

P.R. 3-1(c) EXHIBIT 7

U.S. Patent No. 11,381,285: Samsung Devices¹

Claim 11	Analysis	Select Evidence						
An apparatus for communication in a wireless network, comprising:	The Samsung Galaxy S22 ("Galaxy S22") is a non-limiting example of an apparatus for communication in a wireless communication network (e.g., 5G network). As shown to the right, the Galaxy S22 is a 5G device, and adheres to the 5G specification.	 Galaxy S22, 128GB (Unlocked) SM-S901UZKAXAA ★★★★★ 3.9 (1358) Write a review Share your product experience ***** <table> <tr> <td> Network 2G GSM GSM850,GSM900,DCS1800,PC S1900 </td><td> 3G UMTS B1(2100),B2(1900),B4(AWS),B5 (850),B8(900) </td><td> 4G FDD LTE B1(2100),B2(1900),B3(1800),B 4(AWS),B5(850),B7(2600),B8(9 00),B12(700),B13(700),B14(70 0),B18(800),B19(800),B20(800),B25(1900),B26(850),B28(700),B29(700),B30(2300),B66(AWS -3),B71(600) </td></tr> <tr> <td> 4G TDD LTE B38(2600),B39(1900),B40(230 0),B41(2500),B46(5200),B48(3 600) </td><td> 5G FDD Sub6 N1(2100),N3(1800),N5(850),N7 (2600),N8(900),N20(800),N28 (700),N66(AWS-3),N71(600) </td><td> 5G TDD Sub6 N260(39GHz),N261(28GHz) </td></tr> </table> Source: https://www.samsung.com/us/business/mobile/phones/galaxy-s/galaxy-s22-128gb-unlocked-sm-s901uzkaxaa/#specs GC0007293-94; GC0007311)	Network 2G GSM GSM850,GSM900,DCS1800,PC S1900	3G UMTS B1(2100),B2(1900),B4(AWS),B5 (850),B8(900)	4G FDD LTE B1(2100),B2(1900),B3(1800),B 4(AWS),B5(850),B7(2600),B8(9 00),B12(700),B13(700),B14(70 0),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(230 0),B41(2500),B46(5200),B48(3 600)	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)
Network 2G GSM GSM850,GSM900,DCS1800,PC S1900	3G UMTS B1(2100),B2(1900),B4(AWS),B5 (850),B8(900)	4G FDD LTE B1(2100),B2(1900),B3(1800),B 4(AWS),B5(850),B7(2600),B8(9 00),B12(700),B13(700),B14(70 0),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(230 0),B41(2500),B46(5200),B48(3 600)	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)						

¹ This chart applies to all Samsung devices, including those listed in Appendix A and identified in the Complaint at paragraph 31. Other Samsung 5G-enabled devices, including any recently discontinued 5G-enabled devices, infringe this patent in a substantially similar, if not identical, manner.

Claim 11	Analysis	Select Evidence																				
a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:	The Galaxy S22 includes a Qualcomm Snapdragon 8 Gen 1 chipset with processor. The Galaxy S22 has at least one non-transitory computer-readable memory in communication with the processor. The memory stores executable instructions for using the 5G cellular network.	<table><tr><td rowspan="5">PLATFORM</td><td>OS</td><td>Android 12, upgradable to Android 14, One UI 6.1</td></tr><tr><td>Chipset</td><td>Exynos 2200 (4 nm) - Europe Qualcomm SM8450 Snapdragon 8 Gen 1 (4 nm) - ROW</td></tr><tr><td>CPU</td><td>Octa-core (1x2.8 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.8 GHz Cortex-A510) - Europe Octa-core (1x3.00 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.80 GHz Cortex-A510) - ROW</td></tr><tr><td>GPU</td><td>Xclipse 920 - Europe Adreno 730 - ROW</td></tr><tr><td rowspan="2">MEMORY</td><td>Card slot</td><td>No</td></tr><tr><td>Internal</td><td>128GB 8GB RAM, 256GB 8GB RAM UFS 3.1</td></tr></table> Source: https://www.gsmarena.com/samsung_galaxy_s22_5g-11253.php (GC0007380) Ground-breaking innovations in AI, photography, gaming, and connectivity—for the premium experiences your devices deserve. The Snapdragon® 8 Gen 1 Mobile Platform is our most advanced 5G platform ever, with our Snapdragon® X65 5G Modem-RF System ushering in unprecedented speeds up to 10 Gbps while supp... * * * * <table><tr><td colspan="2">Memory</td></tr><tr><td>Speed:</td><td>3200 MHz⁵</td></tr><tr><td>Type:</td><td>LPDDR5</td></tr></table> Source: https://www.qualcomm.com/products/mobile/snapdragon/smartphones/snapdragon-8-series-mobile-platforms/snapdragon-8-gen-1-mobile-platform (GC0007688)	PLATFORM	OS	Android 12, upgradable to Android 14, One UI 6.1	Chipset	Exynos 2200 (4 nm) - Europe Qualcomm SM8450 Snapdragon 8 Gen 1 (4 nm) - ROW	CPU	Octa-core (1x2.8 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.8 GHz Cortex-A510) - Europe Octa-core (1x3.00 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.80 GHz Cortex-A510) - ROW	GPU	Xclipse 920 - Europe Adreno 730 - ROW	MEMORY	Card slot	No	Internal	128GB 8GB RAM, 256GB 8GB RAM UFS 3.1	Memory		Speed:	3200 MHz ⁵	Type:	LPDDR5
PLATFORM	OS	Android 12, upgradable to Android 14, One UI 6.1																				
	Chipset	Exynos 2200 (4 nm) - Europe Qualcomm SM8450 Snapdragon 8 Gen 1 (4 nm) - ROW																				
	CPU	Octa-core (1x2.8 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.8 GHz Cortex-A510) - Europe Octa-core (1x3.00 GHz Cortex-X2 & 3x2.50 GHz Cortex-A710 & 4x1.80 GHz Cortex-A510) - ROW																				
	GPU	Xclipse 920 - Europe Adreno 730 - ROW																				
	MEMORY	Card slot	No																			
Internal		128GB 8GB RAM, 256GB 8GB RAM UFS 3.1																				
Memory																						
Speed:	3200 MHz ⁵																					
Type:	LPDDR5																					

Claim 11	Analysis	Select Evidence
encoding a set of data symbols with a set of complex-valued codes, to produce a set of subcarrier values;	The Galaxy S22 encodes data symbols with complex-valued codes to produce a set of subcarrier values during the transform precoding step required by the 5G specification. The DFT used for transform precoding includes an exponential term that corresponds to complex-valued codes that are then multiplied by the data symbols.	6.3.1.4 Transform precoding If transform precoding is not enabled according to 6.1.3 of [6, TS38.214], $y^{(\lambda)}(i) = x^{(\lambda)}(i)$ for each layer $\lambda = 0, 1, \dots, v-1$. If transform precoding is enabled according to 6.1.3 of [6, TS38.214], $v = 1$ and $\tilde{x}^{(0)}(i)$ depends on the configuration of phase-tracking reference signals. If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, <u>the block of complex-valued symbols $x^{(0)}(0), \dots, x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ for the single layer $\lambda = 0$ shall be divided into $M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}}$ sets, each corresponding to one OFDM symbol and $\tilde{x}^{(0)}(i) = x^{(0)}(i)$.</u> If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, <u>the block of complex-valued symbols $x^{(0)}(0), \dots, x^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$ shall be divided into sets, each set corresponding to one OFDM symbol, and where set l contains $M_{\text{sc}}^{\text{PUSCH}} - \varepsilon_l N_{\text{samp}}^{\text{group}} N_{\text{group}}^{\text{PTRS}}$ symbols and is mapped to the complex-valued symbols $\tilde{x}^{(0)}(l M_{\text{sc}}^{\text{PUSCH}} + i')$ corresponding to OFDM symbol l prior to transform precoding, with $i' \in \{0, 1, \dots, M_{\text{sc}}^{\text{PUSCH}} - 1\}$ and $i' \neq m$. The index m of PT-RS samples in set l, the number of samples per PT-RS group $N_{\text{samp}}^{\text{group}}$, and the number of PT-RS groups $N_{\text{group}}^{\text{PTRS}}$ are defined in clause 6.4.1.2.2.2. The quantity $\varepsilon_l = 1$ when OFDM symbol l contains one or more PT-RS samples, otherwise $\varepsilon_l = 0$.</u> * * * * Transform precoding shall be applied according to $y^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + k) = \frac{1}{\sqrt{M_{\text{sc}}^{\text{PUSCH}}}} \sum_{i=0}^{M_{\text{sc}}^{\text{PUSCH}}-1} \tilde{x}^{(0)}(l \cdot M_{\text{sc}}^{\text{PUSCH}} + i) e^{-j \frac{2\pi i k}{M_{\text{sc}}^{\text{PUSCH}}}}$ $k = 0, \dots, M_{\text{sc}}^{\text{PUSCH}} - 1$ $l = 0, \dots, M_{\text{symb}}^{\text{layer}} / M_{\text{sc}}^{\text{PUSCH}} - 1$ resulting in a block of complex-valued symbols $y^{(0)}(0), \dots, y^{(0)}(M_{\text{symb}}^{\text{layer}} - 1)$. The variable $M_{\text{sc}}^{\text{PUSCH}} = M_{\text{RB}}^{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}}$, where $M_{\text{RB}}^{\text{PUSCH}}$ represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil $M_{\text{RB}}^{\text{PUSCH}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$ where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004373)

Claim 11	Analysis	Select Evidence
modulating the set of subcarrier values onto a set of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers assigned for use by the user device, to produce a plurality of modulated subcarriers; and	The Galaxy S22 modulates subcarrier values on the subcarriers during OFDM baseband signal generation required by the 5G specification. Baseband signal generation converts frequency-domain values from transform precoding into time-domain values (waveforms) used during transmission.	5.3.1 OFDM baseband signal generation for all channels except PRACH The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0, 1, \dots, N_{\text{slot}}^{\text{subframe}, \mu} N_{\text{symbol}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by $s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}, \mu}^{\text{size}} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi \left((k+k_0^{\mu} - N_{\text{grid}, \mu}^{\text{size}} N_{\text{sc}}^{\text{RB}} / 2) \Delta f (t - N_{\text{CP}, J}^{\mu} T_c - t_{\text{start}, l}^{\mu}) \right)}$ $k_0^{\mu} = \left(N_{\text{grid}, \mu}^{\text{start}} + N_{\text{grid}, \mu}^{\text{size}} / 2 \right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid}, \mu}^{\text{start}, \mu_0} + N_{\text{grid}, \mu}^{\text{size}, \mu_0} / 2 \right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$ where $t_{\text{start}, l}^{\mu} \leq t < t_{\text{start}, l}^{\mu} + (N_{\text{u}}^{\mu} + N_{\text{CP}, J}^{\mu}) T_c$ is the time within the subframe, $N_{\text{u}}^{\mu} = 2048 \kappa \cdot 2^{-\mu}$ $N_{\text{CP}, J}^{\mu} = \begin{cases} 512 \kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144 \kappa \cdot 2^{-\mu} + 16 \kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^{\mu} \\ 144 \kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \neq 0 \text{ and } l \neq 7 \cdot 2^{\mu} \end{cases}$ Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrier. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004368)

Claim 11	Analysis	Select Evidence
producing a time-domain waveform that comprises a superposition of the plurality of modulated subcarriers, the time-domain waveform to be transmitted in the wireless network by the user device;	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 OFMD baseband generation step employed by the Galaxy S22 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. The set of subcarrier values causes the time-domain waveform to resemble a single carrier.	5.3.1 OFDM baseband signal generation for all channels except PRACH The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0, 1, \dots, N_{\text{slot}}^{\text{subframe}, \mu} N_{\text{symbol}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by $s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid},x}^{\text{size}, \mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi \left((k+k_0^{\mu} - N_{\text{grid},x}^{\text{size}, \mu} N_{\text{sc}}^{\text{RB}} / 2) \Delta f (t - N_{\text{CP},J}^{\mu} T_c - t_{\text{start},l}^{\mu}) \right)}$ $k_0^{\mu} = \left(N_{\text{grid},x}^{\text{start}, \mu} + N_{\text{grid},x}^{\text{size}, \mu} / 2 \right) N_{\text{sc}}^{\text{RB}} - \left(N_{\text{grid},x}^{\text{start}, \mu_0} + N_{\text{grid},x}^{\text{size}, \mu_0} / 2 \right) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$ where $t_{\text{start},l}^{\mu} \leq t < t_{\text{start},l}^{\mu} + (N_{\text{u}}^{\mu} + N_{\text{CP},J}^{\mu}) T_c$ is the time within the subframe, $N_{\text{u}}^{\mu} = 2048 \kappa \cdot 2^{-\mu}$ $N_{\text{CP},J}^{\mu} = \begin{cases} 512 \kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144 \kappa \cdot 2^{-\mu} + 16 \kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^{\mu} \\ 144 \kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \neq 0 \text{ and } l \neq 7 \cdot 2^{\mu} \end{cases}$ Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrier. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004368) <u>A key enabler for OFDM is the use of the Inverse Fast Fourier Transform (IFFT) to efficiently create the time domain waveform from the array of modulated subcarriers.</u> The resulting OFDM signal is in digital Source: https://www.5gtechnologyworld.com/the-basics-of-5gs-modulation-ofdm/ (GC0007083)

Claim 11	Analysis	Select Evidence
wherein the set of subcarrier values comprises a first polyphase code that encodes a first of the set of data symbols and at least a second polyphase code that encodes at least a second of the set of data symbols;	As shown to the right and as discussed above, transform precoding applies a DFT to generate subcarrier values. Application of the exponential term (which phase shifts inputs) of the DFT generates polyphase codes for each set of data symbols.	Transform precoding shall be applied according to $y^{(0)}(l \cdot M_{sc}^{PUSCH} + k) = \frac{1}{\sqrt{M_{sc}^{PUSCH}}} \sum_{i=0}^{M_{sc}^{PUSCH}-1} \tilde{x}^{(0)}(l \cdot M_{sc}^{PUSCH} + i) e^{-j \frac{2\pi i k}{M_{sc}^{PUSCH}}}$ $k = 0, \dots, M_{sc}^{PUSCH} - 1$ $l = 0, \dots, M_{symb}^{layer} / M_{sc}^{PUSCH} - 1$ resulting in a block of complex-valued symbols $y^{(0)}(0), \dots, y^{(0)}(M_{symb}^{layer} - 1)$. The variable $M_{sc}^{PUSCH} = M_{RB}^{PUSCH} \cdot N_{sc}^{RB}$, where M_{RB}^{PUSCH} represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil $M_{RB}^{PUSCH} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5}$ where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers. Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004373)

Claim 11	Analysis	Select Evidence																		
wherein the first polyphase code causes constructive and destructive interference between the plurality of modulated subcarriers to produce a first periodic pulse waveform having a peak value that is centered at a first time in an OFDM symbol interval, and the second polyphase code causes constructive and destructive interference between the plurality of modulated subcarriers to produce a second periodic pulse waveform having a peak value that is centered at a second time in the OFDM symbol interval, the second time different from the first time.	As is known in the art, the principle of superposition of waves states that when two or more propagating waves of the same type are incident on the same point, the resultant amplitude at that point is equal to the vector sum of the amplitudes of the individual waves. If a crest of a wave meets a crest of another wave of the same frequency at the same point, then the amplitude is the sum of the individual amplitudes—this is constructive interference. If a crest of one wave meets a trough of another wave, then the amplitude is equal to the difference in the individual amplitudes—this is destructive interference. In OFDM, the subcarriers are uniformly spaced by frequency Δf, so the time-domain OFDM symbol is periodic with a symbol period of $1/\Delta f$. Equivalently, in the digital domain, the N-point IDFT used in OFDM transmission produces a discrete-time OFDM signal with N samples and period N.	4.2 Numerologies Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter <i>subcarrierSpacing</i> and <i>cyclicPrefix</i>, respectively. Table 4.2-1: Supported transmission numerologies. <table> <tr> <th>μ</th><th>$\Delta f = 2^\mu \cdot 15$ [kHz]</th><th>Cyclic prefix</th></tr> <tr> <td>0</td><td>15</td><td>Normal</td></tr> <tr> <td>1</td><td>30</td><td>Normal</td></tr> <tr> <td>2</td><td>60</td><td>Normal, Extended</td></tr> <tr> <td>3</td><td>120</td><td>Normal</td></tr> <tr> <td>4</td><td>240</td><td>Normal</td></tr> </table> * * * * <u>Δf</u> Subcarrier spacing * * * * μ Subcarrier spacing configuration, $\Delta f = 2^\mu \cdot 15$ [kHz] Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004359, GC0004357)	μ	$\Delta f = 2^\mu \cdot 15$ [kHz]	Cyclic prefix	0	15	Normal	1	30	Normal	2	60	Normal, Extended	3	120	Normal	4	240	Normal
μ	$\Delta f = 2^\mu \cdot 15$ [kHz]	Cyclic prefix																		
0	15	Normal																		
1	30	Normal																		
2	60	Normal, Extended																		
3	120	Normal																		
4	240	Normal																		

Claim 11	Analysis	Select Evidence
	If values of a first polyphase code are chosen properly, the codes provide phase offsets to the subcarriers that cause all of the subcarriers' phases to align at a particular time inside the symbol period, which causes constructive interference, resulting in a pulse waveform being centered at that time. If a second polyphase code also produces a pulse waveform, that pulse waveform is preferably centered at a different time in order for it to be distinguished from the first pulse waveform. This happens when the codes are chosen from the rows or columns of a DFT matrix. A person of ordinary skill in the art at the time of the invention would understand that the DFT used for transform precoding can be depicted as a complex matrix transform. Values are calculated by multiplying a matrix of complex-valued codes with a matrix of data symbols. In the equation at right, $x(N-1)$ corresponds to the x variable in the 5G transform precoding equation shown above.	The DFT consists of inner products of the input signal $\underline{x}$ with sampled complex sinusoidal sections $\underline{s}_k$: $X(\omega_k) \triangleq \langle \underline{x}, \underline{s}_k \rangle \triangleq \sum_{n=0}^{N-1} \underline{x}(n) e^{-j2\pi nk/N}, \quad k = 0, 1, 2, \dots, N-1$ By collecting the DFT output samples into a column vector, we have $\underbrace{\begin{bmatrix} X(\omega_0) \\ X(\omega_1) \\ X(\omega_2) \\ \vdots \\ X(\omega_{N-1}) \end{bmatrix}}_{\underline{X}} = \underbrace{\begin{bmatrix} \overline{s_0(0)} & \overline{s_0(1)} & \cdots & \overline{s_0(N-1)} \\ \overline{s_1(0)} & \overline{s_1(1)} & \cdots & \overline{s_1(N-1)} \\ \overline{s_2(0)} & \overline{s_2(1)} & \cdots & \overline{s_2(N-1)} \\ \vdots & \vdots & \ddots & \vdots \\ \overline{s_{N-1}(0)} & \overline{s_{N-1}(1)} & \cdots & \overline{s_{N-1}(N-1)} \end{bmatrix}}_{\mathbf{S}_N^*} \underbrace{\begin{bmatrix} x(0) \\ x(1) \\ x(2) \\ \vdots \\ x(N-1) \end{bmatrix}}_{\underline{x}}$ ***** where $\mathbf{S}_N^*$ denotes the <i>DFT matrix</i> $\mathbf{S}_N^*[k, n] \triangleq W_N^{-kn} \triangleq e^{-j2\pi kn/N}$, i.e., $\mathbf{S}_N^* \triangleq [\underline{s}_0 \quad \underline{s}_1 \quad \cdots \quad \underline{s}_{N-1}]^*$ $\triangleq \begin{bmatrix} \overline{s_0(0)} & \overline{s_0(1)} & \cdots & \overline{s_0(N-1)} \\ \overline{s_1(0)} & \overline{s_1(1)} & \cdots & \overline{s_1(N-1)} \\ \overline{s_2(0)} & \overline{s_2(1)} & \cdots & \overline{s_2(N-1)} \\ \vdots & \vdots & \ddots & \vdots \\ \overline{s_{N-1}(0)} & \overline{s_{N-1}(1)} & \cdots & \overline{s_{N-1}(N-1)} \end{bmatrix}$ $\triangleq \begin{bmatrix} 1 & 1 & 1 & \cdots & 1 \\ 1 & e^{-j2\pi/N} & e^{-j4\pi/N} & \cdots & e^{-j2\pi(N-1)/N} \\ 1 & e^{-j4\pi/N} & e^{-j8\pi/N} & \cdots & e^{-j2\pi 2(N-1)/N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & e^{-j2\pi(N-1)/N} & e^{-j2\pi 2(N-1)/N} & \cdots & e^{-j2\pi(N-1)(N-1)/N} \end{bmatrix}$ Source: https://ccrma.stanford.edu/~jos/st/Matrix_Formulation_DFT.html (GC0007076-77)

Claim 17	Analysis	Select Evidence
The apparatus of claim 11, further comprising adding a cyclic prefix to the time-domain waveform.	The Galaxy S22 is further configured to add a cyclic prefix to the time-domain waveform (e.g., SC-FDMA signal) prior to transmit. As shown to the right, a cyclic prefix of length $N_{CP,l}^\mu$ is added when converting the SC-FDMA frequency domain signal into a time domain signal.	<u>$N_{CP,l}^\mu$</u> Cyclic prefix length; see clause 5.3.1 * * * * 5.3 OFDM baseband signal generation 5.3.1 OFDM baseband signal generation for all channels except PRACH The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0, 1, \dots, N_{\text{slot}}^{\text{subframe}, \mu} N_{\text{slot}}^{\text{symbol}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by $s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}}^{\text{size}, \mu} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi(k+k_0^\mu - N_{\text{grid},x}^{\text{size}, \mu} N_{\text{sc}}^{\text{RB}}/2) \Delta f (t - N_{CP,l}^\mu T_c - t_{\text{start},l}^\mu)}$ $k_0^\mu = (N_{\text{grid},x}^{\text{start}, \mu} + N_{\text{grid},x}^{\text{size}, \mu}/2) N_{\text{sc}}^{\text{RB}} - (N_{\text{grid},x}^{\text{start}, \mu_0} + N_{\text{grid},x}^{\text{size}, \mu_0}/2) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$ where $t_{\text{start},l}^\mu \leq t < t_{\text{start},l}^\mu + (N_u^\mu + N_{CP,l}^\mu) T_c$ is the time within the subframe, $N_u^\mu = 2048\kappa \cdot 2^{-\mu}$ $N_{CP,l}^\mu = \begin{cases} 512\kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^\mu \\ 144\kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \neq 0 \text{ and } l \neq 7 \cdot 2^\mu \end{cases}$ Source: https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.07.00_60/ts_136211v080700p.pdf (GC0004358, GC0004368)

Claim 19	Analysis	Select Evidence																																																
The apparatus of claim 11, wherein modulating comprises selecting one of a set of subcarrier frequency spacings.	The 5G standard supports multiple OFDM numerologies, and specifies the subcarrier spacing to be selected from 15kHz, 30kHz, 60kHz, 120kHz and 240 kHz. As shown to the right, subcarrier spacing $\Delta f = 2^\mu \cdot 15[\text{kHz}]$ wherein the scaling factor is the subcarrier spacing configuration μ.	4.2 Numerologies Multiple OFDM numerologies are supported as given by Table 4.2-1 where μ and the cyclic prefix for a bandwidth part are obtained from the higher-layer parameter <i>subcarrierSpacing</i> and <i>cyclicPrefix</i>, respectively. Table 4.2-1: Supported transmission numerologies. <table><tr><th>μ</th><th>$\Delta f = 2^\mu \cdot 15[\text{kHz}]$</th><th>Cyclic prefix</th></tr><tr><td>0</td><td>15</td><td>Normal</td></tr><tr><td>1</td><td>30</td><td>Normal</td></tr><tr><td>2</td><td>60</td><td>Normal, Extended</td></tr><tr><td>3</td><td>120</td><td>Normal</td></tr><tr><td>4</td><td>240</td><td>Normal</td></tr></table> * * * * Δf Subcarrier spacing * * * * μ Subcarrier spacing configuration, $\Delta f = 2^\mu \cdot 15[\text{kHz}]$ Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004359, GC0004357) OFDM Symbol Duration <table><tr><th>Parameter / Numerology (u)</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th></tr><tr><td>Subcarrier Spacing (Khz)</td><td>15</td><td>30</td><td>60</td><td>120</td><td>240</td></tr><tr><td>OFDM Symbol Duration (us)</td><td>66.67</td><td>33.33</td><td>16.67</td><td>8.33</td><td>4.17</td></tr><tr><td>Cyclic Prefix Duration (us)</td><td>4.69</td><td>2.34</td><td>1.17</td><td>0.57</td><td>0.29</td></tr><tr><td>OFDM Symbol including CP (us)</td><td>71.35</td><td>35.68</td><td>17.84</td><td>8.92</td><td>4.46</td></tr></table> Source: https://www.sharetechnote.com/html/5G/5G_FrameStructure.html (GC0005145)	μ	$\Delta f = 2^\mu \cdot 15[\text{kHz}]$	Cyclic prefix	0	15	Normal	1	30	Normal	2	60	Normal, Extended	3	120	Normal	4	240	Normal	Parameter / Numerology (u)	0	1	2	3	4	Subcarrier Spacing (Khz)	15	30	60	120	240	OFDM Symbol Duration (us)	66.67	33.33	16.67	8.33	4.17	Cyclic Prefix Duration (us)	4.69	2.34	1.17	0.57	0.29	OFDM Symbol including CP (us)	71.35	35.68	17.84	8.92	4.46
μ	$\Delta f = 2^\mu \cdot 15[\text{kHz}]$	Cyclic prefix																																																
0	15	Normal																																																
1	30	Normal																																																
2	60	Normal, Extended																																																
3	120	Normal																																																
4	240	Normal																																																
Parameter / Numerology (u)	0	1	2	3	4																																													
Subcarrier Spacing (Khz)	15	30	60	120	240																																													
OFDM Symbol Duration (us)	66.67	33.33	16.67	8.33	4.17																																													
Cyclic Prefix Duration (us)	4.69	2.34	1.17	0.57	0.29																																													
OFDM Symbol including CP (us)	71.35	35.68	17.84	8.92	4.46																																													

Claim 19	Analysis	Select Evidence
	As discussed above and as shown to the right, OFDM baseband signal generation requires the use of subcarrier spacings, with the subcarrier spacings selected from the numerologies.	5.3.1 OFDM baseband signal generation for all channels except PRACH The time-continuous signal $s_l^{(p,\mu)}(t)$ on antenna port p and subcarrier spacing configuration μ for OFDM symbol $l \in \{0, 1, \dots, N_{\text{slot}}^{\text{subframe}, \mu} N_{\text{ymb}}^{\text{slot}} - 1\}$ in a subframe for any physical channel or signal except PRACH is defined by $s_l^{(p,\mu)}(t) = \sum_{k=0}^{N_{\text{grid}, \mu}^{\text{size}} N_{\text{sc}}^{\text{RB}} - 1} a_{k,l}^{(p,\mu)} \cdot e^{j2\pi(k + k_0^{\mu} - N_{\text{grid}, \mu}^{\text{size}} N_{\text{sc}}^{\text{RB}} / 2) \Delta f (t - N_{\text{CP}, l}^{\mu} T_c - t_{\text{start}, l}^{\mu})}$ $k_0^{\mu} = (N_{\text{grid}, \mu}^{\text{start}} + N_{\text{grid}, \mu}^{\text{size}} / 2) N_{\text{sc}}^{\text{RB}} - (N_{\text{grid}, \mu}^{\text{start}, \mu_0} + N_{\text{grid}, \mu}^{\text{size}, \mu_0} / 2) N_{\text{sc}}^{\text{RB}} 2^{\mu_0 - \mu}$ where $t_{\text{start}, l}^{\mu} \leq t < t_{\text{start}, l}^{\mu} + (N_{\text{u}}^{\mu} + N_{\text{CP}, l}^{\mu}) T_c$ is the time within the subframe, $N_{\text{u}}^{\mu} = 2048 \kappa \cdot 2^{-\mu}$ $N_{\text{CP}, l}^{\mu} = \begin{cases} 512 \kappa \cdot 2^{-\mu} & \text{extended cyclic prefix} \\ 144 \kappa \cdot 2^{-\mu} + 16 \kappa & \text{normal cyclic prefix, } l = 0 \text{ or } l = 7 \cdot 2^{\mu} \\ 144 \kappa \cdot 2^{-\mu} & \text{normal cyclic prefix, } l \neq 0 \text{ and } l \neq 7 \cdot 2^{\mu} \end{cases}$ Δf is given by clause 4.2, μ is the subcarrier spacing configuration, and μ_0 is the largest μ value among the subcarrier spacing configurations provided to the UE for this carrier. The starting position of OFDM symbol l for subcarrier spacing configuration μ in a subframe is given by Source: https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/15.02.00_60/ts_138211v150200p.pdf (GC0004368)