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P.R. 3-1(c) EXHIBIT 1

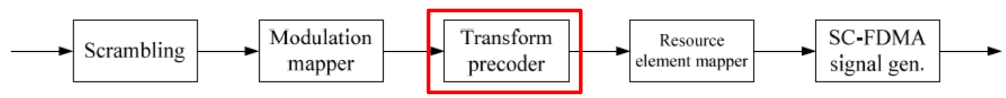
U.S. Patent No. 9,768,842: Samsung devices[1]

Claim 1	Analysis	Select Evidence
An OFDM transmitter, comprising:	Samsung devices (e.g., Galaxy S22) include at least one OFDM transmitter which provides LTE capability that meets every element of claim 1. (Continued on next page)	 **Galaxy S22, 128GB (Unlocked)** SM-S901UZKAXAA 3.9 (1358) Write a review Share your product experience * * * * Network **2G GSM** GSM850,GSM900,DCS1800,PCS1900 **3G UMTS** B1(2100),B2(1900),B4(AWS),B5(850),B8(900) **4G FDD LTE** B1(2100),B2(1900),B3(1800),B4(AWS),B5(850),B7(2600),B8(900),B12(700),B13(700),B14(700),B18(800),B19(800),B20(800),B25(1900),B26(850),B28(700),B29(700),B30(2300),B66(AWS-3),B71(600) **4G TDD LTE** B38(2600),B39(1900),B40(2300),B41(2500),B46(5200),B48(3600) **5G FDD Sub6** N1(2100),N3(1800),N5(850),N7(2600),N8(900),N20(800),N28(700),N66(AWS-3),N71(600) **5G TDD Sub6** N260(39GHz),N261(28GHz) Source: https://www.samsung.com/us/business/mobile/phones/galaxy-s/galaxy-s22-128gb-unlocked-sm-s901uzkaxaa/#specs (GC0007293-94; GC0007311)

[1] This chart applies to all Samsung devices, including those listed in Appendix A and identified in the Complaint at paragraph 30. Other Samsung LTE-enabled devices, including any recently discontinued LTE-enabled devices, infringe this patent in a substantially similar, if not identical, manner.

Claim 1	Analysis	Select Evidence
	As shown to the right, LTE uses OFDMA for the physical channel downlink (e.g., base station to user device), and SC-FDMA for the physical channel uplink (e.g., user device to base station).	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 (GC0004802) The downlink physical layer of LTE is based on OFDMA. However, despite its many advantages, OFDMA has certain drawbacks such as high sensitivity to frequency offset (resulting from instability of electronics and Doppler spread due to mobility) and high peak-to-average power ratio (PAPR). PAPR occurs due to random constructive addition of sub-carriers and results in spectral spreading of the signal leading to adjacent channel interference. It is a problem that can be overcome with high compression point power amplifiers and amplifier linearization techniques. While these methods can be used on the base station, they become expensive on the User Equipment (UE). Hence, LTE uses Single Carrier FDMA (SC-FDMA) with cyclic prefix on the uplink which reduces PAPR as there is only a single carrier as opposed to *N* carriers. Figure 2 illustrates the concepts of OFDMA and SC-FDMA. Source: https://frankrayal.com/wp-content/uploads/2017/02/LTE-in-a-Nutshell-Physical-Layer.pdf (GC0004322)

Claim 1	Analysis	Select Evidence
	As will be discussed in more detail subsequently, SC-FDMA entails mapping/modulating frequency domain points onto an OFDM symbol. The OFDM symbol is then transmitted by the user device, such that an OFDM transmitter is required.	In SC-FDMA, the user data is modulated onto a single carrier modulation format (QPSK, 16QAM, or 64QAM), and the time domain symbols are transformed to the frequency domain by an FFT. Then the frequency domain points are mapped onto the subcarriers assigned to the user in the OFDM symbol. Finally, an IFFT is performed on the entire OFDM symbol and resulting time data is transmitted. The following image illustrates this process. Source: https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (GC0004793) Each data symbol is DFT transformed before mapping to subcarriers, hence the SC-FDMA is called *DFT-precoded* OFDM. In a standard OFDM, each data symbol is carried on a separate subcarrier. In SC-FDMA, multiple subcarriers carry each data symbol due to mapping of the symbols' frequency domain samples to subcarriers. As each data symbol is spread over multiple subcarriers, SC-FDMA offers spreading gain or frequency diversity gain in a frequency selective channel. Thus, SC-FDMA can be viewed as *frequency-spread OFDM* or *DFT-spread OFDM*. * * * * As SC-FDMA is built over OFDM modulation, let's first review an OFDM system structure. A typical OFDM transmitter and receiver structure is shown in Figure 2. A transmitter includes a baseband modulator, subcarrier mapping, inverse Fourier transform, cyclic prefix addition, parallel-serial conversion, and a digital-to-analog converter followed by an I-Q RF modulator. Unlike other modulation techniques that operate symbol by symbol, OFDM transmits a block of data symbols simultaneously over one OFDM symbol. An OFDM symbol is the time used to transmit all of subcarriers that are modulated by the block of input data symbols. Source: https://support.ixiacom.com/sites/default/files/resources/whitepaper/sc-fdma-indd.pdf (GC0004314; GC0004313)

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. The LTE specification requires transform precoding the data symbols using the DFT shown at right to generate a block of transform precoded complex-valued symbols $z(0),\ldots z(M_{symb}\text{-}1)$. These are the DFT-spread data signals. The transform precoding process employs a DFT to spread data symbols. Specifically, the portion of the DFT $e^{-j\frac{2\pi ik}{M_{sc}^{PUSCH}}}$ generates multiple spreading codes that are applied to the data symbols to generate the spread symbols. The spreading codes are complex-valued coefficients.	**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 $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $$z(l \cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}}\cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil $$M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\leq N_{\text{RB}}^{\text{UL}}$$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf (GC0004231; GC0004232)

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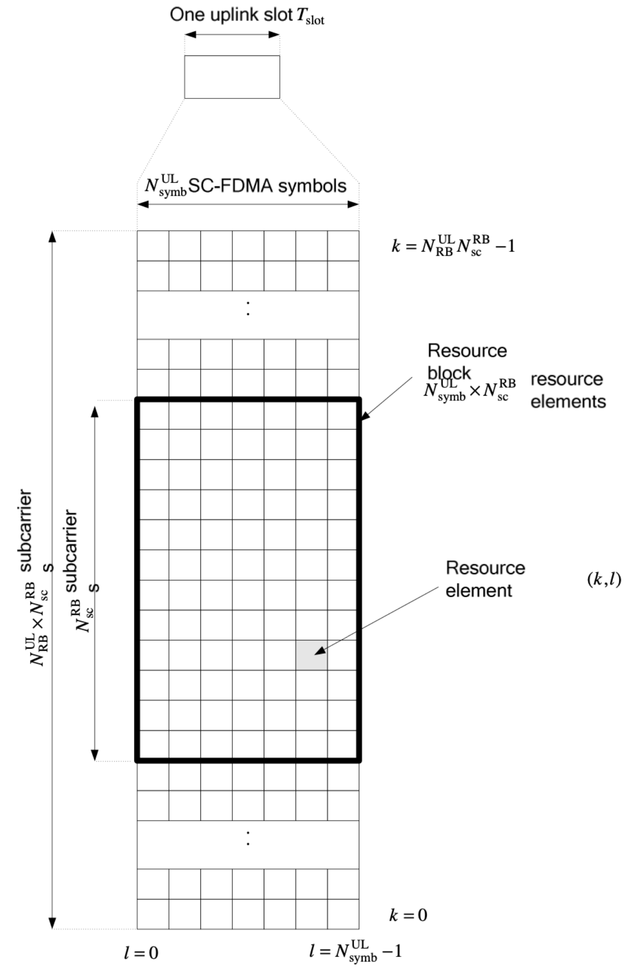
Claim 1	Analysis	Select Evidence
	SC-FDMA "is built over OFDM modulation," and thus "can be viewed as … *DFT-spread OFDM*."	Each data symbol is DFT transformed before mapping to subcarriers, hence the SC-FDMA is called *DFT-precoded* OFDM. In a standard OFDM, each data symbol is carried on a separate subcarrier. In SC-FDMA, multiple subcarriers carry each data symbol due to mapping of the symbols' frequency domain samples to subcarriers. As each data symbol is spread over multiple subcarriers, SC-FDMA offers spreading gain or frequency diversity gain in a frequency selective channel. Thus, SC-FDMA can be viewed as *frequency-spread OFDM* or *DFT-spread OFDM*. * * * * As SC-FDMA is built over OFDM modulation, let's first review an OFDM system structure. A typical OFDM transmitter and receiver structure is shown in Figure 2. A transmitter includes a baseband modulator, subcarrier mapping, inverse Fourier transform, cyclic prefix addition, parallel-serial conversion, and a digital-to-analog converter followed by an I-Q RF modulator. Unlike other modulation techniques that operate symbol by symbol, OFDM transmits a block of data symbols simultaneously over one OFDM symbol. An OFDM symbol is the time used to transmit all of subcarriers that are modulated by the block of input data symbols. Source: https://support.ixiacom.com/sites/default/files/resources/whitepaper/sc-fdma-indd.pdf (GC0004314; GC0004313)

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. The DFT-spread data signal is "mapped onto the subcarriers assigned to the user in the OFDM symbol."	**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 * * * * **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 (GC0004231; GC0004232) In SC-FDMA, the user data is modulated onto a single carrier modulation format (QPSK, 16QAM, or 64QAM), and the time domain symbols are transformed to the frequency domain by an FFT. Then the frequency domain points are mapped onto the subcarriers assigned to the user in the OFDM symbol. Finally, an IFFT is performed on the entire OFDM symbol and resulting time data is transmitted. The following image illustrates this process. Source: https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (GC0004793)

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 (GC0004230)

<table>
<tr><th>Claim 1</th><th>Analysis</th><th>Select Evidence</th></tr>
<tr>
<td>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.</td>
<td>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.

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.</td>
<td>

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

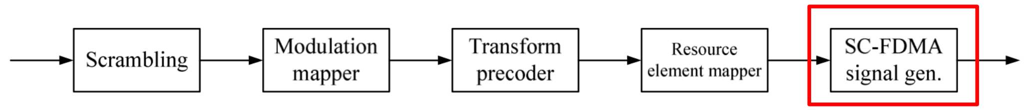


Figure 5.3-1: Overview of uplink physical channel processing.

* * * *

5.6 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
(GC0004231; GC0004250)
</td>
</tr>
</table>

Claim 1	Analysis	Select Evidence
	As discussed previously and as shown to the right, the DFT-spread data signals are mapped onto subcarriers, and then modulated onto those subcarriers during SC-FDMA baseband signal generation. The IFFT discussed at right is the SC-FDMA baseband signal generation equation shown on the previous page. A person of ordinary skill in the art at the time of the invention would understand that an OFDM signal is a superposition of subcarriers. The LTE specification's SC-FDMA baseband generation step uses an IFFT for transforming from the frequency-domain to the time-domain transformation. Each input symbol to an IFFT is modulated onto a particular subcarrier frequency, and the output of the IFFT is a discrete-time signal. If multiple symbols are input to the IFFT at the same time, the output discrete-time signal is a sum (i.e., superposition) of the subcarrier frequencies modulated with their corresponding symbols. In short, superposition is the sum of the subcarrier frequencies at a given time. Another result of using SC-FDMA is that it reduces peak-to-average power ratio (PAPR).	In SC-FDMA, the user data is modulated onto a single carrier modulation format (QPSK, 16QAM, or 64QAM), and the time domain symbols are transformed to the frequency domain by an FFT. Then the frequency domain points are mapped onto the subcarriers assigned to the user in the OFDM symbol. Finally, an IFFT is performed on the entire OFDM symbol and resulting time data is transmitted. The following image illustrates this process. Source: https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (GC0004793) Single Carrier Frequency Division Multiple Access (SC-FDMA) is a promising technique for high data rate uplink communication and has been adopted by 3GPP for it next generation cellular system, called Long-Term Evolution (LTE). SC-FDMA is a modified form of OFDM with similar throughput performance and complexity. This is often viewed as DFT-coded OFDM where time-domain data symbols are transformed to frequency-domain by a discrete Fourier transform (DFT) before going through the standard OFDM modulation. Thus, SC-FDMA inherits all the advantages of OFDM over other well-known techniques such as TDMA and CDMA. The major problem in extending GSM TDMA and wideband CDMA to broadband systems is the increase in complexity with the multipath signal reception. The main advantage of OFDM, as is for SC-FDMA, is its robustness against multipath signal propagation, which makes it suitable for broadband systems. SC-FDMA brings additional benefit of low peak-to-average power ratio (PAPR) compared to OFDM making it suitable for uplink transmission by user-terminals. Source: https://support.ixiacom.com/sites/default/files/resources/whitepaper/sc-fdma-indd.pdf (GC0004307)

Claim 2	Analysis	Select Evidence
The OFDM transmitter recited in claim 1, wherein the OFDM spreader comprises an N-point DFT and the OFDM modulator comprises an M-point inverse discrete Fourier Transform, wherein M>N.	As discussed above and as shown to the right, the transform precoding DFT is the OFDM spreader. The DFT is an N-point DFT. As discussed above, the SC-FDMA baseband signal generator uses an inverse DFT (IFFT). The IFFT is an M-point inverse DFT. The N in the N-point DFT data symbols used, and M in the M-point IFFT corresponds to the total number of subcarriers assigned to the user. Because a user will use fewer data symbols (N) than the total number of subcarriers assigned to the user (M), M will be greater than N.	**5.3.3 Transform precoding** The block of complex-valued symbols $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $z(l \cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} d(l \cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$ $l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$ resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil $M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq N_{\text{RB}}^{\text{UL}}$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. * * * * **5.6 SC-FDMA baseband signal generation** This section applies to all uplink physical signals and physical channels except the physical random access channel. The time-continuous signal $s_l(t)$ in SC-FDMA symbol l in an uplink slot is defined by $s_l(t)=\sum_{k=-\lfloor N_{\text{RB}}^{\text{UL}}N_{\text{sc}}^{\text{RB}}/2 \rfloor}^{\lceil N_{\text{RB}}^{\text{UL}}N_{\text{sc}}^{\text{RB}}/2 \rceil-1} a_{k^{(-)},l} \cdot e^{j2\pi(k+1/2)\Delta f(t-N_{\text{CP},l}T_s)}$ for $0 \leq t < (N_{\text{CP},l}+N)\times T_s$ where $k^{(-)}=k+\lfloor N_{RB}^{UL}N_{sc}^{RB}/2 \rfloor$, $N=2048$, $\Delta f=15$ kHz and $a_{k,l}$ is the content of resource element (k,l). The SC-FDMA symbols in a slot shall be transmitted in increasing order of l, starting with $l=0$, where SC-FDMA symbol $l>0$ starts at time $\sum_{l'=0}^{l-1}(N_{\text{CP},l'}+N)T_s$ within the slot. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf (GC0004232; GC0004250)

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. 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 $k^{(-)}=k+\lfloor N_{RB}^{UL}N_{sc}^{RB}/2\rfloor$, $N=2048$, $\Delta f=15$ 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 (GC0004250)

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Claim 4	Analysis	Select Evidence
The OFDM transmitter recited in claim 1, wherein the data symbols comprise reference-signal symbols, which comprise at least one of known training symbols and synchronization symbols.	As discussed above, Samsung devices comply with the LTE specification, including 36.211 v8.7.0, release 8. A later release—release 15—introduced requirements for reference signals used in the physical channel uplink, as shown to the right. Samsung devices comply with this release as well. These requirements specify that at least one of the data symbols is a reference signal used for demodulation and synchronization. Demodulation reference signals are used for channel estimation, while synchronization reference signals are used for signal-quality estimation. Both channel estimation and signal-quality estimation are types of training symbols.	5.5.2.1 Demodulation reference signal for PUSCH 5.5.2.1.1 Reference signal sequence The PUSCH demodulation reference signal sequence $r_{\text{PUSCH}}^{(\lambda)}(\cdot)$ associated with layer $\lambda \in \{0,1,...,\upsilon-1\}$ is defined by $$r_{\text{PUSCH}}^{(\lambda)}\left(m \cdot M_{\text{sc}}^{\text{RS}} + n\right) = w^{(\lambda)}(m) r_{u,v}^{(\alpha_\lambda, \delta)}(n)$$ where $$m = \begin{cases} 0 & \text{for special subframe and (sub)slot - PUSCH} \\ 0,1 & \text{otherwise} \end{cases}$$ $$n = 0,...,M_{\text{sc}}^{\text{RS}} - 1$$ and $M_{\text{sc}}^{\text{RS}} = M_{\text{sc}}^{\text{PUSCH}}/2$ if - the higher-layer parameter *ul-DMRS-IFDMA* is set and the most recent uplink-related DCI contains the *Cyclic Shift Field mapping table for DMRS bit* field which indicates the use of Table 5.5.2.1.1-3, or, - the *Cyclic Shift Field mapping table for DMRS bit* field is set in the most recent uplink-related DCI format 7 which indicates the use of Table 5.5.2.1.1-4, or, - subslot-PUSCH/slot-PUSCH for the transport block is semi-persistently scheduled (i.e. higher layer parameter *sps-ConfigUL-STTI* is configured, see 3GPP TS 36.331 [9]), and *ifdma-Config-SPS* is set. * * * * 5.5.3 Sounding reference signal 5.5.3.1 Sequence generation The sounding reference signal sequence $r_{\text{SRS}}^{(\tilde{p})}(n) = r_{u,v}^{(\alpha_{\tilde{p}}, \delta)}(n)$ is defined by clause 5.5.1, where u is the sequence-group number defined in clause 5.5.1.3, v is the base sequence number defined in clause 5.5.1.4, and $\delta = 0$. The cyclic shift $\alpha_{\tilde{p}}$ of the sounding reference signal is given as $$\alpha_{\tilde{p}} = 2\pi \frac{n_{\text{SRS}}^{\text{cs},\tilde{p}}}{n_{\text{SRS}}^{\text{cs,max}}}$$ $$n_{\text{SRS}}^{\text{cs},\tilde{p}} = \left(n_{\text{SRS}}^{\text{cs}} + \frac{n_{\text{SRS}}^{\text{cs,max}} \tilde{p}}{N_{\text{ap}}} \right) \bmod n_{\text{SRS}}^{\text{cs,max}} ,$$ $$\tilde{p} \in \{0,1,...,N_{\text{ap}} - 1\}$$ where $n_{\text{SRS}}^{\text{cs}} = \{0,1,...,n_{\text{SRS}}^{\text{cs,max}} - 1\}$ is configured separately for periodic and each configuration of aperiodic sounding by the higher-layer parameters *cyclicShift* and *cyclicShift-ap*, respectively, for each UE and N_{ap} is the number of antenna ports used for sounding reference signal transmission. The parameter $n_{\text{SRS}}^{\text{cs,max}} = 8$ if $K_{\text{TC}} = 2$, otherwise $n_{\text{SRS}}^{\text{cs,max}} = 12$. The parameter K_{TC} is given by the higher layer parameter *transmissionCombNum* if configured, otherwise $K_{\text{TC}} = 2$. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/15.02.00_60/ts_136211v150200p.pdf (GC0004509; GC0004522)

Claim 7	Analysis
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.

Select Evidence

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].

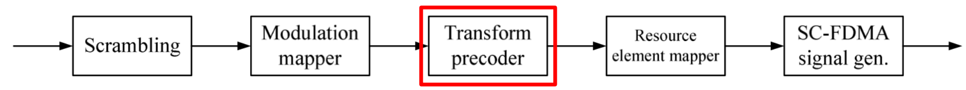
The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by higher layers and is given in Table 5.2.3-1.

* * * *

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
(GC0004228; GC0004229; GC0004231)

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. Transform precoding can be used for channel precoding.	**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 $d(0),...,d(M_{\text{symb}}-1)$ is divided into $M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one SC-FDMA symbol. Transform precoding shall be applied according to $$z(l\cdot M_{\text{sc}}^{\text{PUSCH}}+k)=\frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}}\sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1}d(l\cdot M_{\text{sc}}^{\text{PUSCH}}+i)e^{-j\frac{2\pi ik}{M_{\text{sc}}^{\text{PUSCH}}}}$$ $$k=0,...,M_{\text{sc}}^{\text{PUSCH}}-1$$ $$l=0,...,M_{\text{symb}}/M_{\text{sc}}^{\text{PUSCH}}-1$$ resulting in a block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$. The variable $M_{\text{sc}}^{\text{PUSCH}}=M_{\text{RB}}^{\text{PUSCH}}\cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil $$M_{\text{RB}}^{\text{PUSCH}}=2^{\alpha_2}\cdot 3^{\alpha_3}\cdot 5^{\alpha_5}\le N_{\text{RB}}^{\text{UL}}$$ where $\alpha_2,\alpha_3,\alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf (GC0004231; GC0004232)

Claim 9	Analysis	Select Evidence
The OFDM transmitter recited in claim 1, wherein the plurality of data symbols are at least one of time-multiplexed with reference-signal symbols, frequency-multiplexed with reference-signal symbols, and code-multiplexed with reference-signal symbols.	As discussed above, Samsung devices comply with the LTE specification, including 36.211 v8.7.0, release 8. A later release—release 15—introduced requirements for reference signals used in the physical channel uplink, as shown to the right. Samsung devices comply with this release as well. These requirements specify that at least one of the data symbols is a reference signal used for demodulation and synchronization.	5.5.2.1 Demodulation reference signal for PUSCH 5.5.2.1.1 Reference signal sequence The PUSCH demodulation reference signal sequence $r^{(\lambda)}_{\mathrm{PUSCH}}(\cdot)$ associated with layer $\lambda \in \{0,1,...,\upsilon-1\}$ is defined by $r^{(\lambda)}_{\mathrm{PUSCH}}\left(m \cdot M^{\mathrm{RS}}_{\mathrm{sc}}+n\right)=w^{(\lambda)}(m)r^{(\alpha_\lambda,\delta)}_{u,v}(n)$ where $m=\begin{cases}0 & \text{for special subframe and (sub)slot - PUSCH}\\ 0,1 & \text{otherwise}\end{cases}$ $n=0,...,M^{\mathrm{RS}}_{\mathrm{sc}}-1$ and $M^{\mathrm{RS}}_{\mathrm{sc}}=M^{\mathrm{PUSCH}}_{\mathrm{sc}}/2$ if - the higher-layer parameter *ul-DMRS-IFDMA* is set and the most recent uplink-related DCI contains the *Cyclic Shift Field mapping table for DMRS bit* field which indicates the use of Table 5.5.2.1.1-3, or, - the *Cyclic Shift Field mapping table for DMRS bit* field is set in the most recent uplink-related DCI format 7 which indicates the use of Table 5.5.2.1.1-4, or, - subslot-PUSCH/slot-PUSCH for the transport block is semi-persistently scheduled (i.e. higher layer parameter *sps-ConfigUL-STTI* is configured, see 3GPP TS 36.331 [9]), and *ifdma-Config-SPS* is set. * * * * 5.5.3 Sounding reference signal 5.5.3.1 Sequence generation The sounding reference signal sequence $r^{(\tilde{p})}_{\mathrm{SRS}}(n)=r^{(\alpha_{\tilde{p}},\delta)}_{u,v}(n)$ is defined by clause 5.5.1, where u is the sequence-group number defined in clause 5.5.1.3, v is the base sequence number defined in clause 5.5.1.4, and $\delta=0$. The cyclic shift $\alpha_{\tilde{p}}$ of the sounding reference signal is given as $\alpha_{\tilde{p}}=2\pi\frac{n^{\mathrm{cs},\tilde{p}}_{\mathrm{SRS}}}{n^{\mathrm{cs,max}}_{\mathrm{SRS}}}$ $n^{\mathrm{cs},\tilde{p}}_{\mathrm{SRS}}=\left(n^{\mathrm{cs}}_{\mathrm{SRS}}+\frac{n^{\mathrm{cs,max}}_{\mathrm{SRS}}\tilde{p}}{N_{\mathrm{ap}}}\right)\bmod n^{\mathrm{cs,max}}_{\mathrm{SRS}}$, $\tilde{p}\in\{0,1,...,N_{\mathrm{ap}}-1\}$ where $n^{\mathrm{cs}}_{\mathrm{SRS}}=\{0,1,...,n^{\mathrm{cs,max}}_{\mathrm{SRS}}-1\}$ is configured separately for periodic and each configuration of aperiodic sounding by the higher-layer parameters *cyclicShift* and *cyclicShift-ap*, respectively, for each UE and N_{ap} is the number of antenna ports used for sounding reference signal transmission. The parameter $n^{\mathrm{cs,max}}_{\mathrm{SRS}}=8$ if $K_{\mathrm{TC}}=2$, otherwise $n^{\mathrm{cs,max}}_{\mathrm{SRS}}=12$. The parameter K_{TC} is given by the higher layer parameter *transmissionCombNum* if configured, otherwise $K_{\mathrm{TC}}=2$. Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/15.02.00_60/ts_136211v150200p.pdf (GC0004509; GC0004522)

Claim 9	Analysis	Select Evidence
	The reference signals are at least time multiplexed with other uplink transmissions from the same device. A person of ordinary skill in the art at the time of the invention would also understand that reference signals from one device are frequency multiplexed with uplink transmissions from multiple devices.	UPLINK REFERENCE SIGNALS There are two types of reference signals for uplink in LTE. The first is Demodulation Reference Signals (DM-RS) which are used to enable coherent signal demodulation at the eNodeB. These signals are time multiplexed with uplink data and are transmitted on the fourth or third SC-FDMA symbol of an uplink slot for normal or extended CP, respectively, using the same bandwidth as the data. Source: https://frankrayal.com/wp-content/uploads/2017/02/LTE-in-a-Nutshell-Physical-Layer.pdf (GC0004327)