Outlook

GenghisComm patent portfolio

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Date Thu 11/19/2020 4:52 PM
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1 attachment (10 MB)
2020-11-19- Letter to samsung re GenghisComm.pdf;

Hi Kevin and Jamal:

Attached is a letter about GenghisComm's patent portfolio. Please let us know if Samsung would like to discuss a license.

Regards,

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November 19, 2020

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Re: *GenghisComm Holdings Patent Portfolio*

Dear Sirs:

We represent GenghisComm Holdings, LLC, the owner of the portfolio of 60+ issued patents detailed in Appendix A. In addition to those on Appendix A, nearly 40 additional and continuation patents are pending, which will disclose and teach even more technological innovation to the industry, including Samsung. Steve Shattil, Director of GenghisComm, is the named inventor on the patents and holds advanced degrees in physics and electrical engineering.

Many of GenghisComm's patents relate to signal-processing technology that Samsung includes and uses in all of its Samsung phones, tablets, netbooks, etc. (e.g. Samsung Galaxy phones, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S). Although GenghisComm did not participate in setting the standards, many of GenghisComm's patents recite features that the LTE, 4G and 5G technical specifications later incorporated.

GenghisComm's patented technology has reduced smartphone costs and improved their performance. For example, GenghisComm's patented technology has improved the power efficiency of uplink transmissions while also reducing interference, thereby improving device battery life. GenghisComm's patented technology allows for a less expensive power amplifier and battery. GenghisComm's patented technology also allows for a smaller battery, which enables today's slim smartphone form-factors. GenghisComm's pending patents will provide even more significant improvements to these technologies, which could provide Samsung additional competitive advantages and enable new and better products and services.

Others, including AT&T, Cisco, Dell, Facebook, Fujitsu, Movandi, Innowireless and others have cited the patents in this portfolio during prosecution of their own patents.

We are writing today to offer Samsung a license to this patent portfolio.

Evidence of Samsung's Use of Technology

The example claim charts at Attachments 1-5 provide examples of evidence of Samsung's use of GenghisComm's patented technology. These infringement charts include:

1. U.S. Patent 9,768,842 - Pre-coding in multi-user MIMO
2. U.S. Patent 9,800,448 - Spreading and precoding in OFDM
3. U.S. Patent 10,009,208- Spreading and precoding in OFDM
4. U.S. Patent 10,200,227 - Pre-coding in multi-user MIMO
5. U.S. Patent 10,389,568 - Single carrier frequency division multiple access baseband signal generation

All of Samsung's LTE-enabled devices use the technology recited in these GenghisComm patents and claims. Each of these charted claims are entitled to a priority date at least as early as May 14, 2002. Expiration dates for patents in GenghisComm's portfolio extend into at least 2039.

Accordingly, Samsung should be licensed to continue using GenghisComm's patented technologies. You may wish to have your patent counsel examine the patents and claim charts with respect to Samsung's devices. Please let us know once you've had an opportunity to review and consider our identified patents with reference to Samsung's products and services.

Please let us know if Samsung would like to discuss a license to this portfolio.

Very truly yours,

Enclosures

Notice

This letter shall not be construed to grant any express or implied license, authorization, covenant-not-to-sue, immunity, forbearance, indulgence, waiver, release or any other right with respect to these patents or otherwise. The owners reserve all rights with regard to its patents, including but not limited to: (1) the right to seek injunctive or other relief, including royalties or other damages going back at least as far as the last six years; (2) the right to change any royalty rates at any time; and (3) the right to change or withdraw any licensing offer at any time without notice. You should not rely on any communication, lack of communication, and/or any inactivity from Global IP Law Group or these owners as a relinquishment, acquiescence, waiver, or compromise of any of these owners' rights or as a change or withdrawal of any prior assertions stated. This letter and any subsequent related discussions do not create any obligation by the owners to proceed with any license or other contract with you. These owners reserve the right, in its sole discretion, to abandon or withdraw from at any time for any reason any discussions contemplated by this letter.

Appendix A

Country	Application No.	Patent No.	Title
US	11/187,107	8,670,390	Cooperative Beamforming in Wireless Networks
US	12/545,572	8,750,264	Cooperative Wireless Networks
US	14/168,442	8,942,082	Cooperative Subspace Multiplexing in CDNs
US	14/275,161	9,042,333	Cooperative Wireless Networks
US	14/276,309	9,048,897	Cooperative Wireless Networks
US	14/511,585	9,136,931	Cooperative Wireless Networks
US	14/164,253	9,225,471	Cooperative Subspace Multiplexing in Comm Nets
US	14/164,254	9,270,421	Cooperative Subspace Demultiplexing in Comm Nets
US	13/647,686	9,325,805	Content Delivery in Wireless Wide Area Networks
US	14/498,499	9,473,226	Sharing Resources Between Wireless Networks
US	14/967,633	9,485,063	Pre-Coding in Multi-User MIMO
US	15/149,382	9,628,231	Spreading and Precoding in OFDM
US	15/283,881	9,768,842	Pre-Coding in Multi-User MIMO
US	15/075,975	9,774,505	Content Delivery in Wireless Wide Area Networks
US	15/218,609	9,798,329	Airborne Relays in Cooperative MIMO
US	15/489,664	9,800,448	Spreading and Precoding in OFDM
US	15/076,000	9,806,953	Content Delivery in Wireless Wide Area Networks
US	14/168,466	9,819,449	Cooperative Subspace Demultiplexing in CDNs
US	14/980,493	9,844,061	LPI/LPD Communication Systems
US	14/709,936	9,893,774	Cloud Radio Access Network
US	15/618,888	9,967,007	Cooperative Wireless Networks
US	15/644,209	10,009,208	Spreading and Precoding in OFDM
US	15/642,850	10,015,034	Spreading and Precoding in OFDM
US	15/268,992	10,015,801	Sharing Resources Between Wireless Networks
US	15/152,028	10,021,175	Edge Server Selection for Device-

Country	Application No.	Patent No.	Title
			Specific Network Topologies
US	15/792,122	10,038,584	Spreading and Precoding in OFDM
US	15/406,926	10,142,082	Pre-Coding in OFDM
US	16/027,007	10,158,617	Sharing Resources Between Wireless Networks
US	15/396,567	10,200,227	Pre-Coding in Multi-User MIMO
US	15/295,271	10,211,892	Spread-OFDM Receiver
US	16/026,001	10,230,559	Spreading and Precoding in OFDM
US	16/021,001	10,243,773	Efficient Peak-to-Average-Power Reduction for OFDM and MIMO-OFDM
US	15/810,760	10,305,636	Cooperative MIMO
US	14/789,949	10,355,720	Distributed Software-Defined Radio
US	15/786,270	10,389,568	Single carrier frequency division multiple access baseband signal generation
US	16/030,852	10,419,533	Edge Server Selection for Device-Specific Network Topologies
US	14/733,013	10,425,135	Coordinated Multipoint Systems
US	16/199,199	10,444,766	Airborne Relays in Cooperative MIMO
US	16/263,970	10,447,520	Efficient Peak-to-Average-Power Reduction for OFDM and MIMO-OFDM
US	15/347,415	10,499,409	Cooperative and Parasitic Radio Access Networks
US	16/364,734	10,505,774	Efficient Peak-to-Average-Power Reduction for OFDM and MIMO-OFDM
US	15/785,692	10,514,709	Airborne Relays in Cooperative MIMO
US	16/027,191	10,574,497	Spreading and Precoding in OFDM
US	15/810,828	10,587,369	Cooperative Subspace Multiplexing
US	16/393,877	10,637,544	Distributed Radio System
US	15/988,898	10,637,705	Peak-to-Average-Power Reduction for OFDM Multiple Access
US	16/199,221	10,644,916	Spreading and Precoding in OFDM
US	10/145,854	10,673,758	Carrier Interferometry Networks
US	16/709,093	10,728,074	Efficient Peak-to-Average-Power

Country	Application No.	Patent No.	Title
			Reduction for OFDM and MIMO-OFDM
US	16/569,033	10,735,503	Content Delivery in Wireless Wide Area Networks
US	16/426,240	10,778,492	Single carrier frequency division multiple access baseband signal generation
US	16/502,700	10,797,732	Distributed Antenna Systems
US	16/502,723	10,797,733	Distributed Antenna Systems
US	16/779,659	10,797,766	Distributed Radio System
US	13/116,984	10,014,882	Method and Apparatus for Fast Prototyping of Wireless Transceivers
US	16/442,493	10,756,790	Distributed Radio System
US	15/973,523	10,840,978	Cooperative Wireless Networks
US	10/131,163	7,430,257	Multicarrier Sub-layer
US	11621014	7,593,449	Multicarrier Sub-layer
US	12/328,917	7,965,761	Multicarrier Sub-layer
AU	2016297892	2016297892	Airborne Relays in Cooperative MIMO

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U.S. Patent No. 9,768,842: Samsung LTE-enabled devices[1]

Claim 1	Analysis	Select Evidence
An OFDM transmitter, comprising:	Samsung LTE-enabled devices ("Samsung devices") include at least one OFDM transmitter which provides LTE capability that meets every element of claim 1. (Continued on next page)	Galaxy S20 FE 5G | S20 5G | S20+ 5G | S20 Ultra 5G — From $10.84/mo for HIGHLIGHTS DESIGN CAMERA MODELS S20 FE 5G SPECS ACCESSORIES COMPARE LTE Enhanced 4x4 MIMO, Up to 7CA, LTE Cat.20 Up to 2.0Gbps Download / Up to 150Mbps Upload Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network Number of SIM: Single-SIM SIM Slot Type: SIM 1 + MicroSD Network/Bearer (S/W Enabled) 3G UMTS: B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE: B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network/Bearer (S/W Enabled) 3G UMTS: B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE: B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Book S GALAXY BOOK S DESIGN PERFORMANCE CONNECTIVITY ACCESSORIES SPECS Network: LTE Cat.18 Nano SIM *May differ by region, country, market and mobile operator. Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

[1] This chart applies to all Samsung LTE-enabled devices, including, but not limited to, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled phone, watch, laptop and tablet, infringe this patent in a substantially similar, if not identical, manner.

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IPR2025-00788, 10,389,568
GC EX2001

Claim 1	Analysis	Select Evidence
	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that Samsung devices must include an OFDM (orthogonal frequency division multiplexing) transmitter.	GSM was developed to carry real time services, in a circuit switched manner (blue in figure 1), with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (green in figure 1) solution was taken with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). To reach higher data rates in UMTS (Universal Mobile Terrestrial System) a new access technology WCDMA (Wideband Code Division Multiple Access) was developed. The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for datacom services (black in figure 1). In UMTS the IP address is allocated to the UE when a datacom service is established and released when the service is released. Incoming datacom services are therefore still relying upon the circuit switched core for paging. The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected viathe X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte

Samsung v. GenghisComm
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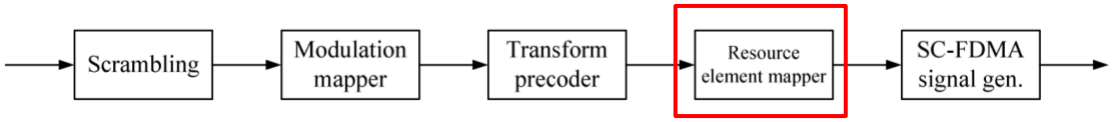
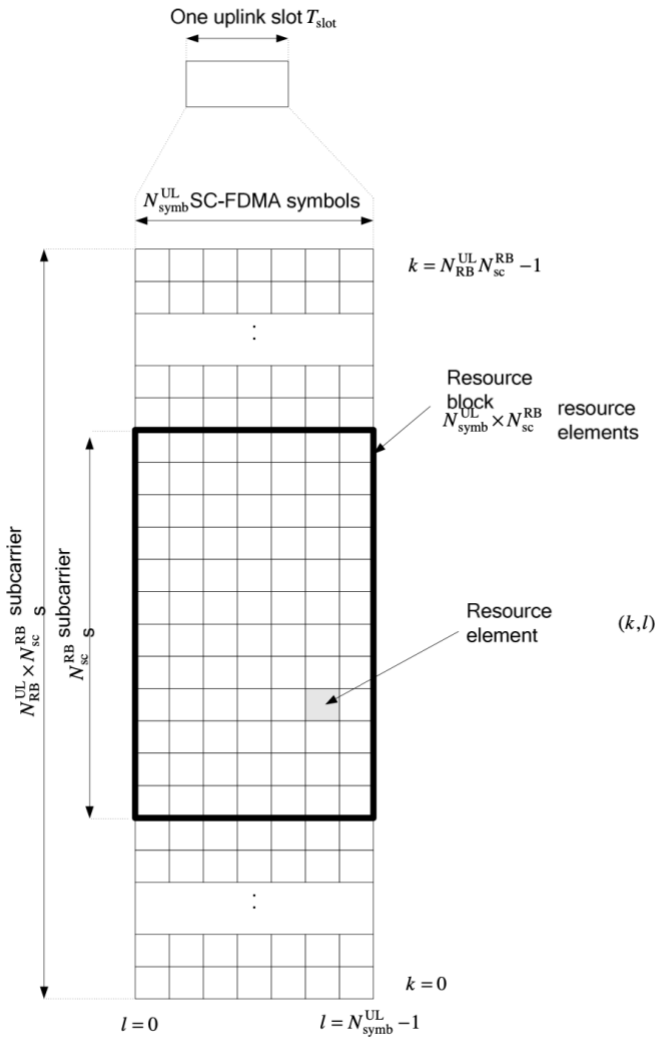
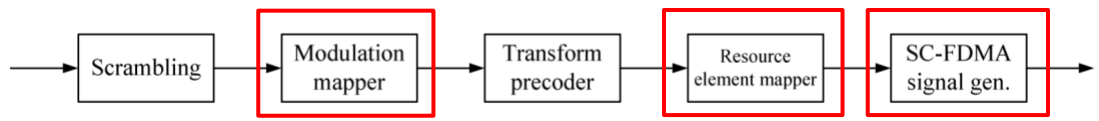
GC EX2001

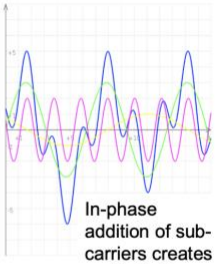
Claim 1	Analysis	Select Evidence
an OFDM spreader configured to spread a plurality of data symbols with Fourier coefficients to generate a discrete Fourier Transform (DFT)-spread data signal;	The transmitter in Samsung devices includes an OFDM spreader configured to spread a plurality of data symbols with Fourier coefficients to generate a discrete Fourier Transform (DFT)-spread data signal. As shown to the right, the LTE specification requires transform precoding that is applied using a Fourier transform. Application of the precoding transform (e.g., Samsung devices' transmitter) "result[s] in a block of complex-valued symbols" to be spread onto an uplink resource (shown below).	**5.1.1 Physical channels** An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined: - Physical Uplink Shared Channel, PUSCH - Physical Uplink Control Channel, PUCCH - Physical Random Access Channel, PRACH * * * * **5.1.2 Physical signals** An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined: - Reference signal * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
a mapper configured to map the DFT-spread data signal to a plurality of OFDM subcarriers; and	The transmitter in Samsung devices includes a mapper configured to map the DFT-spread data signal to a plurality of OFDM subcarriers. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to map the DFT-spread data signals (e.g., the complex-valued symbols discussed above) to multiple subcarriers.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, the LTE-defined uplink resource grid includes "SC-FDMA symbols" generated using the DFT discussed above. The symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

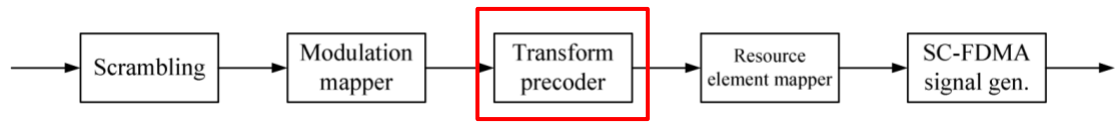
Claim 1	Analysis	Select Evidence
an OFDM modulator configured to modulate the DFT-spread data signal onto the plurality of OFDM subcarriers to produce an OFDM transmission signal comprising a superposition of the OFDM subcarriers,	The transmitter in Samsung devices includes an OFDM modulator configured 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. As shown to the right, to comply with LTE standards, the OFDM modulator in Samsung devices must be able to modulate the DFT-spread data signals (e.g., the complex-valued symbols discussed above) onto multiple subcarriers to produce an OFDM transmission signal (e.g., SC-FDMA baseband signal as described in section 5.6 of LTE standard) for each antenna port. As is known in the art, the superposition of subcarriers is the complex-valued time-domain OFDM signal, which is the sum of OFDM subcarriers.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** **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. **Table 5.3.2-1: Uplink modulation schemes** Physical channel: **PUSCH** — Modulation schemes: **QPSK, 16QAM, 64QAM** **5.4.3 Mapping to physical resources** The block of complex-valued symbols $z(i)$ shall be multiplied with the amplitude scaling factor β_{PUCCH} in order to conform to the transmit power P_{PUCCH} specified in Section 5.1.2.1 in [4], and mapped in sequence starting with $z(0)$ to resource elements. PUCCH uses one resource block in each of the two slots in a subframe. Within the physical resource block used for transmission, the mapping of $z(i)$ to resource elements (k,l) not used for transmission of reference signals shall be in increasing order of first k, then l and finally the slot number, starting with the first slot in the subframe.

Claim 1	Analysis	Select Evidence
	During SC-FDMA baseband signal generation, the DFT-spread data signals are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. **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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein the OFDM spreader is configured to provide the superposition with a reduced peak-to-average power ratio.	As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal EE Times powered by techonline Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

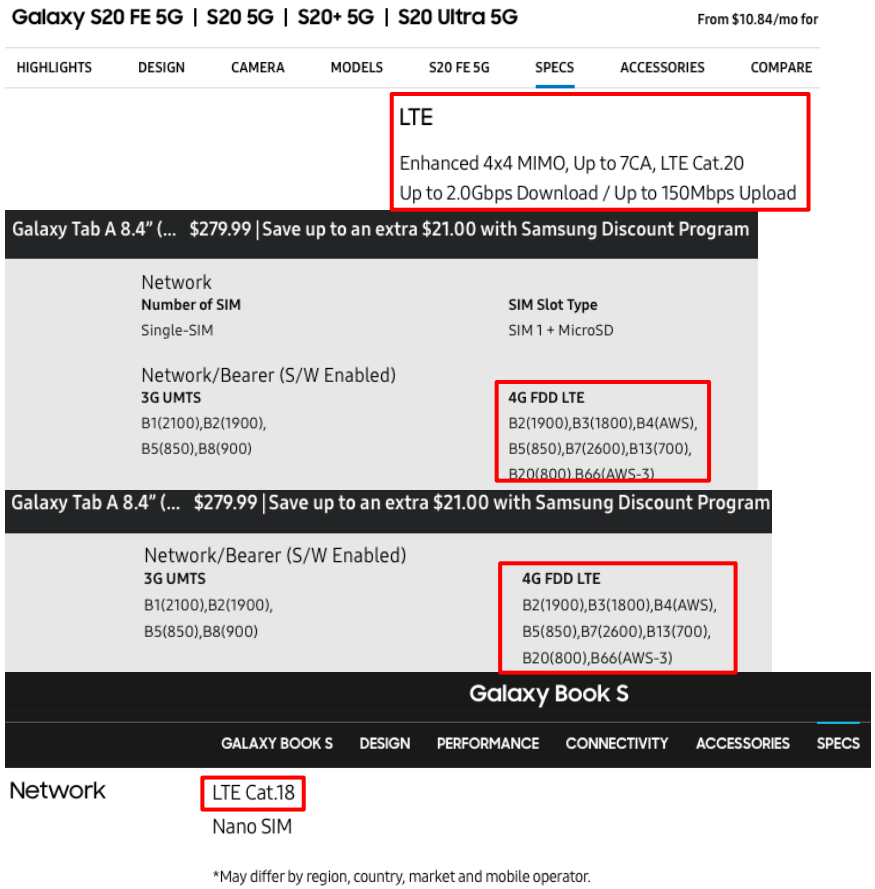
Claim 3	Analysis	Select Evidence
The OFDM transmitter recited in claim 1, wherein the OFDM modulator comprises an inverse fast Fourier transform.	Samsung devices include an OFDM transmitter described in claim 1 wherein the OFDM modulator comprises an inverse fast Fourier transform. As shown to the right, to comply with LTE standards, the OFDM modulator in Samsung devices must comprise an inverse fast Fourier transform to produce the time-continuous signal $S_l(t)$ in SC-FDMA as described in section 5.6 of the LTE Standard.	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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 7	Analysis	Select Evidence
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.	Samsung devices include an OFDM transmitter described in claim 1 further comprising a cyclic prefix appender configured to append at least a cyclic prefix, to the OFDM transmission signal. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must include a cyclic prefix appender configured to append at least a cyclic prefix as described in section 5.2 of the LTE Standard.	**Table 4.2-1: Configuration of special subframe (lengths of DwPTS/GP/UpPTS).** Special subframe configuration; Normal cyclic prefix in downlink: DwPTS, UpPTS (Normal cyclic prefix in uplink, Extended cyclic prefix in uplink); Extended cyclic prefix in downlink: DwPTS, UpPTS (Normal cyclic prefix in uplink, Extended cyclic prefix in uplink) 0: $6592 \cdot T_s$; $7680 \cdot T_s$ 1: $19760 \cdot T_s$; $20480 \cdot T_s$; $2192 \cdot T_s$; $2560 \cdot T_s$ 2: $21952 \cdot T_s$; $2192 \cdot T_s$; $2560 \cdot T_s$; $23040 \cdot T_s$ 3: $24144 \cdot T_s$; $25600 \cdot T_s$ 4: $26336 \cdot T_s$; $7680 \cdot T_s$ 5: $6592 \cdot T_s$; $20480 \cdot T_s$; $4384 \cdot T_s$; $5120 \cdot T_s$ 6: $19760 \cdot T_s$; $23040 \cdot T_s$; $4384 \cdot T_s$; $5120 \cdot T_s$ 7: $21952 \cdot T_s$; - ; - ; - 8: $24144 \cdot T_s$; - ; - ; - * * * * ## 5.2 Slot structure and physical resources ### 5.2.1 Resource grid The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 8	Analysis	Select Evidence
The OFDM transmitter recited in claim 1, wherein the OFDM spreader is configured to provide channel precoding.	Samsung devices include an OFDM transmitter described in claim 1 wherein the OFDM spreader is configured to provide channel precoding. As shown to the right, SC-FDMA signal generation includes a transform precoding step.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

GLOBAL IP LAW GROUP

U.S. Patent No. 9,800,448: Samsung LTE-enabled devices[1]

Claim 1	Analysis	Select Evidence
An apparatus, comprising:	Samsung LTE-enabled devices ("Samsung devices") include an LTE chip for transmitting and receiving cellular LTE signals.	 Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

[1] This chart applies to all Samsung LTE-enabled devices, including, but not limited to, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled phone, watch, laptop and tablet, infringe this patent in a substantially similar, if not identical, manner.

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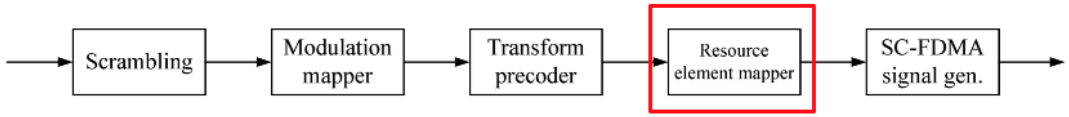
IPR2025-00788, 10,389,568
GC EX2001

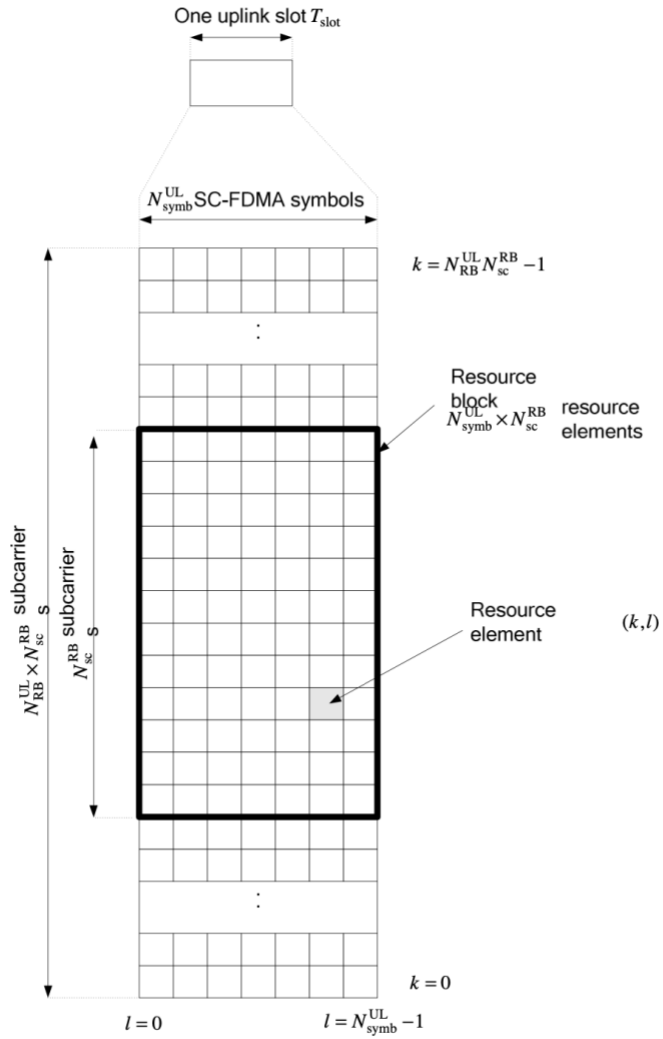
Claim 1	Analysis	Select Evidence
	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that Samsung devices must be able to handle OFMDA transmissions.	GSM was developed to carry real time services, in a circuit switched manner (blue in figure 1), with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (green in figure 1) solution was taken with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). To reach higher data rates in UMTS (Universal Mobile Terrestrial System) a new access technology WCDMA (Wideband Code Division Multiple Access) was developed. The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for datacom services (black in figure 1). In UMTS the IP address is allocated to the UE when a datacom service is established and released when the service is released. Incoming datacom services are therefore still relying upon the circuit switched core for paging. The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected viathe X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte

Samsung v. GenghisComm
IPR2025-00788, 10,389,568
GC EX2001

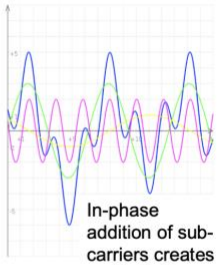
Claim 1	Analysis	Select Evidence
a transform precoder operable to spread a plurality of data symbols with a plurality of orthogonal spreading codes comprising complex-valued coefficients of a discrete Fourier transform (DFT) to produce a plurality of spread symbols;	To comply with the LTE specification for uplink physical channels, Samsung devices must include a transform precoder. The transform precoder is used to apply complex-valued coefficients (e.g., "complex-valued symbols") to OFDM subcarriers (discussed below). The complex-valued coefficients are values in a discrete Fourier transform. As known in the art, one property of the DFT matrix[2] is that it is an orthogonal matrix, thus the symbols will be orthogonally spread.	**5.1.1 Physical channels** An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined: - Physical Uplink Shared Channel, PUSCH - Physical Uplink Control Channel, PUCCH - Physical Random Access Channel, PRACH * * * * **5.1.2 Physical signals** An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined: - Reference signal * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

[2] See e.g., https://www2.math.uconn.edu/~olshevsky/classes/2018_Spring/math3511/FFT.pdf for a general description of DFT matrix.

Claim 1	Analysis	Select Evidence
a multiple access resource mapper responsive to an assignment of spectrum resources to the apparatus for selecting a plurality of orthogonal frequency division multiplexing (OFDM) subcarriers corresponding to at least one OFDM symbol interval; and	To comply with the LTE specification for uplink physical channels, Samsung devices must include a multiple access resource mapper. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to map the DFT-spread data signals (e.g., the complex-valued symbols discussed above) to multiple subcarriers. Symbols are mapped "to physical resource blocks assigned for transmission of PUSCH."	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, the LTE-defined uplink resource grid includes "SC-FDMA symbols" generated using the DFT discussed above. The symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
a signal generator operable to generate an OFDM signal comprising a superposition of the plurality of OFDM subcarriers modulated by the spread symbols,	To comply with the LTE specification for uplink physical channels, Samsung devices must include a signal generator. As shown to the right, the LTE specification requires SC-FDMA baseband signal generation, requiring a signal generator. During SC-FDMA baseband signal generation, the DFT-spread symbols are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB} / 2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein the transform precoder generates the plurality of orthogonal spreading codes to provide the superposition with a reduced peak-to-average-power ratio;	As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal EE Times techonline Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

Claim 1	Analysis	Select Evidence
and wherein one of the plurality of spread symbols is expressed by: $z(l * M_{sc}^{PUSCH} + k) = \frac{1}{\sqrt{M_{sc}^{PUSCH}}} \sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l * M_{sc}^{PUSCH} + i) e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$	As shown to the right, LTE transform precoding to generate spread symbols (e.g., SC-FDMA symbols) uses the claimed formula.	**5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$ $l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein M_{sc}^{PUSCH} is a DFT length corresponding to the plurality of orthogonal spreading codes,	As shown to the right and as discussed above, M_{sc}^{PUSCH} is used in the DFT to generate SC-FDMA symbols, and is the scheduled bandwidth for uplink transmission, expressed as a number of subcarriers. M_{sc}^{PUSCH} is the total number of OFDM subcarriers and represents the DFT length. Since the DFT length of each code equals M_{sc}^{PUSCH}, each spreading code causes each of the plurality of data symbols to be spread over all of the OFDM subcarriers.	M_{sc}^{PUSCH} Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers * * * * 5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{symb}-1)$ is divided into M_{symb}/M_{sc}^{PUSCH} sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $z(l\cdot M_{sc}^{PUSCH}+k)=\frac{1}{\sqrt{M_{sc}^{PUSCH}}}\sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l\cdot M_{sc}^{PUSCH}+i)e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$ $k=0,\ldots,M_{sc}^{PUSCH}-1$ $l=0,\ldots,M_{symb}/M_{sc}^{PUSCH}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{symb}-1)$. 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 $M_{RB}^{PUSCH}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\le N_{RB}^{UL}$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
l is an index spanning 0 to a number of symbol intervals minus one,	As shown to the right: $l = 0, \ldots, M_{symb}/M_{sc}^{PUSCH} - 1$ where $M_{symb}/M_{sc}^{PUSCH} - 1$ is the number of SC-FDMA symbol intervals in an uplink slot. That is, l is an index spanning from 0 to a number of SC-FDMA symbols minus one.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$\boxed{l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1}$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
k is an index spanning zero to the DFT length M_{sc}^{PUSCH} minus one,	As shown to the right: $k = 0, \ldots, M_{sc}^{PUSCH} - 1$ where M_{sc}^{PUSCH} is the DFT length. That is, k is an index spanning from zero to the DFT length minus one.	**5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$\boxed{k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1}$$ $$l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
i is an index spanning zero to the DFT length M_{sc}^{PUSCH} minus one, d(i) is an ith one of the plurality of data symbols,	As expressed in the summation shown to the right, *i* is an integer-valued index that spans 0 to $M_{sc}^{PUSCH} - 1$, where M_{symb} identifies the number of data symbols. d(i) corresponds to an ith data symbol within the block of data symbols.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

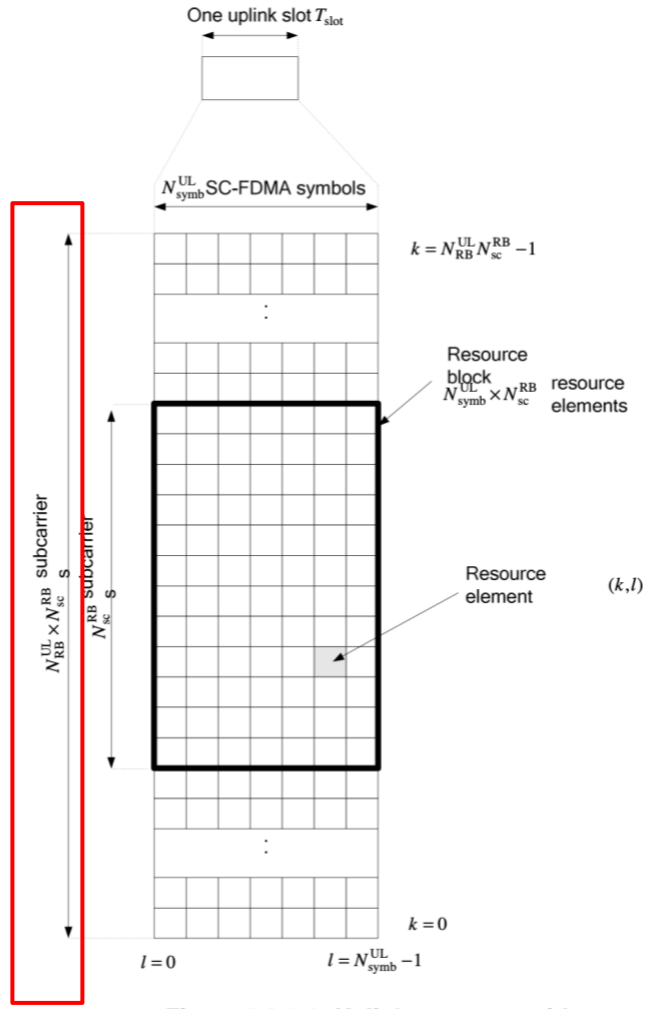
Claim 1	Analysis	Select Evidence
e is natural log, $j = \sqrt{-1}$, and π is mathematical constant Pi.	As is known in the art, *e* is natural log, $j = \sqrt{-1}$, and π is the mathematical constant Pi.	**5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the transform precoder is configured to segment the plurality of data symbols into a plurality of blocks, each of the plurality of blocks being processed by a DFT.	As shown to the right, transform precoding applies a DFT (discrete Fourier transform) "resulting in a block of complex-valued symbols…."	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 4	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the multiple access resource mapper 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, and a frequency-hopping scheme.	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that the resource mapper selects from the plurality of OFDM subcarriers according to at least a frequency division multiple access scheme. SC-FDMA stands for single carrier ***frequency division multiple access***.	The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

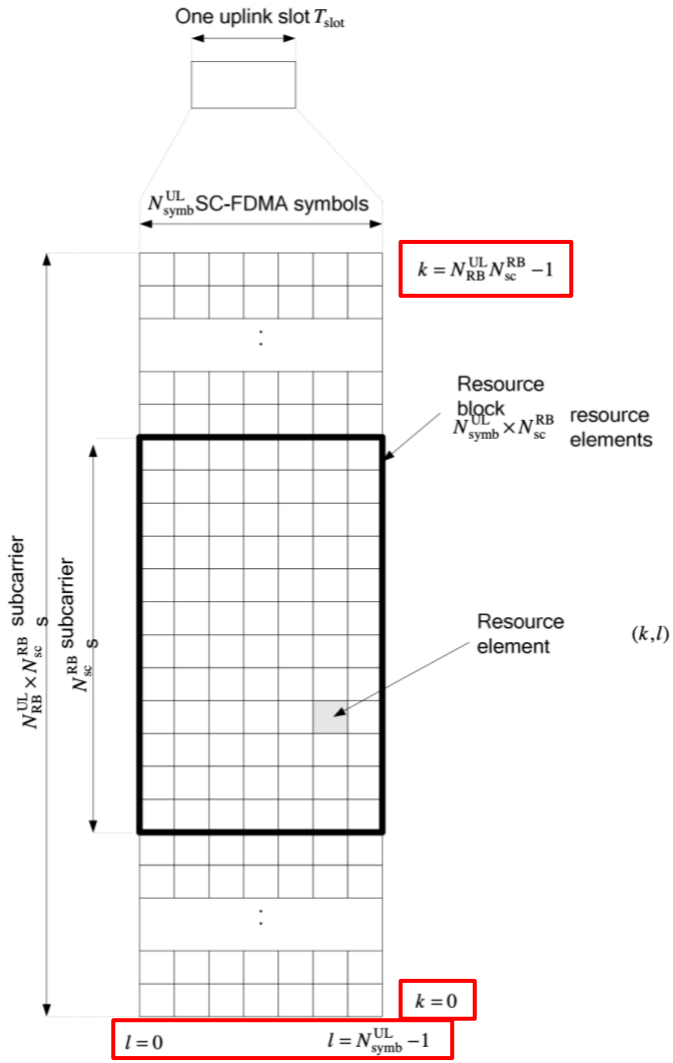
Claim 5	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the signal generator is operable to perform an inverse fast Fourier transform.	Samsung devices include an OFDM transmitter described in claim 1 wherein the OFDM modulator comprises an inverse fast Fourier transform. As shown to the right, to comply with LTE standards, the OFDM modulator in Samsung devices must comprise an inverse DFT to produce the time-continuous signal $S_l(t)$ in SC-FDMA as described in section 5.6 of the LTE Standard. The inverse fast Fourier transform is an algorithmically efficient way of performing the inverse DFT, and it is used universally in OFDM modulators.	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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the superposition comprises a time-continuous signal $s_l(t)$ in symbol interval *l* as a function of time *t*, expressed by: $s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} e^{j2\pi(k+1/2)\Delta f(t - N_{CP,l} T_s)}$, where NB $[N_{RB}^{UL}]$ denotes a transmission bandwidth of the signal $s_l(t)$	As shown to the right, the LTE specification's SC-FDMA baseband signal generation generates a time-continuous signal according to the claimed equation. N_{RB}^{UL} is the uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}.	**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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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. * * * * N_{RB}^{UL} Uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB} Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
and N_{sc}^{RB} denotes a number of OFDM subcarriers per unit of transmission bandwidth such that $N_{RB}^{UL} N_{sc}^{RB}$ equals a total number of the OFDM subcarriers in the superposition,	As shown to the right, N_{sc}^{RB} is a resource block size in the frequency domain expressed as a number of subcarriers. As shown to the right, the total number of subcarriers in the superposition is $N_{RB}^{UL} N_{sc}^{RB}$.	N_{sc}^{RB} Resource block size in the frequency domain, expressed as a number of subcarriers * * * *  **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
k is an index that indicates a range of a summation, $k(-) = k + N_{RB}^{UL} N_{sc}^{RB}/2$, $a_{k,l}$ is a value modulated onto a kth subcarrier in a symbol period *l*, *e* is natural log, $j = \sqrt{-1}$, π is mathematical constant Pi, Δf denotes subcarrier frequency spacing, $N_{CP,l}$ denotes cyclic prefix length in number of time units T_s for symbol interval *l*;	As shown to the right, *k* indicates the range of the summation used in baseband signal generation. As shown to the right, $k(-) = k + N_{RB}^{UL} N_{sc}^{RB}/2$. As shown to the right, $a_{k,l}$ is the content (i.e., a value) of a resource that is modulated onto a kth subcarrier in a symbol period *l*. *k* corresponds to a frequency domain index of the subcarrier, and *l* corresponding to a time domain index (symbol period). As is known in the art, *e* is the natural log, $j = \sqrt{-1}$, and π is mathematical constant Pi. As shown to the right, Δf is "subcarrier spacing." As shown to the right, $N_{CP,l}$ is a "downlink cyclic prefix length for OFDM symbol *l* in a slot," where *l* is the time-domain index value for a resource element. The basic time unit is T_s.	**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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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. * * * * Δf Subcarrier spacing * * * * $N_{CP,l}$ Downlink cyclic prefix length for OFDM symbol l in a slot * * * * (k,l) Resource element with frequency-domain index k and time-domain index l * * * * T_s Basic time unit Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
wherein $a_{k,l}$ comprises a one of the plurality of code symbols corresponding to a kth subcarrier symbol in period *l*.	As shown to the right, $a_{k,l}$ "is the content [or value] of resource element (*k*,*l*)." As discussed above, *l* is time domain index.	**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. * * * * $a_{k,l}^{(p)}$ Value of resource element (k,l) [for antenna port p] * * * * (k,l) Resource element with frequency-domain index k and time-domain index l Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
	As shown to the right, resource elements are included in a resource block, with the resource block defined in terms of the frequency (k) and time (l) domain, such that $a_{k,l}$ is the value of a resource element for each k subcarrier for a given time index l.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

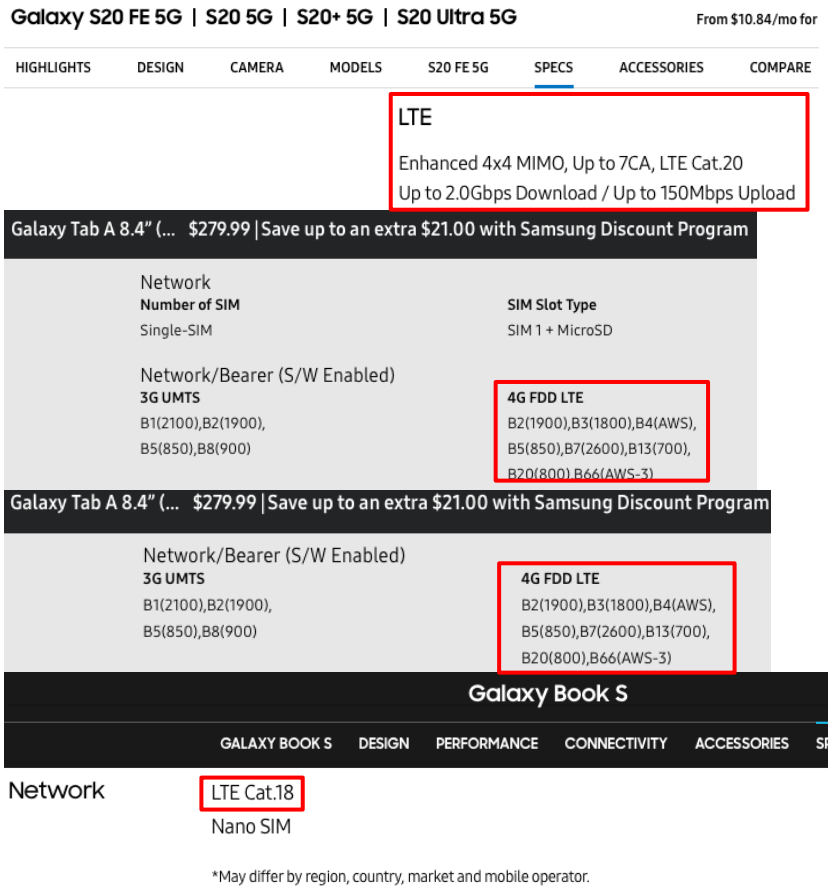
Claim 7	Analysis	Select Evidence
The apparatus recited in claim 1, further comprising a modulator configured to form each of the plurality of data symbols from a plurality of data bits.	Samsung devices include a modulator for forming the plurality of data symbols from a plurality of data bits. As shown to the right, the LTE specification requires modulating "the block of scrambled bits…resulting in a block complex-valued symbols…."	5.3.2 Modulation The block of scrambled bits $\tilde{b}(0),...,\tilde{b}(M_{bit}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),...,d(M_{symb}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel. **Table 5.3.2-1: Uplink modulation schemes** Physical channel: **PUSCH** — Modulation schemes: **QPSK, 16QAM, 64QAM** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 8	Analysis	Select Evidence

The apparatus recited in claim 7, further comprising a pseudo-noise scrambler configured to encode the plurality of data bits with a pseudo-noise code.	Samsung devices include a pseudo-noise scrambler.
	
	As shown to the right, the LTE specification require scrambling a block of bits using "a UE-specific scrambling sequence…resulting in a block of scrambled bits…according to the following pseudo code…."
		5.3.1 Scrambling
		
		The block of bits $b(0),...,b(M_{bit}-1)$, 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 $\tilde{b}(0),...,\tilde{b}(M_{bit}-1)$ according to the following pseudo code
		
		Set $i = 0$
		while $i < M_{bit}$
		if $b(i) = \mathbf{x}$ // ACK/NAK or Rank Indication placeholder bits
		$\tilde{b}(i) = 1$
		else
		if $b(i) = y$ // ACK/NAK or Rank Indication repetition placeholder bits
		$\tilde{b}(i) = \tilde{b}(i-1)$
		Else // Data or channel quality coded bits, Rank Indication coded bits or ACK/NAK coded bits
		$\tilde{b}(i) = (b(i) + c(i)) \bmod 2$
		* * * *
		end if
		end if
		$i = i + 1$
		end while
		
		where **x** and y are tags defined in [3] section 5.2.2.6 and where the scrambling sequence $c(i)$ is given by Section 7.2. The scrambling sequence generator shall be initialised with $c_{init} = n_{RNTI} \cdot 2^{14} + \lfloor n_s/2 \rfloor \cdot 2^9 + N_{ID}^{cell}$ at the start of each subframe where n_{RNTI} corresponds to the RNTI associated with the PUSCH transmission as described in Section 8[4].
		Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

GLOBAL IP LAW GROUP

U.S. Patent No. 10,009,208: Samsung LTE-enabled devices[1]

Claim 1	Analysis	Select Evidence
An apparatus, comprising:	Samsung LTE-enabled devices ("Samsung devices") includes an LTE chip for transmitting and receiving cellular LTE signals.	 Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

[1] This chart applies to all Samsung LTE-enabled devices, including, but not limited to, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled phone, watch, laptop and tablet, infringe this patent in a substantially similar, if not identical, manner.

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Claim 1	Analysis	Select Evidence
	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that Samsung devices must be able to handle OFMDA transmissions.	GSM was developed to carry real time services, in a circuit switched manner (blue in figure 1), with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (green in figure 1) solution was taken with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). To reach higher data rates in UMTS (Universal Mobile Terrestrial System) a new access technology WCDMA (Wideband Code Division Multiple Access) was developed. The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for datacom services (black in figure 1). In UMTS the IP address is allocated to the UE when a datacom service is established and released when the service is released. Incoming datacom services are therefore still relying upon the circuit switched core for paging. The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected viathe X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte

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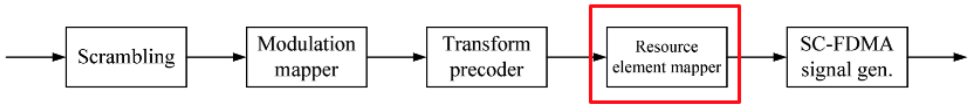
Claim 1	Analysis	Select Evidence
a transform precoder operable to spread a plurality of data symbols with a plurality of orthogonal spreading codes comprising complex-valued coefficients of a discrete Fourier transform (DFT) to produce a plurality of spread symbols;	To comply with the LTE specification for uplink physical channels, Samsung devices must include a transform precoder. The transform precoder is used to apply complex-valued coefficients (e.g., "complex-valued symbols") to OFDM subcarriers (discussed below). The complex-valued coefficients are part of a discrete Fourier transform. As known in the art, one property of the DFT matrix[2] is that it is an orthogonal matrix, thus the symbols will be orthogonally spread.	**5.1.1 Physical channels** An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined: - Physical Uplink Shared Channel, PUSCH - Physical Uplink Control Channel, PUCCH - Physical Random Access Channel, PRACH * * * * **5.1.2 Physical signals** An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined: - Reference signal * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

[2] See e.g., https://www2.math.uconn.edu/~olshevsky/classes/2018_Spring/math3511/FFT.pdf for a general description of DFT matrix.

Claim 1	Analysis	Select Evidence
a multiple access resource mapper responsive to an assignment of spectrum resources to the apparatus for selecting a plurality of orthogonal frequency division multiplexing (OFDM) subcarriers corresponding to at least one OFDM symbol interval; and	To comply with the LTE specification for uplink physical channels, Samsung devices must include a multiple access resource mapper. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to map the DFT-spread data signals (e.g., the complex-valued symbols discussed above) to multiple subcarriers. Symbols are mapped "to physical resource blocks assigned for transmission of PUSCH."	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

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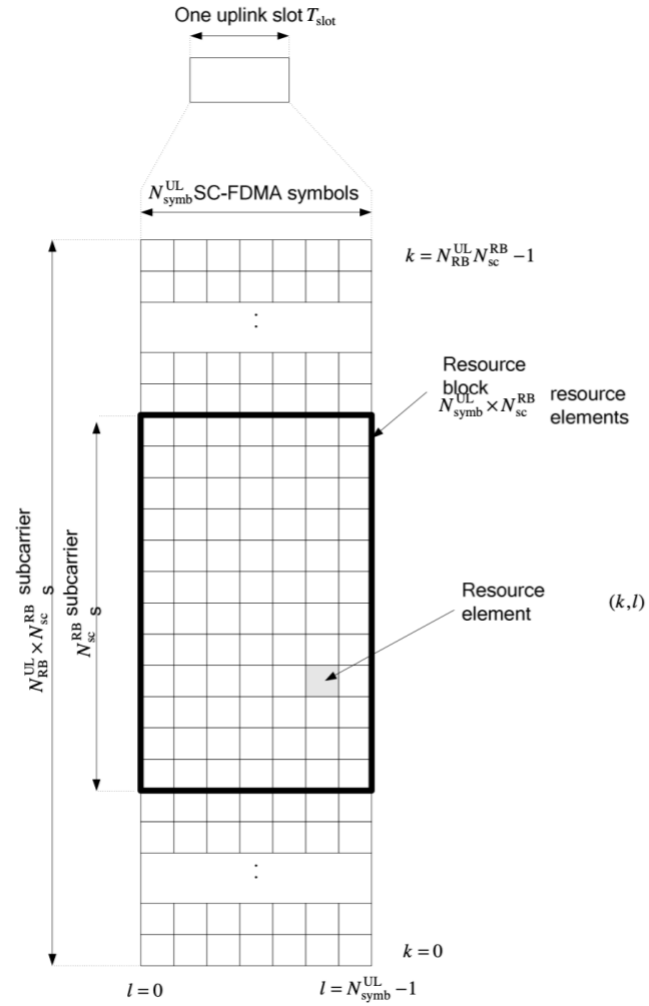
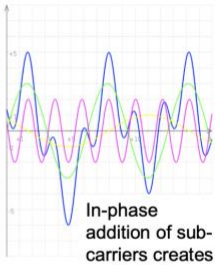
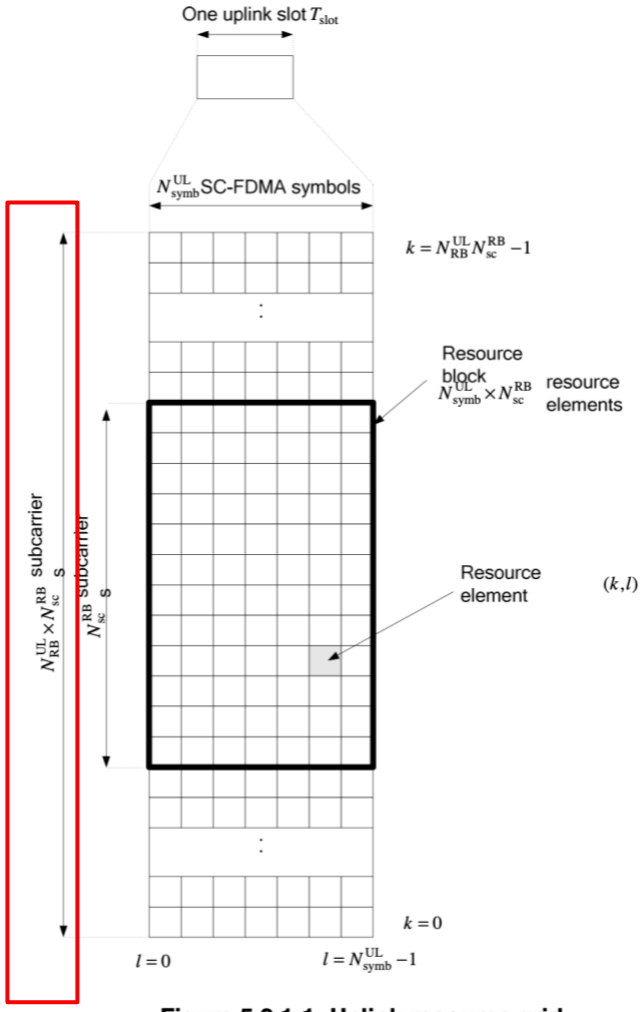
Claim 1	Analysis	Select Evidence
	As shown to the right, the LTE-defined uplink resource grid includes "SC-FDMA symbols" generated using the DFT discussed above. The symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
a signal generator operable to generate an OFDM signal comprising a superposition of the plurality of OFDM subcarriers modulated by the spread symbols,	To comply with the LTE specification for uplink physical channels, Samsung devices must include a signal generator. As shown to the right, the LTE specification requires SC-FDMA baseband signal generation, requiring a signal generator. During SC-FDMA baseband signal generation, the DFT-spread symbols are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein the transform precoder generates the plurality of orthogonal spreading codes to provide the superposition with a reduced peak-to-average-power ratio;	As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal EETimes techonline Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

Claim 1	Analysis	Select Evidence
and wherein the superposition comprises a time-continuous signal $s_l(t)$ in symbol interval l as a function of time t, expressed by: $s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor - 1} a_{k^{(-)},l} e^{j2\pi(k+1/2)\Delta f(t - N_{CP,l} T_s)}$, where N_{RB}^{UL} denotes a transmission bandwidth of the signal $s_l(t)$	As shown to the right, the LTE specification's SC-FDMA baseband signal generation generates a time-continuous signal according to the claimed equation. N_{RB}^{UL} is the uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}.	**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. * * * * N_{RB}^{UL} Uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB} Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
and N_{sc}^{RB} denotes a number of OFDM subcarriers per unit of transmission bandwidth such that $N_{RB}^{UL}N_{sc}^{RB}$ equals a total number of the OFDM subcarriers in the superposition,	As shown to the right, N_{sc}^{RB} is a resource block size in the frequency domain expressed as a number of subcarriers. As shown to the right, the total number of subcarriers in the superposition is $N_{RB}^{UL}N_{sc}^{RB}$.	N_{sc}^{RB} Resource block size in the frequency domain, expressed as a number of subcarriers * * * *  **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
k is an index that indicates a range of a summation, $k^{(-)} = k + N_{RB}^{UL} N_{sc}^{RB}/2$, $a_{k,l}$ is a value modulated onto a kth subcarrier in a symbol period l,	As shown to the right, *k* indicates the range of the summation used in baseband signal generation. As shown to the right, $k(-) = k + N_{RB}^{UL} N_{sc}^{RB}/2$. As shown to the right, $a_{k,l}$ is the content (i.e., a value) of a resource that is modulated onto a kth subcarrier in a symbol period *l*. *k* corresponds to a frequency domain index of the subcarrier, and *l* corresponding to a time domain index (symbol period).	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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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.
e is natural log, $j = \sqrt{-1}$, π is mathematical constant Pi,	As is known in the art, *e* is the natural log, $j = \sqrt{-1}$, and π is mathematical constant Pi.	* * * * Δf Subcarrier spacing * * * * $N_{CP,l}$ Downlink cyclic prefix length for OFDM symbol l in a slot * * * * (k,l) Resource element with frequency-domain index k and time-domain index l * * * * T_s Basic time unit
Δf denotes subcarrier frequency spacing, $N_{CP,l}$ denotes cyclic prefix length in number of time units T_s for symbol interval l;	As shown to the right, Δf is "subcarrier spacing." As shown to the right, $N_{CP,l}$ is a "downlink cyclic prefix length for OFDM symbol *l* in a slot," where *l* is the time-domain index value for a resource element. The basic time unit is T_s.	Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein $a_{k,l}$ comprises a one of the plurality of code symbols corresponding to a kth subcarrier symbol in period l.	As shown to the right, $a_{k,l}$ "is the content [or value] of resource element (*k,l*)." As discussed above, *l* is time domain index.	**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. * * * * $a_{k,l}^{(p)}$ Value of resource element (k,l) [for antenna port p] * * * * (k,l) Resource element with frequency-domain index k and time-domain index l Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
The apparatus recited in claim 1, - wherein one of the plurality of spread symbols is expressed by: $z(l \cdot M_{sc}^{PUSCH} + k) = \frac{1}{\sqrt{M_{sc}^{PUSCH}}} \sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l \cdot M_{sc}^{PUSCH} + i) e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$	As shown to the right, LTE transform precoding to generate spread symbols (e.g., SC-FDMA symbols) uses the claimed formula.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}} - 1$ $l = 0,\ldots,M_{\text{symb}} / M_{\text{sc}}^{\text{PUSCH}} - 1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
wherein M_{sc}^{PUSCH} is a DFT length corresponding to the plurality of orthogonal spreading codes,	As shown to the right and as discussed above, M_{sc}^{PUSCH} is used in the DFT to generate SC-FDMA symbols, and is the scheduled bandwidth for uplink transmission, expressed as a number of subcarriers. M_{sc}^{PUSCH} is the total number of OFDM subcarriers and represents the DFT length. Since the DFT length of each code equals M_{sc}^{PUSCH}, each spreading code causes each of the plurality of data symbols to be spread over all of the OFDM subcarriers.	M_{sc}^{PUSCH} Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers * * * * 5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{symb}-1)$ is divided into M_{symb}/M_{sc}^{PUSCH} sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $z(l\cdot M_{sc}^{PUSCH}+k)=\frac{1}{\sqrt{M_{sc}^{PUSCH}}}\sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l\cdot M_{sc}^{PUSCH}+i)e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$ $k=0,\ldots,M_{sc}^{PUSCH}-1$ $l=0,\ldots,M_{symb}/M_{sc}^{PUSCH}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{symb}-1)$. 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 $M_{RB}^{PUSCH}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\le N_{RB}^{UL}$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
l is an index spanning 0 to a number of symbol intervals minus one,	As shown to the right: $l = 0, \ldots, M_{symb}/M_{sc}^{PUSCH} - 1$ where $M_{symb}/M_{sc}^{PUSCH} - 1$ is the number of SC-FDMA symbol intervals in an uplink slot. That is, l is an index spanning from 0 to a number of SC-FDMA symbols minus one.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$\boxed{l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1}$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
k is an index spanning zero to the DFT length M_{sc}^{PUSCH} minus one,	As shown to the right: $k = 0, \ldots, M_{sc}^{PUSCH} - 1$ where M_{sc}^{PUSCH} is the DFT length. That is, k is an index spanning from zero to the DFT length minus one.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$\boxed{k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}} - 1}$$ $$l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}} - 1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 2	Analysis	Select Evidence
i is an index spanning zero to the DFT length M_{sc}^{PUSCH} minus one, d(i) is an ith one of the plurality of data symbols, *e* is natural log, $j = \sqrt{-1}$, and π is mathematical constant Pi.	As expressed in the summation shown to the right, *i* is an integer-valued index that spans 0 to $M_{sc}^{PUSCH} - 1$, where M_{symb} identifies the number of data symbols. d(i) corresponds to an ith data symbol within the block of data symbols. As is known in the art, *e* is natural log, $j = \sqrt{-1}$, and π is the mathematical constant Pi.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 3	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the transform precoder is configured to segment the plurality of data symbols into a plurality of blocks, each of the plurality of blocks being processed by a DFT.	As shown to the right, transform precoding applies a DFT (discrete Fourier transform) "resulting in a block of complex-valued symbols…."	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$ $l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 5	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the multiple access resource mapper 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, and a frequency-hopping scheme.	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that the resource mapper selects from the plurality of OFDM subcarriers according to at least a frequency division multiple access scheme. SC-FDMA stands for single carrier ***frequency division multiple access***.	The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte 5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
The apparatus recited in claim 1, wherein the signal generator is operable to perform an inverse fast Fourier transform.	Samsung devices includes an OFDM transmitter described in claim 1 wherein the OFDM modulator comprises an inverse fast Fourier transform. As shown to the right, to comply with LTE standards, the OFDM modulator in Samsung devices must comprise an inverse DFT to produce the time-continuous signal $S_l(t)$ in SC-FDMA as described in section 5.6 of the LTE Standard. The inverse fast Fourier transform is an algorithmically efficient way of performing the inverse DFT, and it is used universally in OFDM modulators.	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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

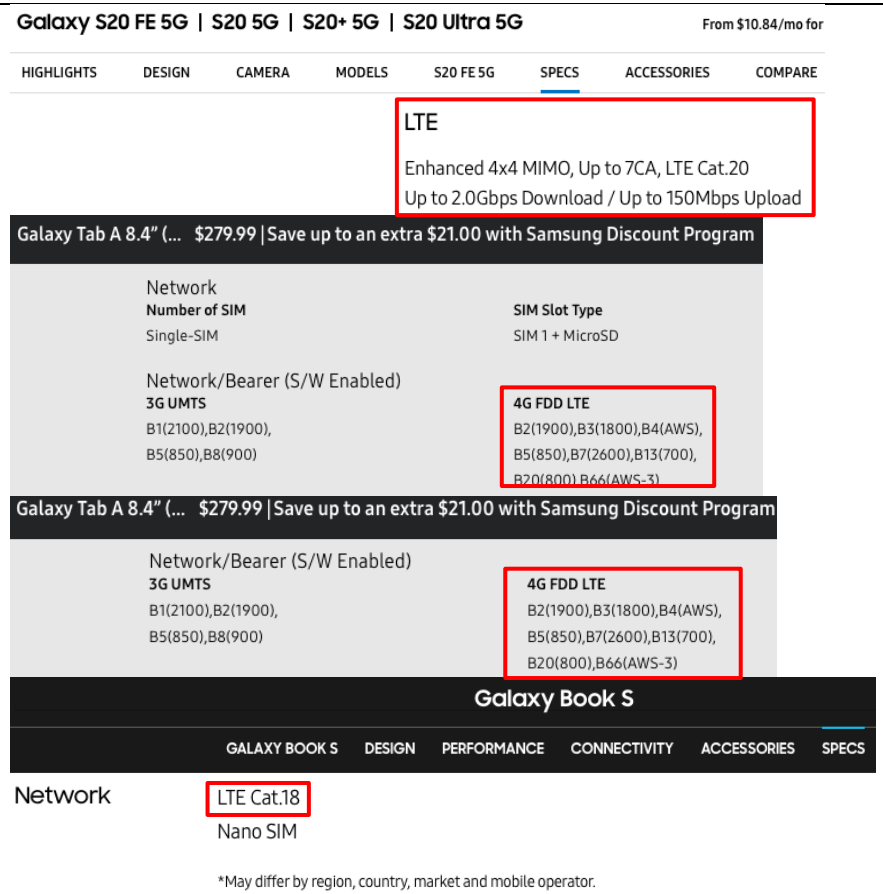
Claim 7	Analysis	Select Evidence
The apparatus recited in claim 1, further comprising a modulator configured to form each of the plurality of data symbols from a plurality of data bits.	Samsung devices includes a modulator for forming the plurality of data symbols from a plurality of data bits. As shown to the right, the LTE specification requires modulating "the block of scrambled bits…resulting in a block complex-valued symbols…."	5.3.2 Modulation The block of scrambled bits $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel. **Table 5.3.2-1: Uplink modulation schemes** Physical channel: **PUSCH** Modulation schemes: **QPSK, 16QAM, 64QAM** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 8	Analysis	Select Evidence

The apparatus recited in claim 7, further comprising a pseudo-noise scrambler configured to encode the plurality of data bits with a pseudo-noise code.	Samsung devices includes a pseudo-noise scrambler.
	
	As shown to the right, the LTE specification require scrambling a block of bits using "a UE-specific scrambling sequence…resulting in a block of scrambled bits…according to the following pseudo code…."
		5.3.1 Scrambling
		
		The block of bits $b(0),\ldots,b(M_{\text{bit}}-1)$, 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 $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ according to the following pseudo code
		
		Set $i = 0$
		while $i < M_{bit}$
		if $b(i) = \text{x}$ // ACK/NAK or Rank Indication placeholder bits
		$\tilde{b}(i) = 1$
		else
		if $b(i) = y$ // ACK/NAK or Rank Indication repetition placeholder bits
		$\tilde{b}(i) = \tilde{b}(i-1)$
		Else // Data or channel quality coded bits, Rank Indication coded bits or ACK/NAK coded bits
		$\tilde{b}(i) = (b(i) + c(i)) \bmod 2$
		* * * *
		end if
		end if
		$i = i + 1$
		end while
		
		where x and y are tags defined in [3] section 5.2.2.6 and where the scrambling sequence $c(i)$ is given by Section 7.2. The scrambling sequence generator shall be initialised with $c_{\text{init}} = n_{\text{RNTI}} \cdot 2^{14} + \lfloor n_s/2 \rfloor \cdot 2^9 + N_{\text{ID}}^{\text{cell}}$ at the start of each subframe where n_{RNTI} corresponds to the RNTI associated with the PUSCH transmission as described in Section 8[4].
		
		Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

GLOBAL IP LAW GROUP

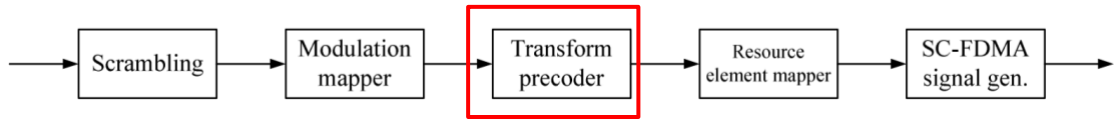
U.S. Patent No. 10,200,227: Samsung LTE-enabled devices[1]

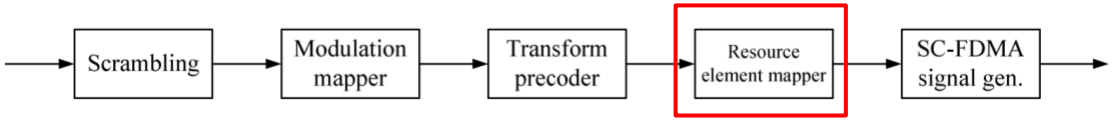
Claim 1	Analysis	Select Evidence
A non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor to implement a method for generating an Orthogonal Frequency Division Multiplexing (OFDM) transmission signal, the method comprising:	Samsung LTE-enabled devices ("Samsung devices") include non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor to implement each and every step of claim 1 for generating an Orthogonal Frequency Division Multiplexing (OFDM) transmission signal which provides LTE capability. (Continued on next page)	 Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

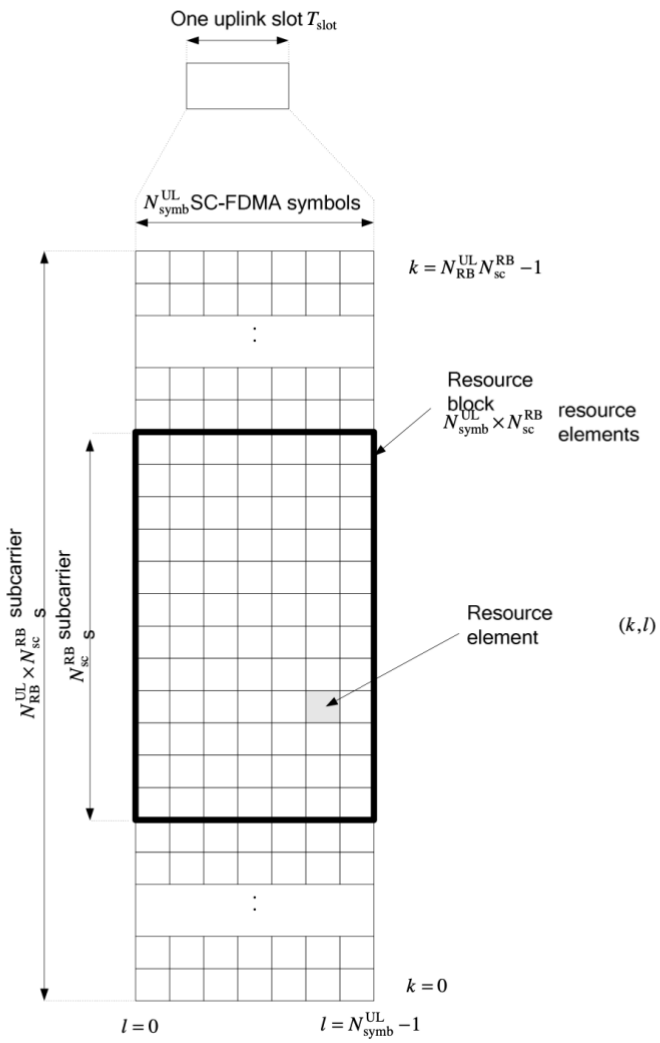
[1] This chart applies to all Samsung LTE-enabled devices, including, but not limited to, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled phone, watch, laptop and tablet, infringe this patent in a substantially similar, if not identical, manner.

Samsung v. GenghisComm
IPR2025-00788, 10,389,568
GC EX2001

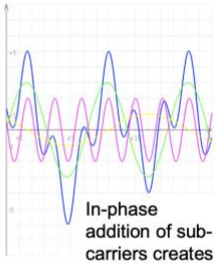
Claim 1	Analysis	Select Evidence
	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that Samsung devices must include an OFDM (orthogonal frequency division multiplexing) transmitter.	GSM was developed to carry real time services, in a circuit switched manner (blue in figure 1), with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (green in figure 1) solution was taken with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). To reach higher data rates in UMTS (Universal Mobile Terrestrial System) a new access technology WCDMA (Wideband Code Division Multiple Access) was developed. The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for datacom services (black in figure 1). In UMTS the IP address is allocated to the UE when a datacom service is established and released when the service is released. Incoming datacom services are therefore still relying upon the circuit switched core for paging. The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected viathe X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte

Claim 1	Analysis	Select Evidence
employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols;	The transmitter in Samsung devices employs an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread symbols. As shown to the right, the LTE specification requires transform precoding that is applied using invertible transform (e.g., a Fourier transform). Application of the precoding transform (e.g., using Samsung devices' transmitter) "result[s] in a block of complex-valued symbols" to be spread onto an uplink resource (shown below).	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
mapping the spread data symbols to a plurality of OFDM subcarriers; and	The transmitter in Samsung devices maps the spread data symbols to a plurality of OFDM subcarriers. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to map the DFT-spread data signals (e.g., the complex-valued symbols discussed above) to multiple subcarriers.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, the LTE-defined uplink resource grid includes “SC-FDMA symbols” generated using the DFT discussed above. The symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
responsive to the mapping, modulating the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers,	The transmitter in Samsung devices modulates the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to modulate the DFT-spread data signals (e.g., the complex-valued symbols $z(0), \ldots, z(M_{symb}-1)$ discussed above) onto multiple subcarriers to produce an OFDM transmission signal (e.g., SC-FDMA baseband signal as described in section 5.6 of LTE standard) for each antenna port. During SC-FDMA baseband signal generation, the DFT-spread data signals are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
wherein employing the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.	The transmitter in Samsung devices employing the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio. As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal EE Times techonline Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

Claim 3	Analysis	Select Evidence
The non-transitory computer-readable medium recited in claim 1, wherein the modulating comprises performing an inverse fast Fourier transform.	Samsung devices perform the modulation comprises performing an inverse fast Fourier transform. As shown to the right, to comply with LTE standards, the OFDM modulator in Samsung devices must comprise an inverse DFT to produce the time-continuous signal $S_l(t)$ in SC-FDMA as described in section 5.6 of the LTE Standard. The inverse fast Fourier transform is an algorithmically efficient way of performing the inverse DFT, and it is used universally in OFDM modulators.	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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

<table>
<tr><th>Claim 7</th><th>Analysis</th><th>Select Evidence</th></tr>
<tr>
<td>The non-transitory computer-readable medium recited in claim 1, further comprising computer-readable program code configured to append at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal.</td>
<td>Samsung devices comprising computer-readable program code are configured to append at least one of a cyclic prefix to the OFDM transmission signal.

As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must include a cyclic prefix appender configured to append at least a cyclic prefix as described in section 5.2 of the LTE Standard.</td>
<td>

Table 4.2-1: Configuration of special subframe (lengths of DwPTS/GP/UpPTS).

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$			$7680 \cdot T_s$		
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$23040 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$		
5	$6592 \cdot T_s$			$20480 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	-	-	-
8	$24144 \cdot T_s$			-	-	-

* * * *

5.2 Slot structure and physical resources

5.2.1 Resource grid

The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil

$$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$

where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7].

The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1.

* * * *

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:
https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

</td>
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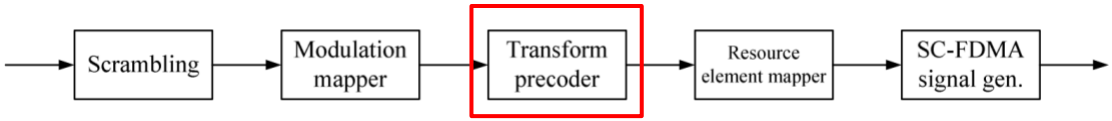
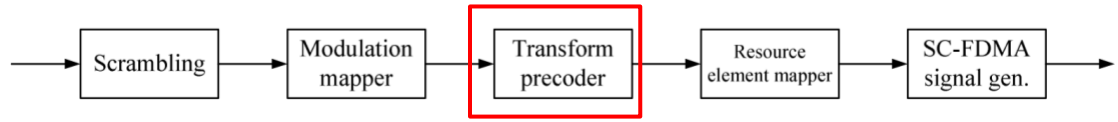
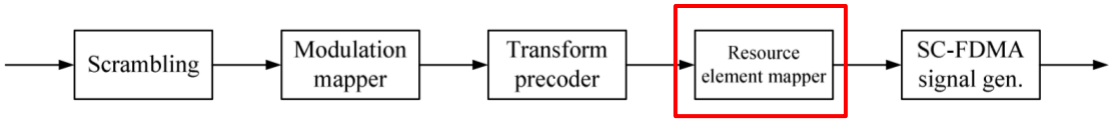
</table>

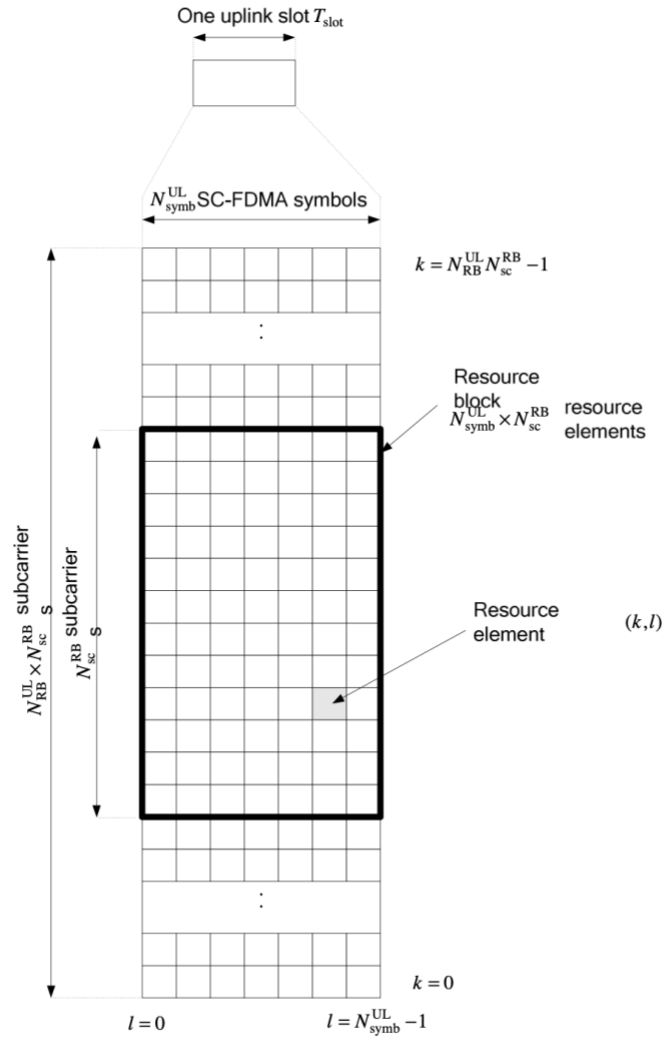
Claim 8	Analysis	Select Evidence
The non-transitory computer-readable medium recited in claim 1, further comprising computer-readable program code to provide channel precoding.	Samsung devices further include computer-readable program code to provide channel precoding. As shown to the right, SC-FDMA signal generation includes a transform precoding step.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
A method, comprising:	Samsung devices include at least one OFDM transmitter which provides LTE capability performs each and every step of claim 11. (Continued on next page)	Galaxy S20 FE 5G | S20 5G | S20+ 5G | S20 Ultra 5G — From $10.84/mo for HIGHLIGHTS DESIGN CAMERA MODELS S20 FE 5G SPECS ACCESSORIES COMPARE LTE Enhanced 4x4 MIMO, Up to 7CA, LTE Cat.20 Up to 2.0Gbps Download / Up to 150Mbps Upload Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network Number of SIM: Single-SIM SIM Slot Type: SIM 1 + MicroSD Network/Bearer (S/W Enabled) 3G UMTS: B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE: B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network/Bearer (S/W Enabled) 3G UMTS: B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE: B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Book S GALAXY BOOK S DESIGN PERFORMANCE CONNECTIVITY ACCESSORIES SPECS Network: LTE Cat.18 Nano SIM *May differ by region, country, market and mobile operator. Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

Claim 11	Analysis	Select Evidence
	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that Samsung devices must include an OFDM (orthogonal frequency division multiplexing) transmitter.	GSM was developed to carry real time services, in a circuit switched manner (blue in figure 1), with data services only possible over a circuit switched modem connection, with very low data rates. The first step towards an IP based packet switched (green in figure 1) solution was taken with the evolution of GSM to GPRS, using the same air interface and access method, TDMA (Time Division Multiple Access). To reach higher data rates in UMTS (Universal Mobile Terrestrial System) a new access technology WCDMA (Wideband Code Division Multiple Access) was developed. The access network in UMTS emulates a circuit switched connection for real time services and a packet switched connection for datacom services (black in figure 1). In UMTS the IP address is allocated to the UE when a datacom service is established and released when the service is released. Incoming datacom services are therefore still relying upon the circuit switched core for paging. The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected viathe X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte

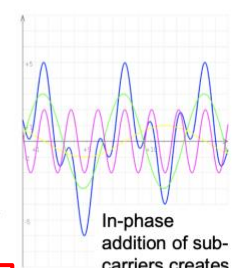
Claim 11	Analysis	Select Evidence
performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols;	The transmitter in Samsung devices performs an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols. As shown to the right, the LTE specification requires transform precoding that is applied using invertible transform (e.g., a Fourier transform). Application of the precoding transform (e.g., using a Samsung devices' transmitter) "result[s] in a block of complex-valued symbols" to be spread onto an uplink resource (shown below).	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
mapping the plurality of spread symbols to a plurality of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers;	The transmitter in Samsung devices maps the plurality of spread symbols to a plurality of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to map the DFT-spread data signals (e.g., the complex-valued symbols discussed above) to multiple subcarriers.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
	As shown to the right, the LTE-defined uplink resource grid includes "SC-FDMA symbols" generated using the DFT discussed above. The symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
modulating the plurality of spread symbols onto the plurality of OFDM subcarriers to produce a spread OFDM signal to be transmitted into a wireless channel,	The transmitter in Samsung devices modulates the plurality of spread symbols onto the plurality of OFDM subcarriers to produce a spread OFDM signal to be transmitted into a wireless channel. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must be able to modulate the DFT-spread data signals (e.g., the complex-valued symbols $z(0), \ldots, z(M_{symb}-1)$ discussed above) onto multiple subcarriers to produce an OFDM transmission signal (e.g., SC-FDMA baseband signal as described in section 5.6 of LTE standard) for each antenna port. During SC-FDMA baseband signal generation, the DFT-spread data signals are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
wherein the spread OFDM signal comprises a superposition of the OFDM subcarriers, and	The spread OFDM signal in the transmitter in Samsung devices comprises a superposition of the OFDM subcarriers. As is known in the art, the superposition of subcarriers is the complex-valued time-domain OFDM signal, which is the sum of OFDM subcarriers.	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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence
wherein the complex-valued spreading matrix is configured to provide the superposition with a reduced peak-to-average power ratio (PAPR).	As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal EE Times techonline Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

Claim 17	Analysis	Select Evidence
The method recited in claim 11, further comprising appending at least one of a cyclic prefix, a postfix, and a guard interval onto the spread OFDM signal.	Samsung devices further comprising appending at least one of a cyclic prefix onto the spread OFDM signal. As shown to the right, to comply with LTE standards, the OFDM transmitter in Samsung devices must include a cyclic prefix appender configured to append at least a cyclic prefix as described in section 5.2 of the LTE Standard.	

Table 4.2-1: Configuration of special subframe (lengths of DwPTS/GP/UpPTS).

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$			$7680 \cdot T_s$		
1	$19760 \cdot T_s$			$20480 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
2	$21952 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$		
5	$6592 \cdot T_s$			$20480 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
6	$19760 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

* * * *

5.2 Slot structure and physical resources

5.2.1 Resource grid

The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil

$$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$

where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7].

The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1.

* * * *

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:
https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 21	Analysis	Select Evidence
A User Equipment configured to perform the method recited in claim 11.	Samsung devices are user equipment configured to perform the method recited in claim 11.	Galaxy S20 FE 5G | S20 5G | S20+ 5G | S20 Ultra 5G From $10.84/mo for HIGHLIGHTS DESIGN CAMERA MODELS S20 FE 5G SPECS ACCESSORIES COMPARE LTE Enhanced 4x4 MIMO, Up to 7CA, LTE Cat.20 Up to 2.0Gbps Download / Up to 150Mbps Upload Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network Number of SIM Single-SIM SIM Slot Type SIM 1 + MicroSD Network/Bearer (S/W Enabled) 3G UMTS B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Tab A 8.4" (... $279.99 | Save up to an extra $21.00 with Samsung Discount Program Network/Bearer (S/W Enabled) 3G UMTS B1(2100),B2(1900), B5(850),B8(900) 4G FDD LTE B2(1900),B3(1800),B4(AWS), B5(850),B7(2600),B13(700), B20(800),B66(AWS-3) Galaxy Book S GALAXY BOOK S DESIGN PERFORMANCE CONNECTIVITY ACCESSORIES SPECS Network LTE Cat.18 Nano SIM *May differ by region, country, market and mobile operator. Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

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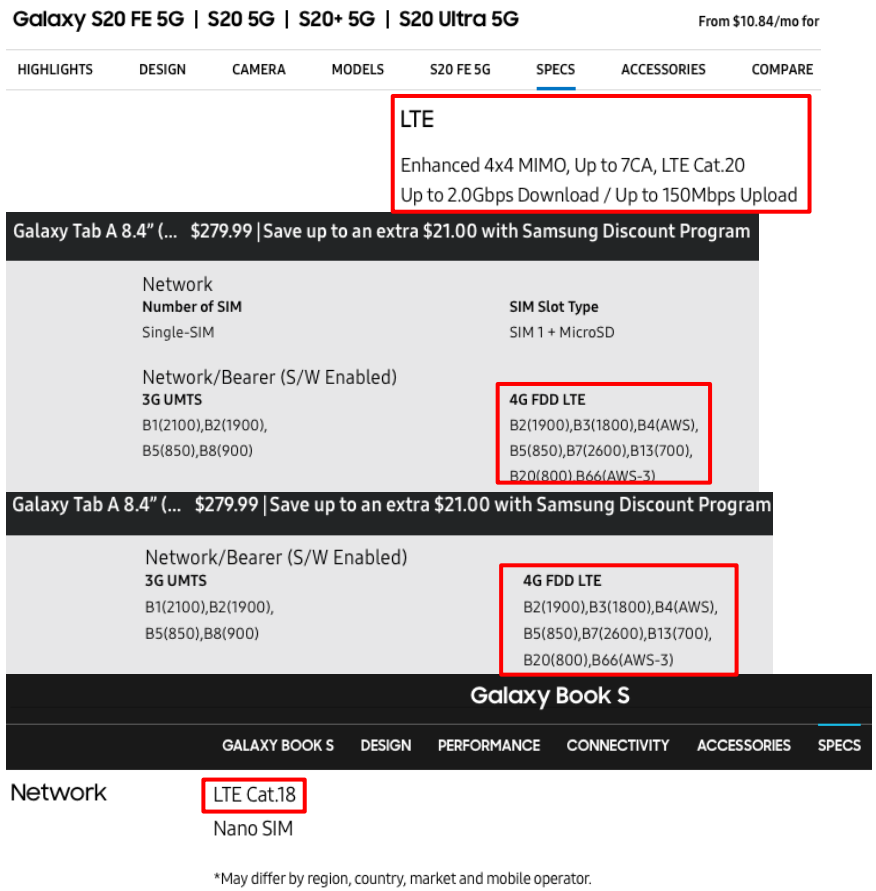
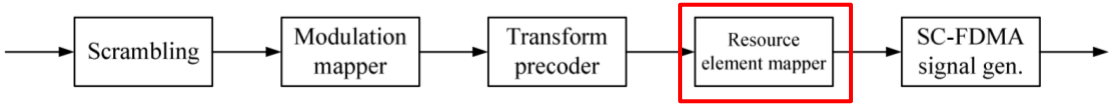
U.S. Patent No. 10,389,568: Samsung LTE-enabled devices [1]

Claim 1	Analysis	Select Evidence
A method comprising:	Samsung LTE-enabled devices ("Samsung devices"), as non-limiting examples, perform the method described below by virtue of their compliance with the LTE specification for physical channel uplink precoding of signals.	 Source: https://www.samsung.com/us/mobile/galaxy-s20-5g/specs/; https://www.samsung.com/us/mobile/tablets/galaxy-tab-a/galaxy-tab-a-8-4-verizon-sm-t307uznavzw/#specs; https://www.samsung.com/us/mobile/wearables/smartwatches/galaxy-watch3-45mm-mystic-silver-lte-sm-r845uzsaxar/#specs; https://www.samsung.com/global/galaxy/galaxy-book-s/specs/

[1] This chart applies to all Samsung LTE-enabled devices, including, but not limited to, Samsung Galaxy S 20, Galaxy Tab A, Galaxy Watch3 and Galaxy Book S. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled phone, watch, laptop and tablet, infringe this patent in a substantially similar, if not identical, manner.

Claim 1	Analysis	Select Evidence
dividing a block of complex-valued symbols into a plurality of sets of complex-valued symbols;	Samsung devices must perform transform precoding to comply with the specification. As shown to the right, transform precoding includes dividing a block of complex-valued symbols into a plurality of sets of complex-valued symbols.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$
transform precoding each of the plurality of sets of complex-valued symbols into a block of transform-precoded complex-valued symbols; and	Transform precoding further results in each set of complex-valued symbols being transform precoded into a block of complex-valued symbols.	resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
generating an Orthogonal Frequency Division Multiplex (OFDM) signal comprising a plurality of OFDM subcarriers modulated by the transform-precoded complex-valued symbols,	Samsung devices must generate an OFDM signal comprising a plurality of OFDM subcarriers modulated by the transform precoded-complex symbol values to comply with the specification. As shown to the right, the LTE specification requires transform precoding that is applied using a Fourier transform. Transform precoding (e.g., using a Samsung devices' transmitter) "result[s] in a block of complex-valued symbols" to be spread onto an uplink resource.	**5.1.1 Physical channels** An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined: - Physical Uplink Shared Channel, PUSCH - Physical Uplink Control Channel, PUCCH - Physical Random Access Channel, PRACH * * * * **5.1.2 Physical signals** An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined: - Reference signal * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, transform precoding maps complex-valued signals to physical resource elements.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.4 Mapping to physical resources** The block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

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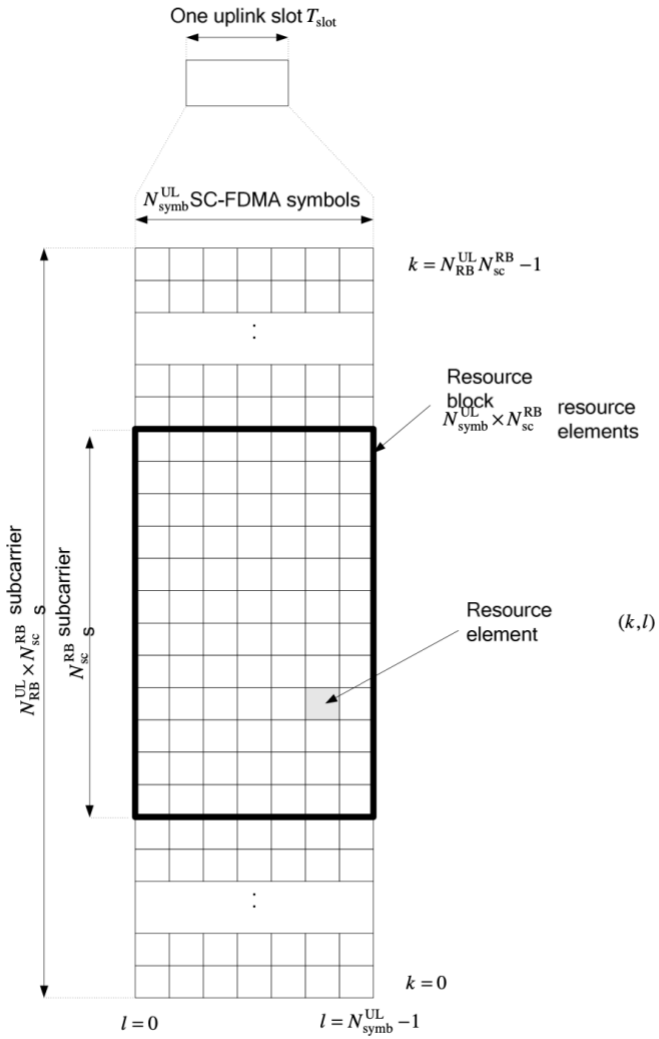
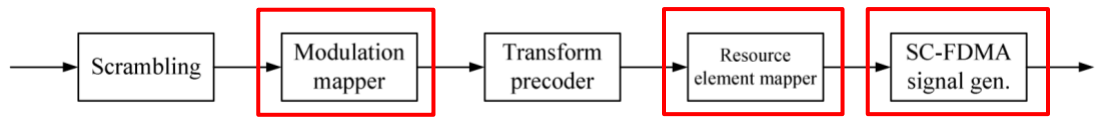
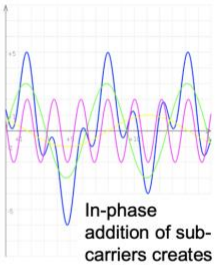
Claim 1	Analysis	Select Evidence
	As shown to the right, the complex-valued symbols are mapped to the resource elements within a resource block, with each resource block including multiple subcarriers.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, mapping to multiple subcarriers uses the modulated and transform precoded complex-valued symbols.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.2 Modulation** The block of scrambled bits $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel. **Table 5.3.2-1: Uplink modulation schemes** Physical channel — Modulation schemes **PUSCH — QPSK, 16QAM, 64QAM** * * * * **5.4.3 Mapping to physical resources** The block of complex-valued symbols $z(i)$ shall be multiplied with the amplitude scaling factor β_{PUCCH} in order to conform to the transmit power P_{PUCCH} specified in Section 5.1.2.1 in [4], and mapped in sequence starting with $z(0)$ to resource elements. PUCCH uses one resource block in each of the two slots in a subframe. Within the physical resource block used for transmission, the mapping of $z(i)$ to resource elements (k,l) not used for transmission of reference signals shall be in increasing order of first k, then l and finally the slot number, starting with the first slot in the subframe. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	The mapping results in an OFDM signal (e.g., SC-FDMA baseband signal) for each antenna port. During SC-FDMA baseband signal generation, the complex-valued symbols are modulated onto the OFDM subcarriers for each uplink slot to produce the time-domain OFDM signal represented by the time-continuous signal equation shown to the right.	**5.2 Slot structure and physical resources** **5.2.1 Resource grid** The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil $$N_{RB}^{min,UL} \le N_{RB}^{UL} \le N_{RB}^{max,UL}$$ where $N_{RB}^{min,UL} = 6$ and $N_{RB}^{max,UL} = 110$ is the smallest and largest uplink bandwidth, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7]. The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1. * * * * **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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB} / 2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
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.	As shown to the right, and as discussed above, baseband signal generation uses the complex-valued symbols that are generated during transform precoding. The transform precoded complex-valued symbols are used to orthogonally spread the symbols onto the subcarriers during baseband signal generation. As is known in the art, the superposition of subcarriers is the complex-valued time-domain OFDM signal, which is the sum of OFDM subcarriers.	**5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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. * * * * **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 $$s_l(t)=\sum_{k=-\lfloor N_{\text{RB}}^{\text{UL}}N_{\text{sc}}^{\text{RB}}/2\rfloor}^{\lceil N_{\text{RB}}^{\text{UL}}N_{\text{sc}}^{\text{RB}}/2\rceil-1} a_{k^{(-)},l}\cdot e^{j2\pi(k+1/2)\Delta f(t-N_{\text{CP},l}T_{\text{s}})}$$ for $0\le t<(N_{\text{CP},l}+N)\times T_{\text{s}}$ 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 $\sum_{l'=0}^{l-1}(N_{\text{CP},l'}+N)T_{\text{s}}$ 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 1	Analysis	Select Evidence
	As shown to the right, research has shown that the use of SC-FDMA, as discussed above, by the LTE specification reduces peak to average power ratio as compared to other uplink strategies (e.g., OFDMA). Thus, Samsung devices, which utilize the LTE standard's SC-FDMA, will show reduced peak-to-average power ratio.	**Performance evaluation of PAPR in OFDM for UMTS-LTE system** Publisher: IEEE Cite This PDF M. Ismail ; Ridza Fauzi ; Jamil Sultan ; N. Misran ; H. Mohamad ; Waheb A. Jabbar All Authors 1 Paper Citation 2 Patent Citations 493 Full Text Views Abstract Document Sections I. Introduction II. PAPR and Constellation Shaping Technique I. Simulation Model **Abstract:** Next generation mobile telecommunication networks will provide high data rates needed for multimedia rich applications as the demand in mobile broadband services is expected to increase in the coming years. Orthogonal Frequency Division Multiplexing (OFDM) technique has been increasing its popularity as a transmission scheme for several radio technologies. One of the challenging issues in OFDM technique is its high peak-to-average power ratio (PAPR). This paper studies the performance of PAPR in long term evolution (LTE) of universal mobile telecommunications system (UMTS). The implementation will be based on specifications and protocols from 3rd Generation Partnership Project (3GPP) work groups. The simulator used to simulate UMTS-LTE environment has been developed in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme. Evaluation results show that reduction of PAPR can be seen in UMTS-LTE model compared to conventional OFDM model. Source: https://ieeexplore.ieee.org/document/6362555 **OFDMA vs. SC-FDMA** • Multi-carrier OFDM signal exhibits high PAPR (Peak to Average Power Ratio) due to in-phase addition of subcarriers. • Power Amplifiers (PAs) must accommodate occasional peaks and this results low efficiency of PAs, typically only 15-20% efficient. Low PA efficiency significantly shortens battery life. • To minimize PAPR, LTE has adapted SC-FDMA (single carrier frequency division multiple access) in the uplink. **SC-FDMA exhibits 3-6 dB less PAPR than OFDMA.**  In-phase addition of sub-carriers creates peaks in the OFDM signal POWERED BY techonline EETimes Source: http://www.octoscope.com/English/Collaterals/Presentations/octoScope_4GPHYTest_20091201.pdf

Claim 2	Analysis	Select Evidence
The method of claim 1, 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.	As discussed above, baseband signal generation uses the transform precoded complex-valued symbols to orthogonally spread the symbols onto the subcarriers during baseband signal generation. As known in the art, one property of the DFT matrix[2] is that it is an orthogonal matrix, thus the symbols will be orthogonally spread. Generation of transform precoded complex-valued symbols entails application of a discrete Fourier transform.[3]	**5.1.1 Physical channels** An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined: - Physical Uplink Shared Channel, PUSCH - Physical Uplink Control Channel, PUCCH - Physical Random Access Channel, PRACH * * * * **5.1.2 Physical signals** An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined: - Reference signal * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

[2] See e.g., https://www2.math.uconn.edu/~olshevsky/classes/2018_Spring/math3511/FFT.pdf for a general description of DFT matrix.
[3] See e.g., http://www.cs.cmu.edu/afs/andrew/scs/cs/15-463/2001/pub/www/notes/fourier/fourier.pdf for a general equation for a discrete Fourier transform.

Claim 3	Analysis	Select Evidence
The method of claim 2, wherein the DFT is a fast Fourier transform (FFT).	The DFT used to transform precode complex-valued symbols is a fast Fourier transform. In digital signal processing, a fast Fourier transform is algorithmically efficient way of performing a DFT.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

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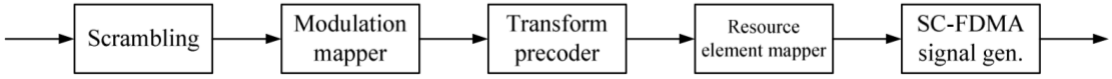
Claim 4	Analysis	Select Evidence
The method of claim 2, wherein: $M_{sc}^{PUSCH} = M_{RB}^{PUSCH} * N_{sc}^{RB}$;	As shown to the right, "[t]he variable $M_{sc}^{PUSCH} = M_{RB}^{PUSCH} * N_{sc}^{RB}$.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ is 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 $z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$ $l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$ 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.
M_{RB}^{PUSCH} is a scheduled bandwidth for uplink transmission expressed as a number of resource blocks; and	As shown to the right, M_{RB}^{PUSCH} is "scheduled bandwidth for uplink transmission, expressed as a number of resource blocks."	* * * * $M_{\text{sc}}^{\text{PUSCH}}$ Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers $M_{\text{RB}}^{\text{PUSCH}}$ Scheduled bandwidth for uplink transmission, expressed as a number of resource blocks * * * *
N_{sc}^{RB} is a resource block size in the frequency domain expressed as a number of subcarriers.	As shown to the right, N_{sc}^{RB} is "resource block size in the frequency domain, expressed as a number of subcarriers."	$N_{\text{sc}}^{\text{RB}}$ Resource block size in the frequency domain, expressed as a number of subcarriers Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 5	Analysis	Select Evidence
The method of claim 4, wherein: $M_{RB}^{PUSCH} \leq N_{RB}^{UL}$;	As shown to the right, the LTE specification requires that $M_{RB}^{PUSCH} \leq N_{RB}^{UL}$.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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. * * * *
N_{RB}^{UL} is an uplink bandwidth configuration expressed in multiples of N_{sc}^{RB}.	As shown to the right, N_{RB}^{UL} is an "uplink bandwidth configuration expressed in multiples of N_{sc}^{RB}."	$N_{\text{RB}}^{\text{UL}}$ Uplink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$ Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 6	Analysis	Select Evidence
The method of claim 1, comprising: mapping the block of transform-precoded complex-valued symbols to physical resource blocks assigned for transmission of a physical uplink shared channel.	As shown to the right, during mapping of complex-valued symbols to resource elements, the transform precoded complex-valued symbols are mapped to physical resource blocks assigned for transmission of a physical uplink shared channel (PUSCH).	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

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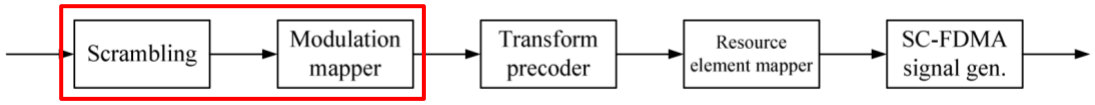
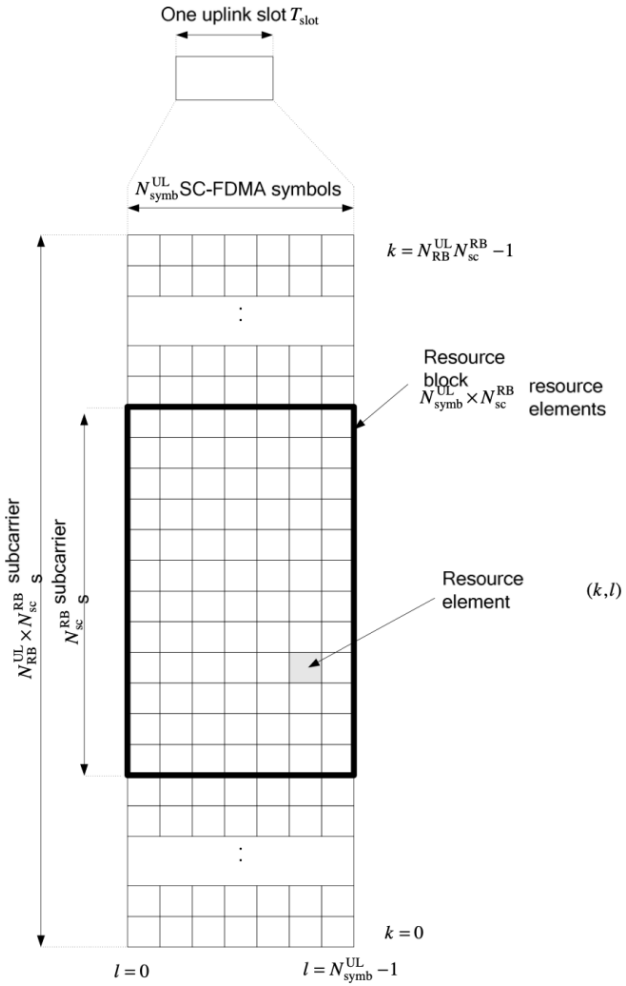
Claim 9	Analysis	Select Evidence
The method of claim 6, wherein the mapping is configured to select the plurality of OFDM subcarriers according to at least one of a frequency division multiple access scheme, a time division multiple access scheme, a space division multiple access scheme, a code division multiple access scheme, and a frequency-hoping scheme.	As shown to the right, LTE "is based on OFDMA (Orthogonal Frequency Division Multiple Access)," such that the mapping is configured to select from the plurality of OFDM subcarriers according to at least a frequency division multiple access scheme. SC-FDMA stands for single carrier ***frequency division multiple access***.	The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off. The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbpsin the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps. Source: https://www.3gpp.org/technologies/keywords-acronyms/98-lte **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 10	Analysis	Select Evidence
The method of claim 1, comprising:	As shown to the right, the LTE specification requires scrambling as part of the baseband signal generation.	**5.3 Physical uplink shared channel** The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - transform precoding to generate complex-valued symbols - mapping of complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port
scrambling a block of bits of one subframe of a physical uplink shared channel resulting in a block of scrambled bits; and	Scrambling entails scrambling the block of bits $b(0),\ldots b(M_{bit}-1)$, with the bits from one subframe, resulting in a block of scrambled bits.	 **Figure 5.3-1: Overview of uplink physical channel processing.** * * * * **5.3.1 Scrambling** The block of bits $b(0),\ldots,b(M_{bit}-1)$, 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 $\tilde{b}(0),\ldots,\tilde{b}(M_{bit}-1)$ according to the following pseudo code * * * *
modulating the block of scrambled bits resulting in the block of complex-valued symbols.	As shown to the right, the LTE specification also requires modulating the scrambled bits to generate complex-valued symbols.	**5.3.2 Modulation** The block of scrambled bits $\tilde{b}(0),\ldots,\tilde{b}(M_{bit}-1)$ shall be modulated as described in Section 7.1, resulting in a block of complex-valued symbols $d(0),\ldots,d(M_{symb}-1)$. Table 5.3.2-1 specifies the modulation mappings applicable for the physical uplink shared channel. **Table 5.3.2-1: Uplink modulation schemes** Physical channel: **PUSCH** — Modulation schemes: **QPSK, 16QAM, 64QAM** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 11	Analysis	Select Evidence

The method of claim 10, wherein the scrambling is configured to scramble the block of bits into a block of scrambled bits with at least one pseudo-noise code.	As shown to the right, the scrambling of the block of bits is accomplished using pseudo-noise code.	5.3.1 Scrambling
		The block of bits $b(0),\ldots,b(M_{\text{bit}}-1)$, 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 $\tilde{b}(0),\ldots,\tilde{b}(M_{\text{bit}}-1)$ according to the following pseudo code
		Set $i=0$
		while $i < M_{bit}$
		if $b(i)=\mathbf{x}$ // ACK/NAK or Rank Indication placeholder bits
		$\tilde{b}(i)=1$
		else
		if $b(i)=y$ // ACK/NAK or Rank Indication repetition placeholder bits
		$\tilde{b}(i)=\tilde{b}(i-1)$
		Else // Data or channel quality coded bits, Rank Indication coded bits or ACK/NAK coded bits
		$\tilde{b}(i)=(b(i)+c(i)) \bmod 2$
		* * * *
		end if
		end if
		$i=i+1$
		end while
		where x and y are tags defined in [3] section 5.2.2.6 and where the scrambling sequence $c(i)$ is given by Section 7.2. The scrambling sequence generator shall be initialised with $c_{\text{init}}=n_{\text{RNTI}}\cdot 2^{14}+\lfloor n_s/2\rfloor\cdot 2^9+N_{\text{ID}}^{\text{cell}}$ at the start of each subframe where n_{RNTI} corresponds to the RNTI associated with the PUSCH transmission as described in Section 8[4].
		Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 12	Analysis	Select Evidence
The method of claim 1, wherein the transform precoding is applied according to $z(l * M_{sc}^{PUSCH} + k) = \frac{1}{\sqrt{M_{sc}^{PUSCH}}} \sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l * M_{sc}^{PUSCH} + i) e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$ wherein: the block of complex-valued symbols and the block of transform-precoded complex-valued symbol comprises a plurality of resource elements;	As shown to the right, the transform precoding according to the LTE specification is applied using the equation as shown. As shown to the right, the complex-valued symbols (both pre-transform precoding and post-transform pre-coding) correspond to SC-FDMA symbols.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $z(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k = 0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$ $l = 0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 12	Analysis	Select Evidence
	As shown to the right, resource blocks are composed of SC-FDMA symbols corresponding to resource elements.	 **Figure 5.2.1-1: Uplink resource grid.** Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 12	Analysis	Select Evidence
l represents a time-domain index of each of the plurality of resource elements; *k* represents a frequency-domain index of each of the plurality of resource elements;	As shown to the right, *l* and *k* make up an index pair that uniquely defines each resource element, where *l* is a time domain index and *k* is a frequency domain index.	(k,l) Resource element with frequency-domain index k and time-domain index l * * * * 5.2.2 Resource elements Each element in the resource grid is called a resource element and is uniquely defined by the index pair (k,l) in a slot where $k=0,\ldots,N_{\mathrm{RB}}^{\mathrm{UL}}N_{\mathrm{sc}}^{\mathrm{RB}}-1$ and $l=0,\ldots,N_{\mathrm{symb}}^{\mathrm{UL}}-1$ are the indices in the frequency and time domain, respectively. Resource element (k,l) corresponds to the complex value $a_{k,l}$. Quantities $a_{k,l}$ corresponding to resource elements not used for transmission of a physical channel or a physical signal in a slot shall be set to zero.
M_{sc}^{PUSCH} is a scheduled bandwidth for uplink transmission expressed as a number of subcarriers;	As shown to the right, M_{sc}^{PUSCH} is a "scheduled bandwidth for uplink transmission, expressed as a number of subcarriers."	* * * * $M_{\mathrm{sc}}^{\mathrm{PUSCH}}$ Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers * * * *
$d(l * M_{sc}^{PUSCH} + i)$ represents resource elements of the block of complex-valued symbols; and	As shown to the right, $d(l * M_{sc}^{PUSCH} + i)$ corresponds to elements of a block of complex-valued symbols.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\mathrm{symb}}-1)$ 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 $z(l\cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+k)=\frac{1}{\sqrt{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}\sum_{i=0}^{M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1}d(l\cdot M_{\mathrm{sc}}^{\mathrm{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\mathrm{sc}}^{\mathrm{PUSCH}}}}$ $k=0,\ldots,M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$ $l=0,\ldots,M_{\mathrm{symb}}/M_{\mathrm{sc}}^{\mathrm{PUSCH}}-1$
$z(l * M_{sc}^{PUSCH} + k)$ represents resource elements of the block of transform precoded complex-valued symbols.	As shown to the right, $z(l * M_{sc}^{PUSCH} + k)$ corresponds to elements of a block of transform precoded complex-valued symbols.	resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\mathrm{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 13	Analysis	Select Evidence
The method of claim 12, 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; and	As shown to the right, the LTE specification requires transform precoding that is applied using a Fourier transform. Application of the precoding transform (e.g., using Samsung devices' transmitter) "result[s] in a block of complex-valued symbols" to be spread onto an uplink resource (shown below).	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1}d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 13	Analysis	Select Evidence
M_{SC}^{PUSCH} is a length of the DFT corresponding to the plurality of orthogonal spreading codes.	As shown to the right and as discussed above, M_{SC}^{PUSCH} is used in the DFT to generate SC-FDMA symbols, and is the scheduled bandwidth for uplink transmission, expressed as a number of subcarriers. M_{SC}^{PUSCH} represents the DFT length corresponding to the plurality of orthogonal spreading codes.	M_{sc}^{PUSCH} Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers * * * * **5.3.3 Transform precoding** The block of complex-valued symbols $d(0),\ldots,d(M_{symb}-1)$ is divided into M_{symb}/M_{sc}^{PUSCH} sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $z(l\cdot M_{sc}^{PUSCH}+k)=\frac{1}{\sqrt{M_{sc}^{PUSCH}}}\sum_{i=0}^{M_{sc}^{PUSCH}-1} d(l\cdot M_{sc}^{PUSCH}+i)e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$ $k=0,\ldots,M_{sc}^{PUSCH}-1$ $l=0,\ldots,M_{symb}/M_{sc}^{PUSCH}-1$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{symb}-1)$. 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 $M_{RB}^{PUSCH}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\le N_{RB}^{UL}$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 20	Analysis	Select Evidence
The method of claim 1, wherein each of the plurality of sets of complex-valued symbols is a single carrier frequency division multiple access (SC-FDMA) symbol.	As shown to the right, the complex-valued symbols are divided into multiple sets, with each set corresponding to one SC-FDMA symbol.	5.3.3 Transform precoding The block of complex-valued symbols $d(0),\ldots,d(M_{\text{symb}}-1)$ 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 $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,\ldots,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,\ldots,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),\ldots,z(M_{\text{symb}}-1)$. 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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf

Claim 21	Analysis	Select Evidence
The method of claim 1, comprising generating a time-continuous signal defined by: $s_l(t) = \sum_{k=-\lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor}^{\lceil N_{RB}^{UL} N_{sc}^{RB}/2 \rceil - 1} a_{k^{(-)},l} e^{j2\pi(k+1/2)\Delta f(t - N_{CP,l} T_s)}$,	As shown to the right, the LTE specification's SC-FDMA baseband signal generation generates a time-continuous signal according to the claimed equation.	**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 $k^{(-)} = k + \lfloor N_{RB}^{UL} N_{sc}^{RB}/2 \rfloor$, $N = 2048$, $\Delta f = 15$ 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. * * * * N_{sc}^{RB} Resource block size in the frequency domain, expressed as a number of subcarriers * * * * N_{RB}^{UL} Uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB} * * * * $a_{k,l}^{(p)}$ Value of resource element (k,l) [for antenna port p] * * * * Δf Subcarrier spacing * * * * $N_{CP,l}$ Downlink cyclic prefix length for OFDM symbol l in a slot * * * * T_s Basic time unit Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf
wherein: N_{sc}^{RB} is a resource block size in a frequency domain express as a number of subcarriers; N_{RB}^{UL} is an uplink bandwidth configuration express in multiples of N_{sc}^{RB}; $a_k(-)_{,l}$ is a value of a resource element; Δf is subcarrier spacing; $N_{CP,l}$ is a downlink cyclic prefix length for OFDM symbol *l* in a slot; and T_S is a basic time unit.	As shown to the right, N_{sc}^{RB} is a "resource block size in the frequency domain, expressed as a number of subcarriers." As shown to the right, N_{RB}^{UL} is an "uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}." As shown to the right, $a_k(-)_{,l}$ is the value of resource element *(k, l)*. As shown to the right, Δf is "subcarrier spacing." As shown to the right, $N_{CP,l}$ is a "downlink cyclic prefix length for OFDM symbol *l* in a slot." As shown to the right, T_S is a "basic time unit."	

Claim 22	Analysis	Select Evidence
The method of claim 21, wherein the time-continuous signal is generated in a single carrier frequency division multiple access (SC-FDMA) symbol.	As shown to the right, the time-continuous signal is generated in an SC-FDMA symbol.	**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: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf