M_{\text{symb}} - 1)$.

236. The encoded complex-valued data symbols are then mapped to, and modulated onto, physical resources (subcarriers) during SC-FDMA baseband signal generation in accordance with the LTE Specification Section 5.6:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{\text{RB}}^{\text{UL}} N_{\text{sc}}^{\text{RB}}/2 \rfloor}^{\lceil N_{\text{RB}}^{\text{UL}} N_{\text{sc}}^{\text{RB}}/2 \rceil - 1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f(t - N_{\text{CP},l} T_s)}$$

for $0 \le t < (N_{\text{CP},l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1} (N_{\text{CP},l'} + N) T_s$ within the slot.

Table 5.6-1lists the values of $N_{\text{CP},l}$ that shall be used. Note that different SC-FDMA symbols within a slot may have different cyclic prefix lengths.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

237. The SC-FDMA baseband signal generation step employs another DFT that spreads OFDM data into a form that resembles a single carrier. The SC-FDMA signal (spread OFDM signal) is then transmitted from Accused LG LTE Devices to base stations.

238. LG directly infringes claim 10 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

239. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXII: INFRINGEMENT OF U.S. PATENT '786 CLAIM 11

240. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

241. Claim 11 of the '786 Patent provides:

Element A	The apparatus of claim 10, wherein selecting is responsive to spectrum allocation or is configured to provide for orthogonal frequency division multiple access.

242. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 11 of the '786 Patent.

243. In accordance with the LTE Specification, Accused LG LTE Devices are assigned physical resources (subcarriers) to be used for the uplink. This assignment of subcarriers is spectrum allocation. Subcarriers are then selected for use from those assigned.

244. LG directly infringes claim 11 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

245. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXIII: INFRINGEMENT OF U.S. PATENT '786 CLAIM 15

246. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

247. Claim 15 of the '786 Patent provides:

Element A	The apparatus of claim 10, wherein the plurality of subcarriers are contiguous subcarriers or interleaved subcarriers.

248. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 15 of the '786 Patent.

249. The use of SC-FDMA (or spread OFDM) allows for subcarriers to be distributed in two manners: contiguously, where subcarriers for a given device are contiguous in the frequency spectrum; or interleaved, where subcarriers for a given device are interspersed with other device subcarriers in the same frequency spectrum.

250. LG directly infringes claim 15 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

251. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXIV: INFRINGEMENT OF U.S. PATENT '786 CLAIM 16

252. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

253. Claim 16 of the '786 Patent provides:

Element A	The apparatus of claim 10, wherein encoding comprises multiplying a vector or matrix of data symbols with a vector or matrix comprising the first set of complex-valued codes.

254. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 16 of the '786 Patent.

255. Accused LG LTE Devices perform transform precoding in accordance with the LTE Specification. The transform precoding step employs a DFT, which itself represents a vector multiplication. The DFT can be represented as a complex matrix multiplication, where data symbols are multiplied by the matrix of complex-valued codes.

256. LG directly infringes claim 16 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

257. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXV: INFRINGEMENT OF U.S. PATENT '786 CLAIM 17

258. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

259. Claim 17 of the '786 Patent provides:

Element A	The apparatus of claim 10, wherein applying comprises modulating the encoded data symbols onto the plurality of subcarriers.

260. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 17 of the '786 Patent.

261. Accused LG LTE Devices process signals for uplink transmission in accordance with the LTE Specification. As part of the signal processing, complex-valued (encoded) data symbols are mapped to, and then modulated onto subcarriers. The modulation of encoded data symbols onto subcarriers is given by Section 5.6 of the LTE Specification.:

5.6 SC-FDMA baseband signal generation

This section applies to all uplink physical signals and physical channels except the physical random access channel.

The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by

$$s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil -1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f(t-N_{CP,l}T_s)}$$

for $0 \le t < (N_{CP,l} + N) \times T_s$ where $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15\,\text{kHz}$ and $a_{k,l}$ is the content of resource element (k,l).

The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l = 0$, where SC-FDMA symbol $l > 0$ starts at time $\sum_{l'=0}^{l-1}(N_{CP,l'} + N)T_s$ within the slot.

Table 5.6-1lists the values of $N_{CP,l}$ that shall be used. Note that different SC-FDMA symbols within a slot may have different cyclic prefix lengths.

Source: 3GPP TS 36.211 version 8.7.0 Release 8

262. LG directly infringes claim 17 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

263. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXVI: INFRINGEMENT OF U.S. PATENT '786 CLAIM 18

264. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

265. Claim 18 of the '786 Patent provides:

Element A	The apparatus of claim 10, wherein the non-transitory computer-readable memory further includes instructions stored thereon and executable by the processor for adding a cyclic prefix to the spread-OFDM signal before transmitting the spread-OFDM signal.

266. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 18 of the '786 Patent.

267. Accused LG LTE Devices process signals for uplink transmission in accordance with the LTE Specification. As part of the signal processing, the LTE Specification section 5.2.3 (and Table 5.2.3-1) requires adding a cyclic prefix to the spread OFDM signal.

Table 5.2.3-1: Resource block parameters.

Configuration	N_{sc}^{RB}	N_{symb}^{UL}
Normal cyclic prefix	12	7
Extended cyclic prefix	12	6

Source: 3GPP TS 36.211 version 8.7.0 Release 8

268. LG directly infringes claim 18 of the '786 Patent by selling, offering to sell, and using the Accused LG LTE Devices.

269. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXVII: INFRINGEMENT OF U.S. PATENT '508 CLAIM 17

270. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

271. Claim 17 of the '508 Patent provides:

Claim 17 Preamble	An apparatus for communicating in a mobile radio communications network, comprising:
Element A	a transceiver-control circuitry configured for:
Element B	provisioning a consecutive series of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers for uplink or downlink communications;
Element C	provisioning a plurality of different selectable subcarrier spacings for the consecutive series of OFDM subcarriers; and
Element D	performing discrete Fourier transform (DFT) coding on a plurality of data symbols to produce DFT coded symbols; and
Element E	an OFDM transceiver communicatively coupled to the transceiver-control circuitry and configured for:
Element F	performing an inverse-DFT on the coded symbols to produce a single-carrier frequency division multiple access signal that comprises a sum of the consecutive series of OFDM subcarriers; and
Element G	transmitting the single-carrier frequency division multiple access signal in the mobile radio communications network;
Element H	wherein provisioning the plurality of different selectable subcarrier spacings comprises providing the single-carrier frequency division multiple access signal with a particular one of a set of different symbol periods by selecting one of the plurality of different selectable subcarrier spacings.

272. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the "5G Specification") and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

273. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 17 of the '508 Patent.

274. The Accused LG 5G Devices have transceiver-control circuitry, such as the Qualcomm SM7250 Snapdragon 765G system-on-a-chip as a non-limiting example, which incorporates a 5G modem and transceiver, configured for 5G physical channel uplink and downlink communications in accordance with the 5G Specification.

275. The 5G Specification requires defining OFDM symbols for use with subcarriers (resource elements) in either the uplink or downlink. The subcarriers used in uplink or downlink communications are allowed to have different subcarriers spacings for selection and use: 15, 30, 60, 120, or 240 kHz. These different spacings are defined in Section 4.3.2 of the 5G Specification:

4.3.2 Slots

For subcarrier spacing configuration μ, slots are numbered $n_s^\mu \in \{0,..., N_{slot}^{subframe,\mu} - 1\}$ in increasing order within a subframe and $n_{s,f}^\mu \in \{0,..., N_{slot}^{frame,\mu} - 1\}$ in increasing order within a frame. There are N_{symb}^{slot} consecutive OFDM symbols in a slot where N_{symb}^{slot} depends on the cyclic prefix as given by Tables 4.3.2-1 and 4.3.2-2. The start of slot n_s^μ in a subframe is aligned in time with the start of OFDM symbol $n_s^\mu N_{symb}^{slot}$ in the same subframe.

OFDM symbols in a slot can be classified as 'downlink', 'flexible', or 'uplink'. Signaling of slot formats is described in subclause 11.1 of [5, TS 38.213].

In a slot in a downlink frame, the UE shall assume that downlink transmissions only occur in 'downlink' or 'flexible' symbols.

In a slot in an uplink frame, the UE shall only transmit in 'uplink' or 'flexible' symbols.

A UE not capable of full-duplex communication is not expected to transmit in the uplink earlier than $N_{Rx\text{-}Tx}T_c$ after the end of the last received downlink symbol in the same cell where $N_{Rx\text{-}Tx}$ is given by [TS 38.101].

Table 4.3.2-1: Number of OFDM symbols per slot, slots per frame, and slots per subframe for normal cyclic prefix.

μ	N_{symb}^{slot}	$N_{slot}^{frame,\mu}$	$N_{slot}^{subframe,\mu}$
0	14	10	1
1	14	20	2
2	14	40	4
3	14	80	8
4	14	160	16

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

276. These selectable subcarrier spacings allow for different numbers of slots (or subframes) to be used for a given radio frame. For example, if a 15Khz spacing is selected, then there will be 1 slot in the frame (OFDM symbol period of ~ 66.6 µs); 30kHz allows for 2 slots (~33.3 µs OFDM symbol period); 60kHz allows for 4 slots (~16.66 µs symbol period); 120kHz allows for 8 slots (8.3µs symbol period). Thus, for each subcarrier spacing, there are different possible symbol periods.

277. The Accused LG 5G Devices perform transform precoding in accordance with the 5G Specification (section 6.3.1.4):

6.3.1.4 Transform precoding

If transform precoding is not enabled according to 6.1.3 of [6, TS38.214], $y^{(\lambda)}(i) = x^{(\lambda)}(i)$ for each layer $\lambda = 0,1,...,\upsilon - 1$.

If transform precoding is enabled according to 6.1.3 of [6, TS38.214], $\upsilon = 1$ and $\tilde{x}^{(0)}(i)$ depends on the configuration of phase-tracking reference signals.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ for the single layer $\lambda = 0$ shall be divided into $M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one OFDM symbol and $\tilde{x}^{(0)}(i) = x^{(0)}(i)$.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ shall be divided into sets, each set corresponding to one OFDM symbol, and where set l contains $M_{\text{sc}}^{\text{PUSCH}} - \varepsilon_l N_{\text{samp}}^{\text{group}} N_{\text{group}}^{\text{PTRS}}$ symbols and is mapped to the complex-valued symbols $\tilde{x}^{(0)}(lM_{\text{sc}}^{\text{PUSCH}} + i')$ corresponding to OFDM symbol l prior to transform precoding, with $i' \in \{0,1,...,M_{\text{sc}}^{\text{PUSCH}} - 1\}$ and $i' \neq m$. The index m of PT-RS samples in set l, the number of samples per PT-RS group $N_{\text{samp}}^{\text{group}}$, and the number of PT-RS groups $N_{\text{group}}^{\text{PTRS}}$ are defined in clause 6.4.1.2.2.2. The quantity $\varepsilon_l = 1$ when OFDM symbol l contains one or more PT-RS samples, otherwise $\varepsilon_l = 0$.

Transform precoding shall be applied according to

$$y^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} \tilde{x}^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $y^{(0)}(0),...,y^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

The transform precoding entails applying a discrete Fourier transform to blocks of complex-valued data symbols $x^{(0)}(0),...x^{(0)}(M_{symb}^{layer} - 1)$ to generate transform pre-coded complex-valued data symbols $y^{(0)}(0),...\ y^{(0)}(M_{symb}^{layer} - 1)$.

278. Accused LG 5G Devices include an OFDM transceiver for sending and receiving physical communications. The OFDM transceiver is in communication with the transceiver-control

circuitry. The OFDM transceiver is configured to perform OFDM baseband signal processing in accordance with the 5G Specification (section 5.3.1 OFDM baseband signal generation):

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,\ldots,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrer. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

OFDM baseband signal generation entails the use of an inverse discrete Fourier transform (highlighted in the equation above) on the pre-coded complex-valued data symbols to generate a single carrier frequency division multiple access (SC-FDMA) signal. Application of the inverse DFT results in modulating the pre-coded complex-valued data symbols onto the OFDM signals. These SC-FDMA signals are then transmitted by Accused LG 5G Devices to base stations/eNode Bs.

279. LG directly infringes claim 17 of the '508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

280. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXVIII: INFRINGEMENT OF U.S. PATENT '508 CLAIM 18

281. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

282. Claim 18 of the '508 Patent provides:

Element A	The apparatus of claim 17, wherein at least one of the plurality of different selectable subcarrier spacings equals at least one other of the plurality of different selectable subcarrier spacings multiplied by a scaling factor that is a power of two.

283. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 18 of the '508 Patent.

284. Accused LG 5G Devices perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification (section 4.2 numerologies) includes selectable subcarrier spacings, ranging from 15kHz to 240kHz:

4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15 [\text{kHz}]$	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

The subcarrier spacings are defined as $\Delta f = 2^{\mu} * 15[\text{kHz}]$, where μ is a subcarrier spacing configuration that represents a scaling factor that is a power of 2.

285. LG directly infringes claim 18 of the '508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

286. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXIX: INFRINGEMENT OF U.S. PATENT '508 CLAIM 19

287. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

288. Claim 19 of the ’508 Patent provides:

Element A	The apparatus of claim 17, wherein the OFDM transceiver is further configured to add a cyclic prefix to the single-carrier frequency division multiple access signal.

289. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 19 of the ’508 Patent.

290. The transceiver in Accused LG 5G Devices is configured to perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification includes OFDM baseband signal generation (Section 5.3.1). This step includes adding a cyclic prefix to the SC-FDMA signal:

5.3 OFDM baseband signal generation

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,...,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

In the above equation, $N_{CP,l}^{\mu}$ is defined as the cyclix prefix length.

291. LG directly infringes claim 19 of the ’508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

292. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXX: INFRINGEMENT OF U.S. PATENT '508 CLAIM 20

293. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

294. Claim 20 of the '508 Patent provides:

Element A	The apparatus of claim 17, wherein the plurality of different selectable subcarrier spacings comprise integer multiples of a first subcarrier spacing.

295. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 20 of the '508 Patent.

296. Accused LG 5G Devices perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification (section 4.2 numerologies) includes selectable subcarrier spacings: 15kHz, 30kHz, 60kHz, 120kHz, and 240kHz. The subcarrier spacings are integers of a first subcarrier spacing, with the integers being 2, 4, 8 and 16.

297. LG directly infringes claim 20 of the '508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

298. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXI: INFRINGEMENT OF U.S. PATENT '508 CLAIM 21

299. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

300. Claim 21 of the '508 Patent provides:

Element A	The apparatus of claim 17, wherein each of the plurality of different selectable subcarrier spacings is configured for one of a plurality of different deployment scenarios, the plurality of different deployment scenarios comprising different system requirements or different channel characteristics.

301. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 21 of the ’508 Patent.

302. Accused LG 5G Devices perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification (section 4.2 numerologies) includes selectable subcarrier spacings: 15kHz, 30kHz, 60kHz, 120kHz, and 240kHz. The different subcarrier spacings are provided because of the wide range of frequency channels allowed for in 5G communication, with each channel having different characteristics. For example, the 5G Specification section 5.5.4.1 explains that two frequency ranges are allowed: FR1 and FR2. FR1 encompasses 410MHz-7125Mhz, and FR2 encompasses 24250MHz-52600Mhz frequencies. The subcarrier spacings allow for different numbers of slots within radio subframes, with the number of subframes utilized for different frequency ranges: subcarrier spacings of 15 and 30kHz are suitable for use with FR1; subcarrier spacing of 60Khz is suitable for both FR1 and FR2; subcarrier spacings of 120 and 240kHz are suitable for use with FR2.

303. The lower frequency ranges have limited spectrum such that smaller subcarrier spacings are used to maximize the data communicated. Conversely, in higher frequency ranges, such as mmWave, frequency drift increases (Doppler spread). To compensate for the drift, larger subcarrier spacings are used.

304. LG directly infringes claim 21 of the ’508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

305. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXII: INFRINGEMENT OF U.S. PATENT ’508 CLAIM 22

306. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

307. Claim 22 of the ’508 Patent provides:

Element A	The apparatus of claim 17, wherein each of the plurality of different selectable subcarrier spacings produces a different number of symbols per frame.

308. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG LTE Devices that meet each and every element of claim 22 of the ’508 Patent.

309. Accused LG 5G Devices perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification (section 4.2 numerologies) includes selectable subcarrier spacings: 15kHz, 30kHz, 60kHz, 120kHz, and 240kHz. Each spacing allows for a different number of subframes and a different number of symbols per frame.

310. Section 4.3.1 of the 5G Specification defines transmissions as organized into frames, with each frame consisting of 10 subframes, with the number of consecutive OFDM symbols per subframe defined as $N_{\text{symb}}^{\text{slot}} \times N_{\text{slot}}^{\text{frame},\mu}$:

4.3.1 Frames and subframes

Downlink and uplink transmissions are organized into frames with $T_f = (\Delta f_{\max} N_f / 100) \cdot T_c = 10\,\text{ms}$ duration, each consisting of ten subframes of $T_{sf} = (\Delta f_{\max} N_f / 1000) \cdot T_c = 1\,\text{ms}$ duration. The number of consecutive OFDM symbols per subframe is $N_{\text{symb}}^{\text{subframe},\mu} = N_{\text{symb}}^{\text{slot}} N_{\text{slot}}^{\text{subframe},\mu}$. Each frame is divided into two equally-sized half-frames of five subframes each with half-frame 0 consisting of subframes 0 – 4 and half-frame 1 consisting of subframes 5 – 9.

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

311. Section 4.3.2 of the 5G Specification further defines subcarrier spacings and the number of OFDM symbols per slot, slots per frame, and slots per subframe:

4.3.2 Slots

For subcarrier spacing configuration μ, slots are numbered $n_s^\mu \in \{0,\dots,N_{\text{slot}}^{\text{subframe},\mu}-1\}$ in increasing order within a subframe and $n_{s,f}^\mu \in \{0,\dots,N_{\text{slot}}^{\text{frame},\mu}-1\}$ in increasing order within a frame. There are $N_{\text{symb}}^{\text{slot}}$ consecutive OFDM symbols in a slot where $N_{\text{symb}}^{\text{slot}}$ depends on the cyclic prefix as given by Tables 4.3.2-1 and 4.3.2-2. The start of slot n_s^μ in a subframe is aligned in time with the start of OFDM symbol $n_s^\mu N_{\text{symb}}^{\text{slot}}$ in the same subframe.

OFDM symbols in a slot can be classified as 'downlink', 'flexible', or 'uplink'. Signaling of slot formats is described in subclause 11.1 of [5, TS 38.213].

In a slot in a downlink frame, the UE shall assume that downlink transmissions only occur in 'downlink' or 'flexible' symbols.

In a slot in an uplink frame, the UE shall only transmit in 'uplink' or 'flexible' symbols.

A UE not capable of full-duplex communication is not expected to transmit in the uplink earlier than $N_{\text{Rx-Tx}} T_c$ after the end of the last received downlink symbol in the same cell where $N_{\text{Rx-Tx}}$ is given by [TS 38.101].

Table 4.3.2-1: Number of OFDM symbols per slot, slots per frame, and slots per subframe for normal cyclic prefix.

μ	$N_{\text{symb}}^{\text{slot}}$	$N_{\text{slot}}^{\text{frame},\mu}$	$N_{\text{slot}}^{\text{subframe},\mu}$
0	14	10	1
1	14	20	2
2	14	40	4
3	14	80	8
4	14	160	16

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

312. Thus, for $\mu = [0, 1, 2, 3, 4]$ the number of OFDM symbols per frame are equal to $N_{\text{symb}}^{\text{slot}} \times N_{\text{slot}}^{\text{frame},\mu} = [140, 280, 560, 1120, 2240]$, where μ is a subcarrier spacing configuration.

313. LG directly infringes claim 22 of the '508 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

314. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXIII: INFRINGEMENT OF U.S. PATENT '005 CLAIM 13

315. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

316. Claim 13 of the '005 Patent provides:

Claim 13 Preamble	An apparatus for communication in a wireless network, comprising:
Element A	at least one processor; and
Element B	at least one non-transitory computer-readable memory in electronic communication with the at least one processor, wherein instructions stored in the at least one non-transitory computer-readable memory are executable by the at least one processor for:
Element C	producing a set of subcarrier values that equals a product of a complex-valued code matrix with a matrix of data symbols;
Element D	selecting a set of subcarriers assigned for use by a user device; and
Element E	modulating the subcarrier values onto the set of subcarriers to produce a plurality of modulated subcarriers; and
Element F	producing a time-domain waveform from a superposition of the plurality of modulated subcarriers, the time-domain waveform to be transmitted in the wireless network by the user device;
Element G	wherein producing the set of subcarrier values employs a plurality of complex-valued codes that shapes interference patterns of the superposition to produce a plurality of cyclic-shifted waveforms that each have one of the data symbols modulated thereon.

317. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the "5G Specification") and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

318. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 13 of the '005 Patent.

319. Accused LG 5G Devices have processors (e.g., Qualcomm SM7250 Snapdragon 765G system-on-a-chip and non-transitory memory (e.g., LPDDR memory, RAM) coupled to the processor for electronically communicating with the processor. The memory of Accused LG 5G Devices store instructions that are executed by the processor of the Accused LG 5G Devices.

320. The 5G Specification requires the production and use of subcarriers and subcarrier values that are generated during the 5G Specification's Transform Precoding step defined in Section 6.3.1.4:

6.3.1.4 Transform precoding

If transform precoding is not enabled according to 6.1.3 of [6, TS38.214], $y^{(\lambda)}(i) = x^{(\lambda)}(i)$ for each layer $\lambda = 0,1,...,\upsilon - 1$.

If transform precoding is enabled according to 6.1.3 of [6, TS38.214], $\upsilon = 1$ and $\tilde{x}^{(0)}(i)$ depends on the configuration of phase-tracking reference signals.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ for the single layer $\lambda = 0$ shall be divided into $M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one OFDM symbol and $\tilde{x}^{(0)}(i) = x^{(0)}(i)$.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ shall be divided into sets, each set corresponding to one OFDM symbol, and where set l contains $M_{\text{sc}}^{\text{PUSCH}} - \varepsilon_l N_{\text{samp}}^{\text{group}} N_{\text{group}}^{\text{PTRS}}$ symbols and is mapped to the complex-valued symbols $\tilde{x}^{(0)}(lM_{\text{sc}}^{\text{PUSCH}} + i')$ corresponding to OFDM symbol l prior to transform precoding, with $i' \in \{0,1,...,M_{\text{sc}}^{\text{PUSCH}} - 1\}$ and $i' \neq m$. The index m of PT-RS samples in set l, the number of samples per PT-RS group $N_{\text{samp}}^{\text{group}}$, and the number of PT-RS groups $N_{\text{group}}^{\text{PTRS}}$ are defined in clause 6.4.1.2.2.2. The quantity $\varepsilon_l = 1$ when OFDM symbol l contains one or more PT-RS samples, otherwise $\varepsilon_l = 0$.

Transform precoding shall be applied according to

$$y^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} \tilde{x}^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$
$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$
$$l = 0,...,M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $y^{(0)}(0),...,y^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

321. The 5G Specification's transform precoding step uses a Discrete Fourier transform (DFT), as shown in the outlined box above. The DFT itself is a complex matrix transform where values are calculated by multiplying a matrix of complex-valued codes with a matrix of data symbols. The complex-valued codes are included in the DFT's exponential term $e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$. This term is a linear phase that defines a circular (cyclic) shift in the time-domain transform when frequency-domain values (inputs) are multiplied by the linear phase.

322. The 5G Specification requires assigning resource blocks to each device, with each resource block consisting of up to 12 consecutive subcarriers. The actual number of subcarriers selected and used depends on the usage scenario. The 5G Specification introduced variable subcarrier spacing (numerology) to accommodate different usage scenarios, with spacings of 15, 30, 60, 120 and 240kHz allowed in the 5G Specification. The number of subcarriers used depends on the subcarrier spacing utilized by the Accused LG 5G Devices.

323. The Accused LG 5G Devices modulate subcarrier values onto subcarriers to produce modulated subcarriers when implementing the 5G Specification's OFDM baseband signal generation step (Section 5.3.1):

5.3 OFDM baseband signal generation

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,...,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

324. The baseband signal generation step converts frequency-domain values from the transform precoding step into time-domain values (waveforms) using an inverse Fast Fourier transform (IFFT). Each input symbol (complex-valued symbols in the frequency domain arising from transform precoding) into the IFFT is modulated onto a particular subcarrier frequency and output as a discrete time signal. If multiple symbols are input into the IFFT at the same time, the output discrete time signal is a sum—or superposition—of the subcarrier frequencies modulated with their corresponding symbols. The resulting signal resembles a single carrier signal.

325. The sum (superposition) of the modulated subcarriers itself is based on the amplitudes of each of the subcarriers, with each subcarrier's amplitude varying in time according to its frequency. When summed, the varying amplitudes of the subcarriers results in a combination of constructive and destructive interference, such that the transform precoding step ultimately shapes interference patterns. Generally speaking, constructive interference is when the crest of a wave meets the crest of another wave at the same point, with the overall amplitude at that point being the sum of the two individual amplitudes. Destructive interference occurs when the crest of one wave meets the trough of another wave at the same point, with the overall amplitude at that point being the difference between the two individual waves.

326. LG directly infringes claim 13 of the '005 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

327. LG has had knowledge of the '005 Patent since December 21, 2022.

328. LG makes, uses, and/or imports the Accused LG 5Gs Devices knowing that LG infringed and continues to infringe claims of the '005 Patent under 35 U.S.C. § 271(a) directly.

329. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXIV: INFRINGEMENT OF U.S. PATENT '005 CLAIM 18

330. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

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331. Claim 18 of the ’005 Patent provides:

Element A	The apparatus of claim 13, wherein modulating and producing the time-domain waveform is performed using an inverse discrete Fourier transform.

332. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 18 of the ’005 Patent.

333. Accused LG 5G Devices comply with the 5G Specification, and apply the 5G Specification’s OFDM baseband signal generation step (Section 5.3.1):

5.3 OFDM baseband signal generation

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,...,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_{\text{c}} - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_{\text{u}}^\mu + N_{\text{CP},l}^\mu\right) T_{\text{c}}$ is the time within the subframe,

$$N_{\text{u}}^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

334. The baseband generation step employs an inverse discrete Fourier transform to modulate data symbols on subcarriers and generate the time-domain waveform.

335. LG directly infringes claim 18 of the ’005 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

336. LG has had knowledge of the ’005 Patent since December 21, 2022.

337. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’005 Patent under 35 U.S.C. § 271(a) directly.

338. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXV: INFRINGEMENT OF U.S. PATENT ’005 CLAIM 19

339. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

340. Claim 19 of the ’005 Patent provides:

Element A	The apparatus of claim 13, wherein selecting the set of subcarriers comprises selecting one of a plurality of selectable subcarrier spacings.

341. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 19 of the ’005 Patent.

342. Accused LG 5G Devices comply with the 5G Specification. The 5G Specification supports multiple OFDM numerologies (subcarrier spacings), shown below, that can be selected depending on the usage scenario. Different subcarrier spacings utilize different numbers of subcarriers.

4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15$ [kHz]	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

343. LG directly infringes claim 19 of the ’005 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

344. LG has had knowledge of the ’005 Patent since December 21, 2022.

345. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’005 Patent under 35 U.S.C. § 271(a) directly.

346. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXVI: INFRINGEMENT OF U.S. PATENT ’285 CLAIM 11

347. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

348. Claim 11 of the ’285 Patent provides:

Claim 11 Preamble	An apparatus for communication in a wireless communication network, the apparatus comprising:
Element A	at least one processor; and
Element B	a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:
Element C	encoding a set of data symbols with a set of complex-valued codes, to produce a set of subcarrier values;
Element D	modulating the set of subcarrier values onto a set of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers assigned for use by the user device, to produce a plurality of modulated subcarriers; and
Element E	producing a time-domain waveform that comprises a superposition of the plurality of modulated subcarriers, the time-domain waveform to be transmitted in the wireless network by the user device;
Element F	wherein the set of subcarrier values comprises a first polyphase code that encodes a first of the set of data symbols and at least a second polyphase code that encodes at least a second of the set of data symbols;
Element G	wherein the first polyphase code causes constructive and destructive interference between the plurality of modulated subcarriers to produce a first periodic pulse waveform having a peak value that is centered at a first time in an OFDM symbol interval, and the second polyphase code causes constructive and destructive interference between the plurality of modulated subcarriers to produce a second periodic pulse waveform having a peak value that is centered at a second time in the OFDM symbol interval, the second time different from the first time.

349. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the "5G Specification") and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

350. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 13 of the '005 Patent.

351. Accused LG 5G Devices have processors (e.g., Qualcomm SM7250 Snapdragon 765G system-on-a-chip and non-transitory memory (e.g., LPDDR memory, RAM) coupled to the processor for electronically communicating with the processor. The memory of Accused LG 5G Devices store instructions that are executed by the processor of the Accused LG 5G Devices.

352. The 5G Specification requires the production and use of subcarriers and subcarrier values that are generated during the 5G Specification's Transform Precoding step defined in Section 6.3.1.4:

6.3.1.4 Transform precoding

If transform precoding is not enabled according to 6.1.3 of [6, TS38.214], $y^{(\lambda)}(i) = x^{(\lambda)}(i)$ for each layer $\lambda = 0,1,...,\upsilon - 1$.

If transform precoding is enabled according to 6.1.3 of [6, TS38.214], $\upsilon = 1$ and $\tilde{x}^{(0)}(i)$ depends on the configuration of phase-tracking reference signals.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ for the single layer $\lambda = 0$ shall be divided into $M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one OFDM symbol and $\tilde{x}^{(0)}(i) = x^{(0)}(i)$.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ shall be divided into sets, each set corresponding to one OFDM symbol, and where set l contains $M_{\text{sc}}^{\text{PUSCH}} - \varepsilon_l N_{\text{samp}}^{\text{group}} N_{\text{group}}^{\text{PTRS}}$ symbols and is mapped to the complex-valued symbols $\tilde{x}^{(0)}(lM_{\text{sc}}^{\text{PUSCH}} + i')$ corresponding to OFDM symbol l prior to transform precoding, with $i' \in \{0,1,...,M_{\text{sc}}^{\text{PUSCH}} - 1\}$ and $i' \neq m$. The index m of PT-RS samples in set l, the number of samples per PT-RS group $N_{\text{samp}}^{\text{group}}$, and the number of PT-RS groups $N_{\text{group}}^{\text{PTRS}}$ are defined in clause 6.4.1.2.2.2. The quantity $\varepsilon_l = 1$ when OFDM symbol l contains one or more PT-RS samples, otherwise $\varepsilon_l = 0$.

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Transform precoding shall be applied according to

$$y^{(0)}(l \cdot M_{sc}^{PUSCH} + k) = \frac{1}{\sqrt{M_{sc}^{PUSCH}}} \sum_{i=0}^{M_{sc}^{PUSCH}-1} \tilde{x}^{(0)}(l \cdot M_{sc}^{PUSCH} + i) e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$$

$$k = 0,...,M_{sc}^{PUSCH} - 1$$

$$l = 0,...,M_{symb}^{layer} / M_{sc}^{PUSCH} - 1$$

resulting in a block of complex-valued symbols $y^{(0)}(0),...,y^{(0)}(M_{symb}^{layer} - 1)$. The variable $M_{sc}^{PUSCH} = M_{RB}^{PUSCH} \cdot N_{sc}^{RB}$, where M_{RB}^{PUSCH} represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{RB}^{PUSCH} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

353. The transform precoding step of the 5G Specification employs a Discrete Fourier transform to encode input data symbols with complex-valued codes to generate subcarriers encoded with the input data. The DFT itself includes an exponential term that corresponds to complex-valued codes (the boxed portion of the equation above). These complex-valued codes are multiplied by the data symbols. The DFT's exponential term is used to phase shift inputs to the DFT by defining codes that are polyphasic. Each polyphase code is applied to the input data symbol.

354. The Accused LG 5G Devices modulate subcarrier values from the transform precoding step onto subcarriers to produce modulated OFDM subcarriers when implementing the 5G Specification's OFDM baseband signal generation step (Section 5.3.1), shown below. Each Accused LG 5G Device is assigned resource blocks for use, with each resource block consisting of up to twelve subcarriers.

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5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,\ldots,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrer. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

355. The baseband signal generation step converts frequency-domain values from the transform precoding step into time-domain values (waveforms) using an inverse Fast Fourier transform (IFFT). Each input symbol (complex-valued symbols in the frequency domain arising from transform precoding) into the IFFT is modulated onto a particular subcarrier frequency and output as a discrete time signal. If multiple symbols are input into the IFFT at the same time, the output discrete time signal is a sum—or superposition—of the subcarrier frequencies modulated with their corresponding symbols. The resulting signal resembles a single carrier signal that is then used during transmission from Accused LG 5G Devices to the 5G network.

356. The sum (superposition) of the modulated subcarriers itself is based on the amplitudes of each of the subcarriers, with each subcarrier's amplitude varying in time according to its frequency. When summed, the varying amplitudes of the subcarriers results in a combination of constructive and destructive interference, such that the transform precoding step ultimately shapes interference patterns. Generally speaking, constructive interference is when the crest of a wave meets the crest of another wave at the same point, with the overall amplitude at that point being the sum of the two individual amplitudes. Destructive interference occurs when the crest of one wave meets the trough of another wave at the same point, with the overall amplitude at that point being the difference between the two individual waves.

357. In OFDM systems, such as the 5G network, subcarriers are uniformly spaced based on a selected subcarrier spacing Δf such that the time-domain OFDM symbol is periodic with a symbol period of $1/f$. As discussed above, the baseband signal generation step employs an inverse DFT which produces a discrete-time OFDM signal having N samples and a period of N. When values of a first polyphase code are chosen, the codes provide phase offsets to the subcarriers that cause all of the subcarriers' phases to align at a particular time inside the symbol period, which causes constructive interference and results in a pulse waveform being centered at that time. If a second polyphase code also produces a pulse waveform, that pulse waveform is preferably centered at a different time in order for it to be distinguished from the first pulse waveform. This happens when the codes are chosen from the rows or columns of a DFT matrix.

358. LG directly infringes claim 11 of the '285 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

359. LG has had knowledge of the '285 Patent since December 21, 2022.

360. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the '285 Patent under 35 U.S.C. § 271(a) directly.

361. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXVII: INFRINGEMENT OF U.S. PATENT '285 CLAIM 17

362. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

363. Claim 17 of the '285 Patent provides:

Element A	The apparatus of claim 11, further comprising adding a cyclic prefix to the time-domain waveform.

364. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 17 of the '285 Patent.

365. The transceiver in Accused LG 5G Devices is configured to perform physical channel uplink and downlink processing in accordance with the 5G Specification. The 5G Specification includes

OFDM baseband signal generation (Section 5.3.1). This step includes adding a cyclic prefix to the signal:

5.3 OFDM baseband signal generation

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,...,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

In the above equation, $N_{CP,l}^{\mu}$ is defined as the cyclic prefix length.

366. LG directly infringes claim 17 of the ’285 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

367. LG has had knowledge of the ’285 Patent since December 21, 2022.

368. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’285 Patent under 35 U.S.C. § 271(a) directly.

369. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXVIII: INFRINGEMENT OF U.S. PATENT ’285 CLAIM 19

370. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

371. Claim 19 of the ’285 Patent provides:

Element A	The apparatus of claim 11, wherein modulating comprises selecting one of a set of subcarrier frequency spacings.

372. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 19 of the ’285 Patent.

373. Accused LG 5G Devices comply with the 5G Specification. The 5G Specification supports multiple OFDM numerologies (subcarrier spacings) that can be selected depending on the usage scenario, as shown below. Different subcarrier spacings utilize different numbers of subcarriers.

4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15\,[\text{kHz}]$	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

374. LG directly infringes claim 19 of the ’285 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

375. LG has had knowledge of the ’285 Patent since December 21, 2022.

376. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’285 Patent under 35 U.S.C. § 271(a) directly.

377. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XXXIX: INFRINGEMENT OF U.S. PATENT ’792 CLAIM 8

378. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

379. Claim 8 of the ’792 Patent provides:

Claim 8 Preamble	An apparatus for providing flexible channel bandwidth in mobile radio communications, comprising:
Element A	at least one processor; and

Element B	at least one non-transitory computer-readable memory in electronic communication with the at least one processor, and instructions stored in the at least one memory, the instructions executable by the at least one processor for:
Element C	provisioning a set of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers for mobile radio communications;
Element D	encoding data symbols with polyphase codes derived from a discrete Fourier transform to produce encoded data symbols; and
Element E	modulating the encoded data symbols onto the OFDM subcarriers to produce a superposition signal that resembles a single-carrier signal and has one of a plurality of different symbol durations;
Element F	wherein provisioning comprises selecting one of a plurality of different selectable subcarrier spacings, to provide for the one of the plurality of different symbol durations.

380. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the "5G Specification") and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

381. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 13 of the '005 Patent.

382. Accused LG 5G Devices have processors (e.g., Qualcomm SM7250 Snapdragon 765G system-on-a-chip) and non-transitory memory (e.g., LPDDR memory, RAM) coupled to the processor for electronically communicating with the processor. The memory of Accused LG 5G Devices store instructions that are executed by the processor of the Accused LG 5G Devices.

383. 5G cellular communications use orthogonal frequency division multiplexing (OFDM) for radio transmissions. As implemented in the 5G Specification, each Accused LG 5G Device is assigned resource blocks, with each resource block consisting of up to twelve subcarriers. The 5G Specification includes various numerologies to accommodate different usage scenarios. These numerologies define various subcarrier spacings, ranging from 15kHz to 240kHz, as shown below:

4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15$ [kHz]	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

384. Depending on the subcarrier spacing selected, the subcarriers will have different symbol durations. For example, an OFDM symbol duration is 66.6 microseconds when using a subcarrier spacing of 15kHz, while the OFDM symbol duration is halved (33.3 microseconds) when the subcarrier spacing is doubled to 30kHz:

Table 5.5.4.1-2: Multiple numerologies in NR

Cyclic Prefix	subcarrier spacing (SCS) [kHz]	Number of subframes per radio frame	Number of slots per subframe	Number of OFDM symbols per slot	Applicable frequency range
normal	15	10	1	14	FR1
normal	30	10	2	14	FR1
normal	60	10	4	14	FR1 and FR2
extended	60	10	4	12	FR1 and FR2
normal	120	10	8	14	FR2
normal	240	10	16	14	FR2

Note: Additional specific numerologies are defined for PRACH, as described in Section 5.5.4.3.

Note that, for the 60 kHz SCS, an extended CP is possible. The extended CP is approximately four times longer than the normal CP and is used for cells having large delay spread. In this case, one slot consists of only 12 OFDM symbols.

The OFDM symbol duration and CP length are inversely proportional of the SCS. E.g. for 15 kHz SCS, the OFDM symbol duration is approximately 66.6 μs and the CP length is approximately 4.7 μs. When the SCS is doubled, i.e. 30 kHz, the OFDM and CP lengths are approximately devided by two compared to the 15kHz SCS.

Source: 5G Specification, 3GPP TR 21.915 version 15.0.0 release 15

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385. The 5G Specification requires a transform precoding step (Section 6.3.1.4) which utilizes a discrete Fourier transform (DFT) to encode input data symbols with polyphase codes to generate transform precoded data symbols:

6.3.1.4 Transform precoding

If transform precoding is not enabled according to 6.1.3 of [6, TS38.214], $y^{(\lambda)}(i) = x^{(\lambda)}(i)$ for each layer $\lambda = 0,1,...,\upsilon - 1$.

If transform precoding is enabled according to 6.1.3 of [6, TS38.214], $\upsilon = 1$ and $\tilde{x}^{(0)}(i)$ depends on the configuration of phase-tracking reference signals.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ for the single layer $\lambda = 0$ shall be divided into $M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one OFDM symbol and $\tilde{x}^{(0)}(i) = x^{(0)}(i)$.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, the block of complex-valued symbols $x^{(0)}(0),...,x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ shall be divided into sets, each set corresponding to one OFDM symbol, and where set l contains $M_{\text{sc}}^{\text{PUSCH}} - \varepsilon_l N_{\text{samp}}^{\text{group}} N_{\text{group}}^{\text{PTRS}}$ symbols and is mapped to the complex-valued symbols $\tilde{x}^{(0)}(lM_{\text{sc}}^{\text{PUSCH}} + i')$ corresponding to OFDM symbol l prior to transform precoding, with $i' \in \{0,1,...,M_{\text{sc}}^{\text{PUSCH}} - 1\}$ and $i' \neq m$. The index m of PT-RS samples in set l, the number of samples per PT-RS group $N_{\text{samp}}^{\text{group}}$, and the number of PT-RS groups $N_{\text{group}}^{\text{PTRS}}$ are defined in clause 6.4.1.2.2.2. The quantity $\varepsilon_l = 1$ when OFDM symbol l contains one or more PT-RS samples, otherwise $\varepsilon_l = 0$.

* * * *

Transform precoding shall be applied according to

$$y^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} \tilde{x}^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$

$$k = 0,...,M_{\text{sc}}^{\text{PUSCH}} - 1$$

$$l = 0,...,M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}} - 1$$

resulting in a block of complex-valued symbols $y^{(0)}(0),...,y^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil

$$M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

386. As shown in the above, the DFT includes an exponential term that generates polyphase codes that are applied to input data symbols.

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387. The 5G Specification requires an OFDM baseband signal generation step (Section 5.3.1), as shown below:

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,\ldots,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right)T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrer. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

388. The baseband signal generation step involves modulating the encoded data symbols generated during the transform precoding step onto OFDM subcarriers. This baseband signal generation step uses an inverse DFT to transform the encoded data symbols from the frequency-domain into the time-domain, with the output being a discrete-time signal. When multiple symbols are input into the inverse DFT at the same time, the output discrete-time signal is a sum (or superposition) of the subcarrier frequencies modulated with their corresponding symbols. This summing of outputs resembles a single carrier.

389. LG directly infringes claim 8 of the ’792 Patent by selling, offering to sell, and using the Accused LG 5G Devices.

390. LG has had knowledge of the ’792 Patent since December 21, 2022.

391. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’792 Patent under 35 U.S.C. § 271(a) directly.

392. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XL: INFRINGEMENT OF U.S. PATENT '792 CLAIM 9

393. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

394. Claim 9 of the '792 Patent provides:

Claim 9	The apparatus of claim 8, wherein at least one of the plurality of different selectable subcarrier spacings equals at least one other of the plurality of different selectable subcarrier spacings multiplied by a scaling factor that is a power of two.

395. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the "5G Specification") and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

396. The 5G Specification's numerologies allow for different subcarrier spacings to be used. The different subcarrier spacings are based on a scaling factor that is a power of two, as shown in the highlighted section below.

4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15\,[\text{kHz}]$	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

* * * *

Δf Subcarrier spacing

* * * *

μ Subcarrier spacing configuration, $\Delta f = 2^{\mu} \cdot 15 [\text{kHz}]$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

397. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 9 of the ’792 Patent.

398. LG has had knowledge of the ’792 Patent since December 21, 2022.

399. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the ’792 Patent under 35 U.S.C. § 271(a) directly.

400. As a direct and proximate result of LG’s acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

COUNT XLI: INFRINGEMENT OF U.S. PATENT ’792 CLAIM 10

401. GenghisComm incorporates by reference the allegations set forth in the preceding paragraphs of this Complaint as though set forth in full herein.

402. Claim 10 of the ’792 Patent provides:

Claim 10	The apparatus of claim 8, further comprising instructions stored in the at least one non-transitory computer-readable memory, the instructions executable by the at least one processor for adding a cyclic prefix to the superposition signal.

403. LG makes, uses, sells, offers for sale, and imports wireless devices that utilize 5G networks and 5G LTE wireless standards (e.g., 3GPP TS 38.211 version 15.2.0 release 15; the “5G Specification”) and the requirements for uplink and downlink physical channel communications. These communications are sent from Accused LG 5G Devices, as defined in paragraph 19, to eNodeB receivers located at cell sites.

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404. The Accused LG 5G Devices have memory (e.g., RAM, LPDDR) that stores programming instructions to implement the requirements of the 5G Specification, including the 5G Specification's use of cyclic prefixes to the OFDM baseband signal:

5.3 OFDM baseband signal generation

5.3.1 OFDM baseband signal generation for all channels except PRACH

The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0,1,...,N_{\text{slot}}^{\text{subframe},\mu} N_{\text{symb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by

$$s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi\left(k + k_0^\mu - N_{\text{grid},x}^{\text{size},\mu} N_{\text{sc}}^{\text{RB}}/2\right)\Delta f\left(t - N_{\text{CP},l}^\mu T_c - t_{\text{start},l}^\mu\right)}$$

$$k_0^\mu = \left(N_{\text{grid},x}^{\text{start},\mu} + N_{\text{grid},x}^{\text{size},\mu}/2\right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start},\mu_0} + N_{\text{grid},x}^{\text{size},\mu_0}/2\right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$$

where $t_{\text{start},l}^\mu \le t < t_{\text{start},l}^\mu + \left(N_u^\mu + N_{\text{CP},l}^\mu\right) T_c$ is the time within the subframe,

$$N_u^\mu = 2048\kappa \cdot 2^{-\mu}$$

$$N_{\text{CP},l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \ne 0 \text{ and } l \ne 7 \cdot 2^\mu \end{cases}$$

Source: 5G Specification, 3GPP TS 38.211 version 15.2.0 release 15

405. LG has and continues to make, use, sell, import, and/or offer for sale the Accused LG 5G Devices that meet each and every element of claim 10 of the '792 Patent.

406. LG has had knowledge of the '792 Patent since December 21, 2022.

407. LG makes, uses, and/or imports the Accused LG 5G Devices knowing that LG infringed and continues to infringe claims of the '792 Patent under 35 U.S.C. § 271(a) directly.

408. As a direct and proximate result of LG's acts of patent infringement, GenghisComm has been and continues to be injured, and has sustained and will continue to sustain damages.

WILLFUL INFRINGEMENT

409. LG has infringed and continues to infringe the above identified claims of each of the Patents-in-Suit despite its knowledge of the '842, '227 and '568 Patents and its knowledge that at least Accused LG LTE Devices and Accused LG 5G Devices, were and are using the technology claimed by them since November 2, 2020, and the objectively high likelihood that its acts constitute patent infringement.

410. LG has infringed and continues to infringe the above identified claims of each of the Patents-in-Suit despite its knowledge of the ’005, ’285 and ’792 Patents and its knowledge that at least the Accused LG 5G Devices, were and are using the technology claimed by them since December 21, 2022, and the objectively high likelihood that its acts constitute patent infringement.

411. LG’s infringement of the Patents-in-Suit is willful and deliberate, entitling GenghisComm to enhanced damages under 35 U.S.C. § 284.

412. LG’s willful infringement and unwillingness to enter into license negotiations with GenghisComm make this an exceptional case such that GenghisComm should be entitled to recover its attorneys’ fees and costs incurred in relation to this matter pursuant to 35 U.S.C. §285.

JURY DEMAND

GenghisComm demands a trial by jury on all issues so triable.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff GenghisComm requests that this Court enter judgment in its favor and against LG as follows:

A. Adjudging, finding, and declaring that LG has infringed of the above-identified claims of each of the Patents-in-Suit under 35 U.S.C. § 271;

B. Awarding the past and future damages arising out of LG’s infringement of the Patents-in-Suit to GenghisComm in an amount no less than a reasonable royalty, together with prejudgment and post-judgment interest, in an amount according to proof;

C. Adjudging, finding, and declaring that LG’s infringement is willful and enhanced damages and fees as a result of that willfulness under 35 U.S.C. § 284;

D. Adjudging, finding, and declaring that this is an “exceptional” case pursuant to 35 U.S.C. § 285;

E. Awarding attorney’s fees, costs, or other damages pursuant to 35 U.S.C. §§ 284 or 285 or as otherwise permitted by law; and

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F. Granting GenghisComm such other further relief as is just and proper, or as the Court deems appropriate.

Dated: July 27, 2023

Respectfully submitted,

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