Appendix E: Simultaneous Transmission Analysis

E.1. Introduction

According to FCC KDB Publication 447498 D04v01, transmitters are considered to be operating simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

Table E-1 - Supported Simultaneous Transmission Scenarios

#	Scenario	Body	Extremity
1	LTE + 2.4 GHz WIFI_MIMO	Yes	Yes
2	LTE + 5 GHz WIFI_MIMO	Yes	Yes
3	LTE + 6 GHz WIFI_MIMO	Yes	Yes
4	LTE + 2.4 GHz Bluetooth_Chain0	Yes	Yes
5	LTE + 2.4 GHz Bluetooth_Chain1	Yes	Yes
6	LTE + 2.4 GHz WIFI_MIMO + 5 GHz WIFI_MIMO	Yes	Yes
7	LTE + 2.4 GHz WIFI_MIMO + 6 GHz WIFI_MIMO	Yes	Yes
8	LTE + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
9	LTE + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
10	LTE + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
11	LTE + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
12	NR + 2.4 GHz WIFI_MIMO	Yes	Yes
13	NR + 5 GHz WIFI_MIMO	Yes	Yes
14	NR + 6 GHz WIFI_MIMO	Yes	Yes
15	NR + 2.4 GHz Bluetooth_Chain0	Yes	Yes
16	NR + 2.4 GHz Bluetooth_Chain1	Yes	Yes
17	NR + 2.4 GHz WIFI_MIMO + 5 GHz WIFI_MIMO	Yes	Yes
18	NR + 2.4 GHz WIFI_MIMO + 6 GHz WIFI_MIMO	Yes	Yes
19	NR + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
20	NR + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
21	NR + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
22	NR + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
23	LTE + NR + 2.4 GHz WIFI_MIMO	Yes	Yes
24	LTE + NR + 5 GHz WIFI_MIMO	Yes	Yes
25	LTE + NR + 6 GHz WIFI_MIMO	Yes	Yes
26	LTE + NR + 2.4 GHz Bluetooth_Chain0	Yes	Yes
27	LTE + NR + 2.4 GHz Bluetooth_Chain1	Yes	Yes
28	LTE + NR + 2.4 GHz WIFI_MIMO + 5 GHz WIFI_MIMO	Yes	Yes
29	LTE + NR + 2.4 GHz WIFI_MIMO + 6 GHz WIFI_MIMO	Yes	Yes
30	LTE + NR + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
31	LTE + NR + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
32	LTE + NR + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain0	Yes	Yes
33	LTE + NR + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_Chain1	Yes	Yes
34	LTE + NR	Yes	Yes

E.2. Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D04v01 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1g or 10g SAR.

Per FCC KDB Publication 941225 D06v02r01, the devices edges with antennas more than 2.5 cm from edge are not required to be evaluated for SAR ("-").

This device is enabled with Qualcomm® Smart Transmit Gen2 with pre-defined sub6 antenna groups (AG0 and AG1). Simultaneous transmission analysis is performed per antenna groups. Below analysis demonstrates the mutually exclusive operation of AG0 and AG1 and the compliance between AG0 and BT/WLAN, and between AG1 and BT/WLAN.

When operating in the same antenna group, Qualcomm Smart Transmit algorithm in WWAN directly adds the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G NR. Smart Transmit algorithm controls the total RF exposure from both 4G and 5G NR to not exceed FCC limit. Therefore, simultaneous transmission compliance between 4G+5G operations within an antenna group is demonstrated in the Part 2 Report during algorithm validation.

E.3. Smart Transmit Antenna Grouping

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined sub6 antenna groups (AG) and mmW module groups (MG). Sub6 Tx antennas in the device are grouped based on spatial variation of RF exposure distributions, where the RF exposure of one AG is mutually exclusive from other AG. This is accomplished by demonstrating either of below conditions for all exposure scenarios:

a) Sum of SAR of each antenna from each of the sub6 AGs and the RF exposure from radios outside Smart Transmit is less than regulatory limits. This condition must be demonstrated for all antenna combinations of sub6 AGs.

(or)

b) Every antenna from each sub6 AG meets SPLSR criteria (Section 4.3.2(c) in FCC KDB 447498 D04) with every antenna from another sub6 AG. This criteria must be demonstrated for all antenna combinations for each pair of AGs.

This device supports two sub6 AG: AG0 and AG1, with AG0 having 2 antennas (Main1, Main2) and AG1 having 4 antennas (Sub, Sub-UHB, 3rd-LMH, 4th-MBHB), and two WIFI/BT antennas outside of Smart Transmit. The conditions are verified through the following criteria:

i) (SAR1 + SAR2 criteria): If SPLSR criteria is not used, then the highest reported SAR at Plimit (or Pmax when Plimit > Pmax) for each antenna should be obtained out of all supported technologies and frequency bands for each DSI. Demonstrate that the sum of reported SAR of one antenna from each of the sub6 AGs and the sum of RF exposure from all supported radios outside of Smart Transmit should be less than the regulatory limit as given below for each DSI.

1. Obtain the worst-case reported SAR for each antenna group (i.e., maximum reported SAR at Plimit (or Pmax when Plimit > Pmax) out of all supported technologies, frequency bands and antennas in AG0 and AG1), denoted as max.SAR.AG0 and max.SAR.AG1, and obtain the worst-case RF exposure for each external radio, and demonstrate that the sum of these RF exposures meets: { [max.SAR.AG0 + max.SAR.AG1] + WIFI/BT} ≤ 1.6 (for 1g,or 4.0 for 10g).

The sum of the 1g and 10g SAR values were ≤1.6 W/kg for 1g and ≤4.0 W/kg for 10g. Therefore, no additional analysis using SPLSR was required.

E.4. Simultaneous Transmission Analysis

Table E-2 - AG0 Maximum Reported SAR Values

	Antenna Group	AG0 (W/kg)		
Exposure Condition	Position	Main1	Main2	Maximum SAR
Body (1g)	Back	0.729	0.658	0.729
Body (1g)	Front	0.710	0.871	0.871
Body (1g)	Top	-	-	0.000
Body (1g)	Bottom	1.101	0.288	1.101
Body (1g)	Right	0.739	-	0.739
Body (1g)	Left	-	0.760	0.760
Extremity (10g)	Bottom	0.823	0.268	0.823

Table E-3 – AG1 Maximum Reported SAR Values

	Antenna Group	AG1 (W/kg)				
Exposure Condition	Position	Sub	Sub-UHB	3rd-LMH	4th-MBHB	Maximum SAR
Body (1g)	Back	0.451	0.281	0.183	0.210	0.451
Body (1g)	Front	0.397	0.557	0.036	0.074	0.557
Body (1g)	Top	0.914	0.804	0.105	-	0.914
Body (1g)	Bottom	-	-	-	-	0.000
Body (1g)	Right	0.240	-	0.200	-	0.240
Body (1g)	Left	-	0.077	-	0.301	0.301

Table E-4 – Maximum Bluetooth/WLAN Simultaneous Transmission Scenarios

	Band/Mode	2.4 GHz WIFI	2.4 GHz WIFI	5 GHz WIFI	6 GHz WIFI	2.4 GHz Bluetooth	2.4 GHz Bluetooth	2.4 GHz WIFI_MIMO (W/kg)	5 GHz WIFI_MIMO (W/kg)	6 GHz WIFI_MIMO (W/kg)	2.4 GHz Bluetooth_Chain0 (W/kg)	2.4 GHz Bluetooth_Chain1 (W/kg)	2.4 GHz WIFI_MIMO + 5 GHz WIFI_MIMO (W/kg)	2.4 GHz WIFI_MIMO + 6 GHz WIFI_MIMO (W/kg)	2.4 GHz Bluetooth_Chain0 + 5 GHz WIFI_MIMO (W/kg)	2.4 GHz Bluetooth_Chain1 + 5 GHz WIFI_MIMO (W/kg)	2.4 GHz Bluetooth_Chain0 + 6 GHz WIFI_MIMO (W/kg)	2.4 GHz Bluetooth_Chain1 + 6 GHz WIFI_MIMO (W/kg)	Max BT/WIFI Simultaneous SAR (W/kg)
	Power Level	Max	Reduced	Max	Max	Max	Max												
	Antenna	MIMO	MIMO	MIMO	MIMO	Chain0	Chain1												
Exposure Condition	Position	1	1	2	3	4	5	1	2	3	4	5	1+2	1+3	2+4	2+5	3+4	3+5	
Body (1g)	Back	0.337	0.107	0.036	0.035	0.082	0.046	0.337	0.036	0.035	0.082	0.046	0.143	0.142	0.118	0.082	0.117	0.081	0.337
Body (1g)	Front	0.058	0.023	0.043	0.025	0.019	0.011	0.058	0.043	0.025	0.019	0.011	0.066	0.048	0.062	0.054	0.044	0.036	0.066
Body (1g)	Top	0.048	0.016	0.010	0.013	0.013	-	0.048	0.010	0.013	0.013	0.000	0.026	0.029	0.023	0.010	0.026	0.013	0.048
Body (1g)	Bottom	0.082	0.028	0.041	0.019	-	-	0.082	0.041	0.019	0.000	0.000	0.069	0.047	0.041	0.041	0.019	0.019	0.082
Body (1g)	Right	0.033	0.012	0.002	0.001	-	0.015	0.033	0.002	0.001	0.000	0.015	0.014	0.013	0.002	0.017	0.001	0.016	0.033
Body (1g)	Left	0.337	0.138	0.128	0.111	0.087	-	0.337	0.128	0.111	0.087	0.000	0.266	0.249	0.215	0.128	0.198	0.111	0.337
Extremity (10g)	Bottom	0.082	-	0.019	0.012	-	0.034	0.082	0.019	0.012	0.000	0.034	0.101	0.094	0.019	0.053	0.012	0.046	0.101

Note: For bottom edge extremity SAR, max power level was used for simultaneous sum as it is more conservative.

Table E-5 – AG0+AG1+BT/WLAN Simultaneous

Exposure Condition	Position	Max AG0 SAR (W/kg)	Max AG1 SAR (W/kg)	Max BT/WIFI SAR (W/kg)	$\sum SAR_{1g}$ (W/kg)	$\sum SAR_{10g}$ (W/kg)
Body (1g)	Back	0.729	0.451	0.337	1.517	-
Body (1g)	Front	0.871	0.557	0.066	1.494	-
Body (1g)	Top	0.000	0.914	0.048	0.962	-
Body (1g)	Bottom	1.101	0.000	0.082	1.183	-
Body (1g)	Right	0.739	0.240	0.033	1.012	-
Body (1g)	Left	0.760	0.301	0.337	1.398	-
Extremity (10g)	Bottom	0.823	0.000	0.101	-	0.924

The above analysis of the simultaneous transmission scenarios is sufficient to show that AG0 is mutually exclusive from AG1 and that simultaneous transmission cases will not exceed the SAR limit. Therefore, no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D04v01 and IEEE 1528-2013 Section 6.3.4.1.