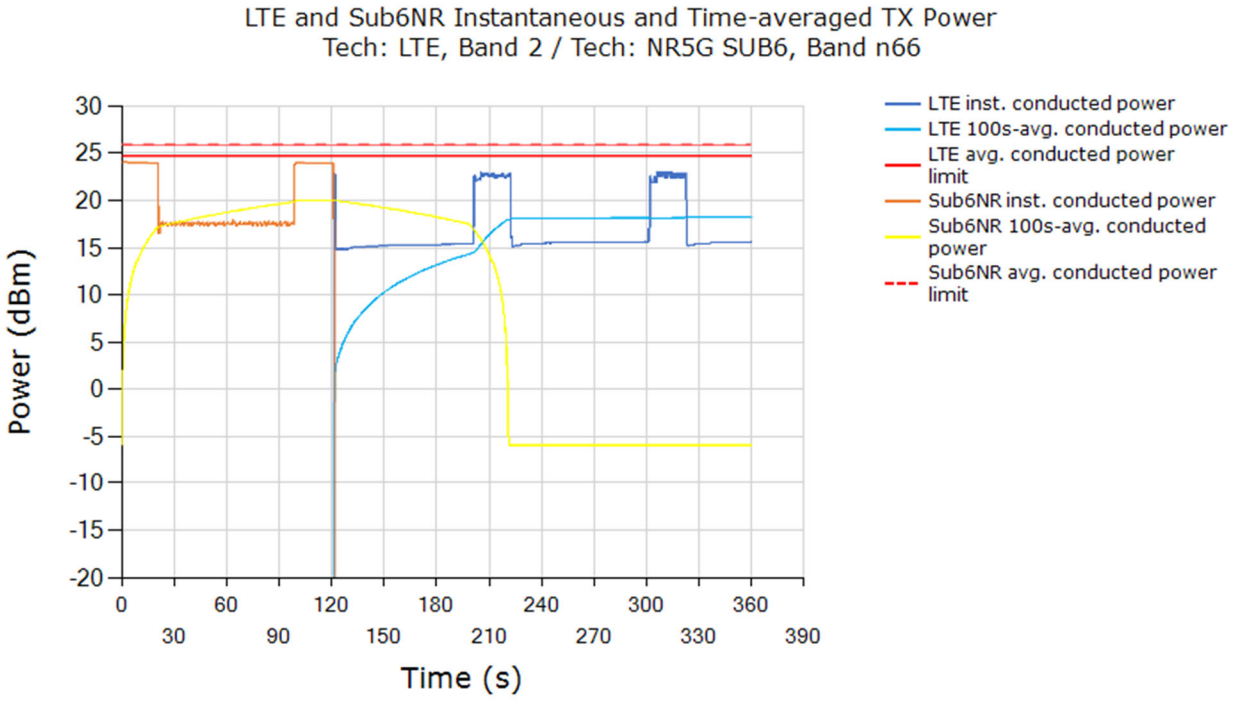
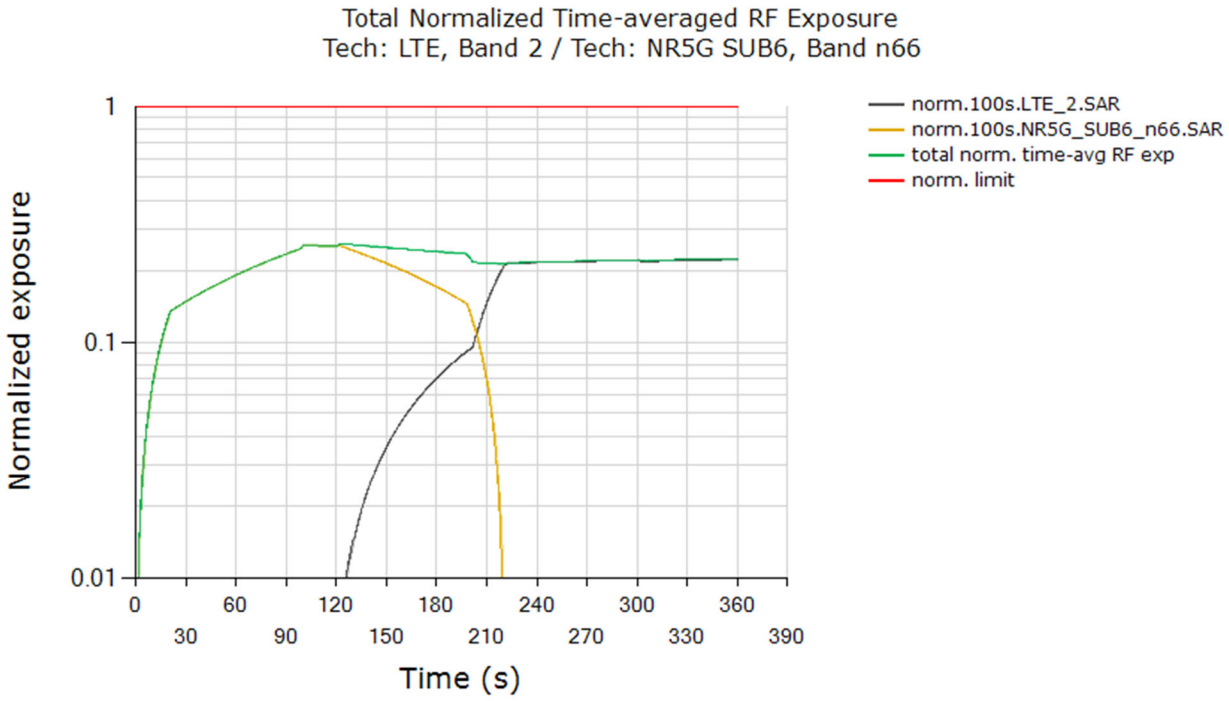
9.6 Switch in SAR exposure test results

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 2 + Sub6 NR Band n66 call. Following procedure detailed in Section 4.3.7 and Appendix F.2, and using the measurement setup shown in Figure 6-1(c) since LTE and Sub6 NR are sharing the same antenna port, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios, i.e., in SAR_{sub6NR} only scenario (t =0s ~120s), SAR_{su6NR} + SAR_{LTE} scenario (t =120s ~ 240s) and SAR_{LTE} only scenario (t > 240s).



Plot Notes: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (7a), (7b) and (7c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (7a) is used to convert the LTE Tx power of device to obtain 100s-averaged normalized SAR in LTE Band 2 as shown in black curve. Similarly, equation (7b) is used to obtain 100s-averaged normalized SAR in Sub6 NR n66 as shown in orange curve. Equation (7c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.263
Validated	

Plot Notes: Device starts predominantly in Sub6 NR SAR exposure scenario between 0s and 120s, and in LTE SAR + Sub6 NR SAR exposure scenario between 120s and 240s, and in predominantly in LTE SAR exposure scenario after t=240s. Here, Smart Transmit allocates a maximum of 100% of exposure margin (based on 3dB reserve margin setting) for Sub6 NR. This corresponds to a normalized 1gSAR exposure value = 100% * 0.403W/kg measured SAR at Sub6 NR *Plimit* / 1.6W/kg limit = 0.252 ± 1dB device related uncertainty (see orange curve between 120s). For predominantly LTE SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.323 W/kg measured SAR at LTE *Plimit* / 1.6W/kg limit = 0.202 ± 1dB device related uncertainty (see black curve after t = 240s). Additionally, in SAR exposure switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1dB device uncertainty. In this test, with a maximum normalized SAR of 0.263 being ≤ 0.79 (= 1.0/1.6 + 1dB device uncertainty), the above test result validated the continuity of power limiting in SAR exposure switch scenario.

10 SYSTEM VERIFICATION (FREQ < 6 GHZ)

10.1 Tissue Verification

Table 10-1
Measured Tissue Properties

Calibrated for Tests Performed on:	Tissue Type	Tissue Temp During Calibration (°C)	Measured Frequency (MHz)	Measured Conductivity, σ (S/m)	Measured Dielectric Constant, ε	TARGET Conductivity, σ (S/m)	TARGET Dielectric Constant, ε	% dev σ	% dev ε
6/9/2021	750 Body	20.5	680	0.944	53.907	0.958	55.804	-1.46%	-3.40%
			695	0.949	53.868	0.959	55.745	-1.04%	-3.37%
			700	0.95	53.849	0.959	55.726	-0.94%	-3.37%
			710	0.954	53.812	0.96	55.687	-0.63%	-3.37%
			725	0.959	53.74	0.961	55.629	-0.21%	-3.40%
			750	0.968	53.642	0.964	55.531	0.41%	-3.40%
			770	0.975	53.587	0.965	55.453	1.04%	-3.37%
			785	0.98	53.558	0.966	55.395	1.45%	-3.32%
			800	0.986	53.522	0.967	55.336	1.96%	-3.28%
6/9/2021	835 Body	20.5	820	0.994	53.441	0.969	55.258	2.58%	-3.29%
			835	0.999	53.385	0.97	55.2	2.99%	-3.29%
			850	1.004	53.348	0.988	55.154	1.62%	-3.27%
6/9/2021	1750 Body	19.8	1710	1.448	54.263	1.463	53.537	-1.03%	1.36%
			1720	1.455	54.238	1.469	53.511	-0.95%	1.36%
			1745	1.473	54.172	1.485	53.445	-0.81%	1.36%
			1750	1.477	54.158	1.488	53.432	-0.74%	1.36%
			1770	1.49	54.119	1.501	53.379	-0.73%	1.39%
			1790	1.504	54.096	1.514	53.326	-0.66%	1.44%
6/2/2021	1900 Body	21.2	1850	1.545	53.285	1.52	53.3	1.64%	-0.03%
			1860	1.553	53.268	1.52	53.3	2.17%	-0.06%
			1880	1.569	53.233	1.52	53.3	3.22%	-0.13%
			1900	1.585	53.209	1.52	53.3	4.28%	-0.17%
			1905	1.589	53.205	1.52	53.3	4.54%	-0.18%
			1910	1.593	53.201	1.52	53.3	4.80%	-0.19%
6/9/2021	1900 Body	19.8	1850	1.544	54.018	1.52	53.3	1.58%	1.35%
			1860	1.552	54.003	1.52	53.3	2.11%	1.32%
			1880	1.568	53.974	1.52	53.3	3.16%	1.26%
			1900	1.583	53.951	1.52	53.3	4.14%	1.22%
			1905	1.587	53.946	1.52	53.3	4.41%	1.21%
			1910	1.59	53.943	1.52	53.3	4.61%	1.21%
6/9/2021	2300 Body	22.5	2300	1.888	50.547	1.809	52.9	4.37%	-4.45%
			2310	1.896	50.537	1.816	52.887	4.41%	-4.44%
			2320	1.904	50.527	1.826	52.873	4.27%	-4.44%
			2400	1.967	50.439	1.902	52.767	3.42%	-4.41%
			2450	2.008	50.366	1.95	52.7	2.97%	-4.43%
			2480	2.032	50.333	1.993	52.662	1.96%	-4.42%
6/9/2021	2600 Body	22.5	2550	2.092	50.225	2.092	52.573	0.00%	-4.47%
			2560	2.101	50.21	2.106	52.56	-0.24%	-4.47%
			2600	2.133	50.166	2.163	52.509	-1.39%	-4.46%
			2650	2.176	50.084	2.234	52.445	-2.60%	-4.50%
			2680	2.203	50.048	2.277	52.407	-3.25%	-4.50%
			2700	2.22	50.028	2.305	52.382	-3.69%	-4.49%

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB Publication 865664 D01v01r04 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

10.2 Test System Verification

Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in Appendix C.

Table 10-2
System Verification Results – 1g

System Verification TARGET & MEASURED												
SAR System #	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp (°C)	Liquid Temp (°C)	Input Power (W)	Source SN	Probe SN	Measured SAR_{1g} (W/kg)	1 W Target SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	$Deviation_{1g}$ (%)
M	1750	BODY	5/27/2021	21.4	21.7	0.1	1148	7570	3.52	36.3	35.200	-3.03%
N	1750	BODY	5/31/2021	23	22.8	0.1	1148	7417	3.35	36.3	33.500	-7.71%
M	1900	BODY	5/25/2021	21.7	21.2	0.1	5d148	7570	3.95	39.1	39.500	1.02%
N	2300	BODY	5/31/2021	22.8	23	0.1	1073	7417	4.78	47.7	47.800	0.21%
M	2600	BODY	5/24/2021	22.6	21.4	0.1	1071	7570	5.6	54.3	56.000	3.13%

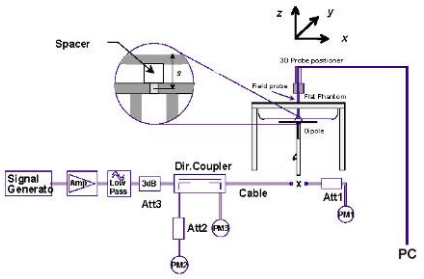


Figure 10-1
System Verification Setup Diagram

Figure 10-2
System Verification Setup Photo

11 SAR TEST RESULTS (FREQ < 6 GHZ)

11.1 Time-varying Tx Power Case

Following Section 4.4 procedure, time-averaged SAR measurements are conducted using a SAR probe at peak location of area scan over 500 seconds. cDASY6 system verification for SAR measurement is provided in Section 10, and the associated SPEAG certificates are attached in Appendix G.

SAR probe integration times depend on the communication signal being tested as defined in the probe calibration parameters.

Since the sampling rate used by cDASY6 for pointSAR measurements is not in user control, the number of points in 100s interval is determined from the scan duration setting in cDASY6 time-average pointSAR measurement by (100s cDASY6_scan_duration * total number of pointSAR values recorded). Running average is performed over these number of points in excel spreadsheet to obtain 100s averaged point SAR.

Following Section 4.4, for each of selected technology/band (listed in Table 8-2):

7. With *Reserve_power_margin* set to 0 dB, area scan is performed at P_{limit}, and time-averaged pointSAR measurements are conducted to determine the pointSAR at P_{limit} at peak location, denoted as *point*SAR_{Plimit}.
8. With *Reserve_power_margin* set to actual (intended) value, two more time-averaged pointSAR measurements are performed at the same peak location for test sequences 1 and 2.

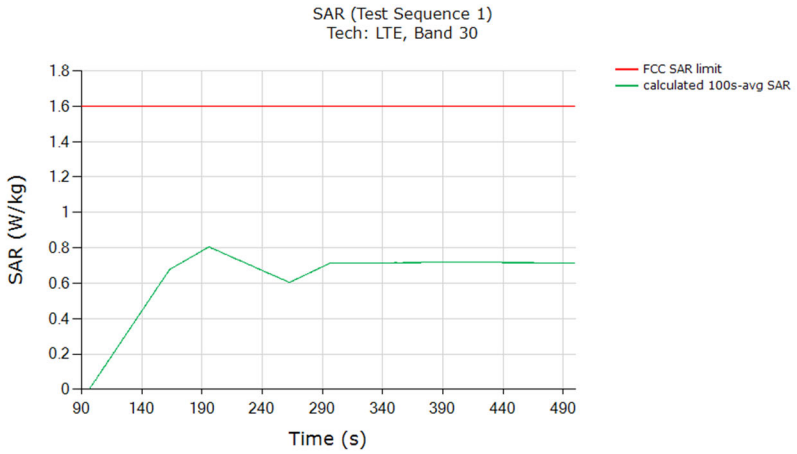
To demonstrate compliance, all the pointSAR measurement results were converted into 1gSAR or 10gSAR values by using Equation (3a), rewritten below:

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \qquad (3a)$$

where, $pointSAR(t)$, $pointSAR\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous point SAR, measured point SAR at P_{limit} from above step 1 and 2, and measured *1gSAR* or 10gSAR values at P_{limit} obtained from Part 1 report and listed in Table 8-2 of this report.

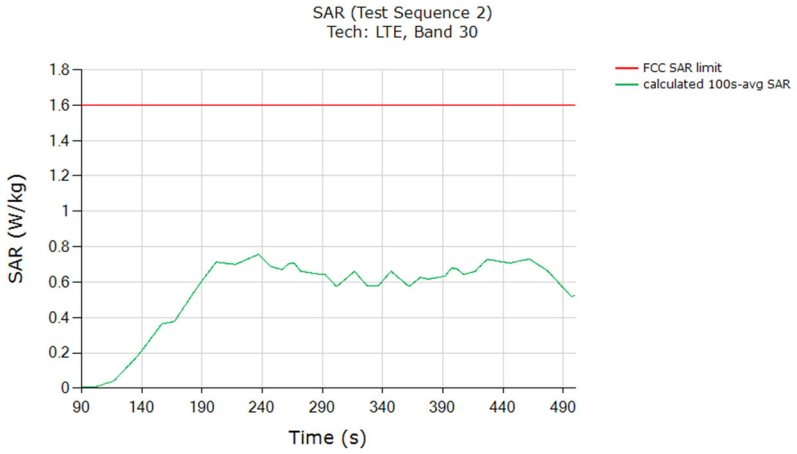
11.1.1 LTE Band 30

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.805
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

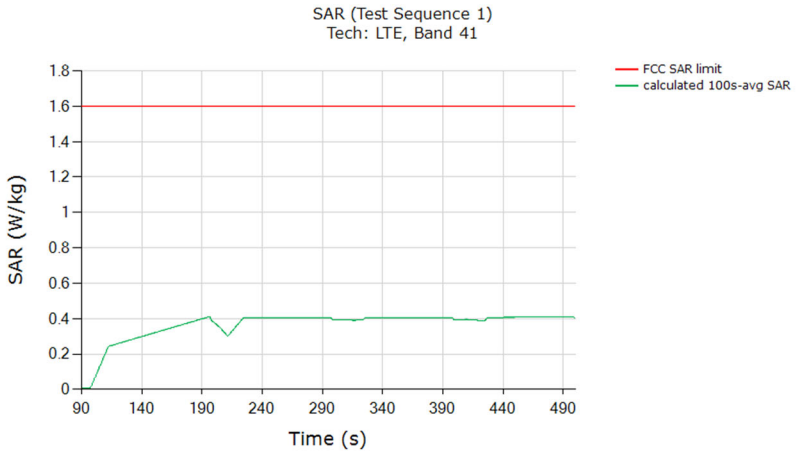
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.755
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

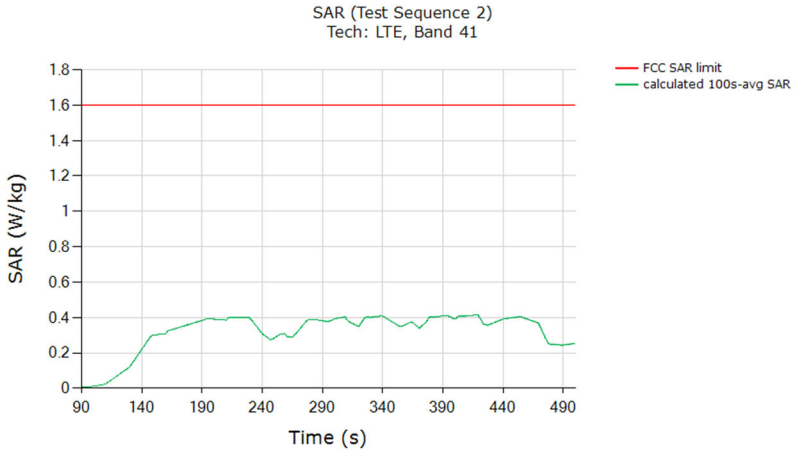
11.1.2 LTE Band 41

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.417
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

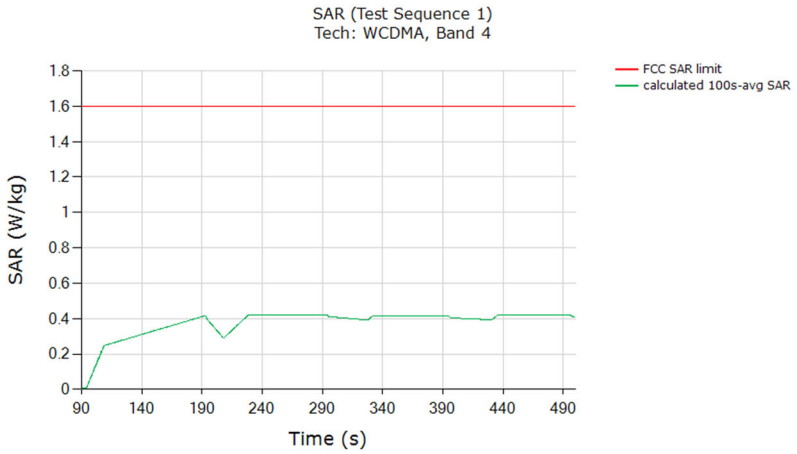
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.415
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

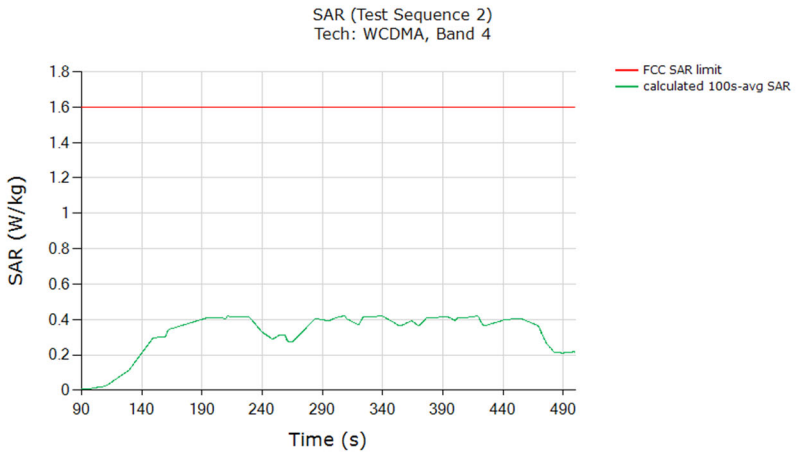
11.1.3 WCDMA Band 4

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.428
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

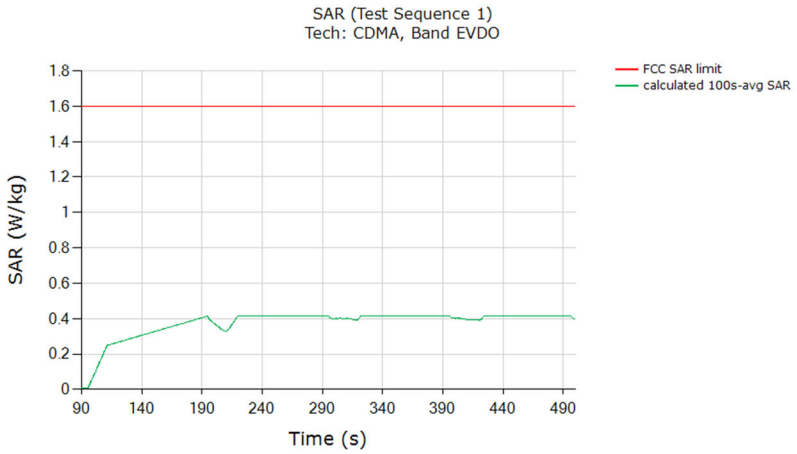
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.421
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

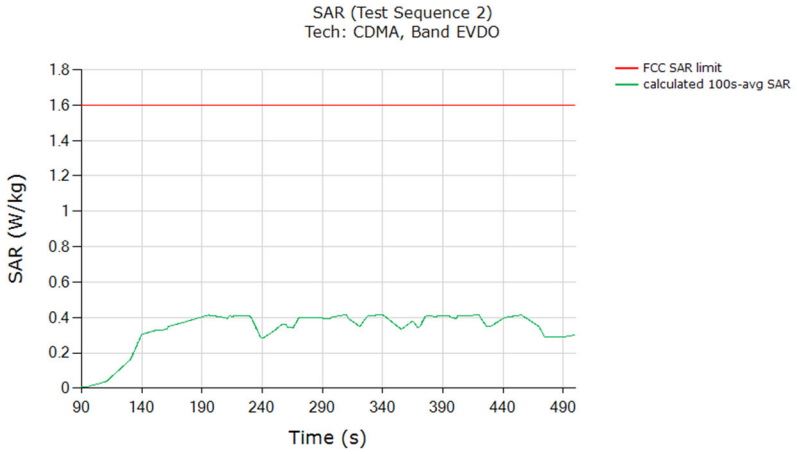
11.1.4 CDMA/EVDO

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.415
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

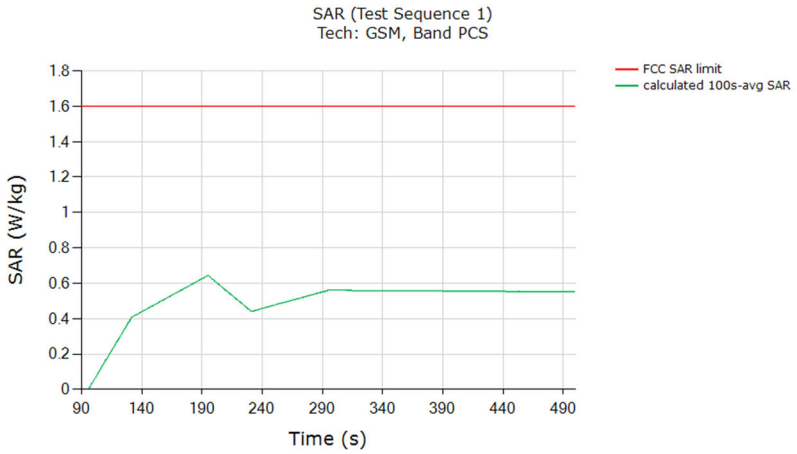
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.415
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

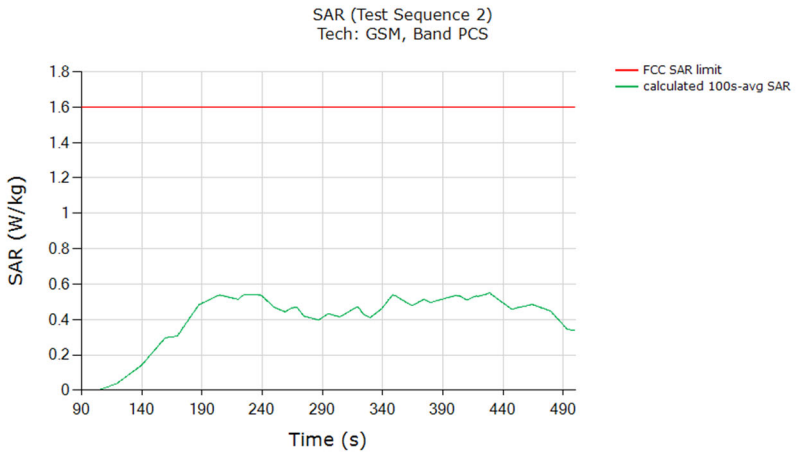
11.1.5 GSM/GPRS/EDGE

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.644
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

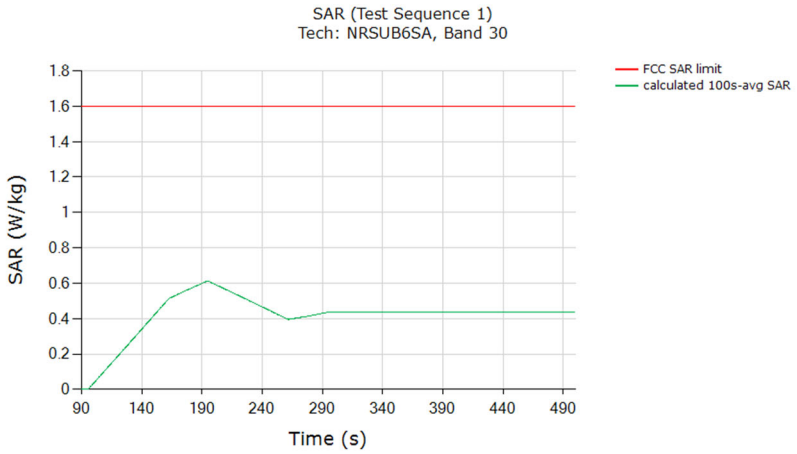
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.549
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

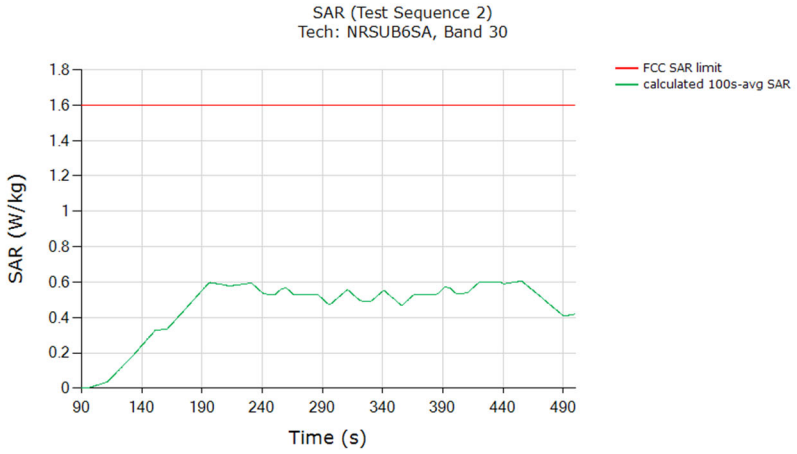
11.1.6 NR n30 SA

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.613
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

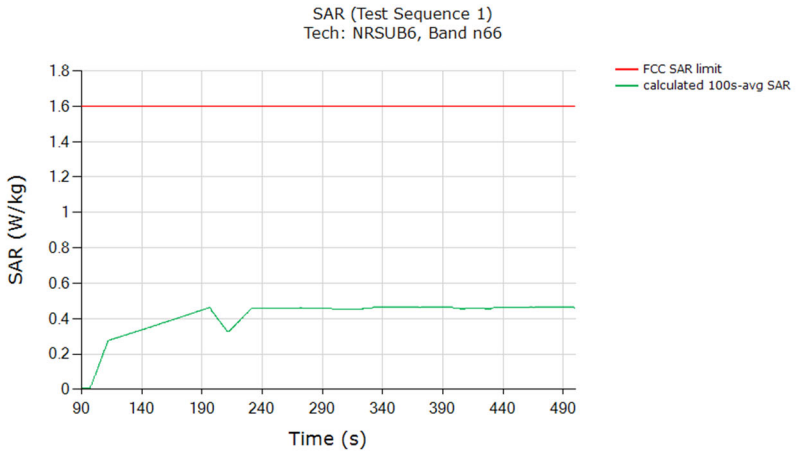
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.605
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

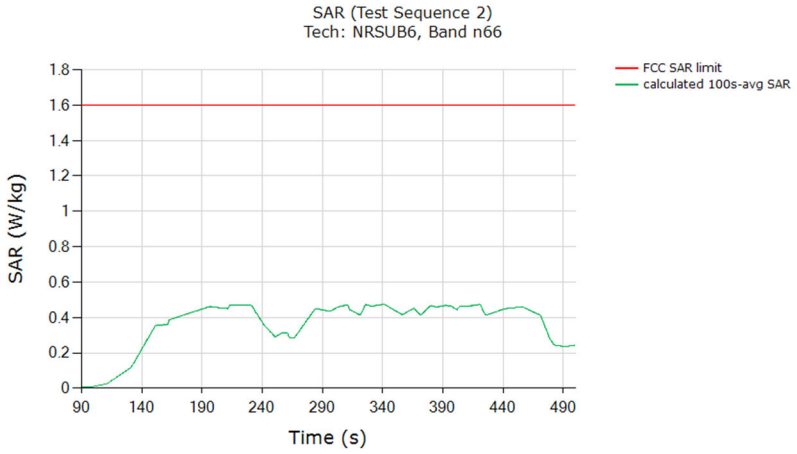
11.1.7 NR n66 SA

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.465
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.474
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 8-2).	

12 TEST CONFIGURATIONS (FREQ > 6 GHZ)

12.1 LTE + mmW NR transmission

Based on the selection criteria described in Section 4.2, the selections for LTE and mmW NR validation test are listed in Table 12-1. The radio configurations used in this test are listed in Table 12-2.

Table 12-1
Selections for LTE + mmW NR validation measurements

Transmission Scenario	Test	Technology and Band	mmWave Beam
Time-varying Tx power test	1. Cond. & Rad. Power meas. 2. PD meas.	LTE Band 2 and n261	Beam ID 21
		LTE Band 2 and n260	Beam ID 24
Switch in SAR vs. PD	1. Cond. & Rad. Power meas.	LTE Band 2 and n261	Beam ID 21
		LTE Band 2 and n260	Beam ID 24
Beam switch test	1. Cond. & Rad. Power meas.	LTE Band 2 and n261	Beam ID 21 to Beam ID 2
		LTE Band 2 and n260	Beam ID 24 to Beam ID 4

Table 12-2
Test configuration for LTE + mmW NR validation

Tech	Band	Antenna	DSI	Channel	Freq (MHz)	RB/RB Offset/Bandwidth (MHz)	Mode	UL Duty Cycle
LTE	2	B	1	18900	1880	1/0/20 MHz BW	QPSK	100%
mmW NR	n261	J	-	2071821	27559.32	66/0/100 MHz BW	CP-OFDM, QPSK	75.6%*
	n260	J	-	2254147	38498.88	66/0/100 MHz BW	CP-OFDM, QPSK	75.6%*

12.2 mmW NR radiated power test results

To demonstrate the compliance, the conducted Tx power of LTE Band 2 in DSI = 1 is converted to 10gSAR exposure by applying the corresponding worst-case 10g SAR value at P_{limit} as reported in Part 1 report and listed in Table 8-2 of this report.

Similarly, following Step 4 in Section 5.3.1, radiated Tx power of mmW Band n261 and n260 for the beams tested is converted by applying the corresponding measured worst-case 4cm^{2}PD values, and listed in below Table 12-3. Qualcomm Smart Transmit feature operates based on time-averaged Tx power reported on a per symbol basis, which is independent of modulation, channel and bandwidth (RBs), therefore the worst-case 4cm^{2}PD was conducted with the EUT in FTM mode, with CW modulation and 100% duty cycle. cDASY6 system verification for power density measurement is provided in Section 14, and the associated SPEAG certificates are attached in Appendix G.

Both the worst-case 10gSAR and 4cm^{2}PD values used in this section are listed in Table 12-3. The measured EIRP at *input.power.limit* for the beams tested in this section are also listed in Table 12-3.

Table 12-3
Worst-case 10gSAR, 4cm^2 avg. PD and EIRP measured at *input.power.limit* for the selected configurations

Tech	Band	Antenna	Beam ID	input.power.limit (dBm)	Measured psPD at input.power.limit		Measured EIRP at input.power.limit (dBm)
					4cm^2 psPD (W/m^2)	Test Position	
mmW NR	n261	J	21	1.7	5.02	Folder Open, Back	15.27
		J	2	7.7	3.93	Folder Open, Back	10.93
mmW NR	n260	J	24	1.5	2.24	Folder Open, Back	13.53
		J	4	6.9	2.66	Folder Open, Back	8.34

Tech	Band	Antenna	DSI	Measured Plimit (dBm)	Measured 10g SAR at Plimit	
					10g SAR (W/kg)	Test Position
LTE	2	B	1	17.75	1.75	Folder open, bottom edge, 0 mm

The 4cm^2 psPD distributions for the highest PD value per band, as listed in Table 12-3, are plotted below.

Figure 12-1
4cm² psPD distribution measured at *input.power.limit* of 1.7 dBm on the folder open, back side for n261 beam 21

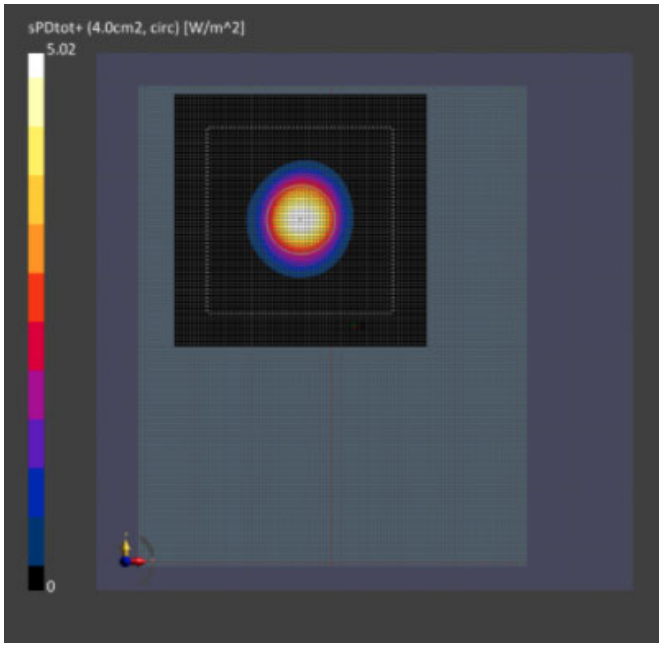
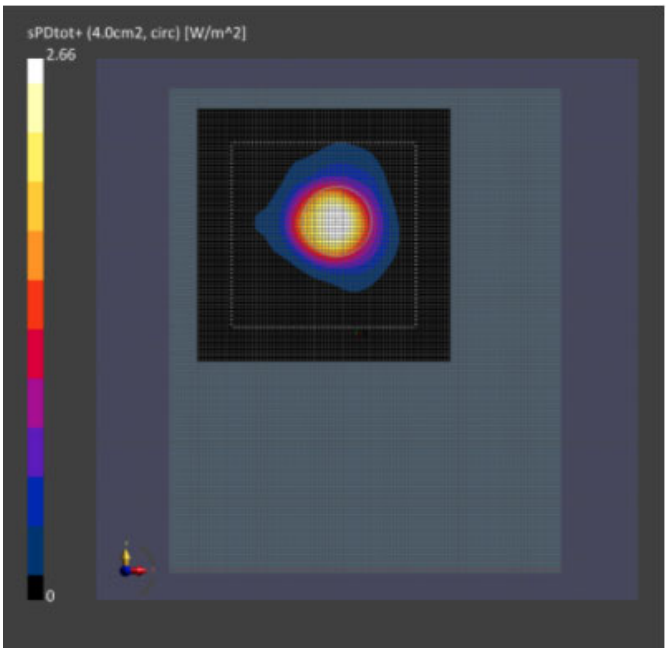


Figure 12-2
4cm² psPD distribution measured at *input.power.limit* of 6.9 dBm on the folder open, back side for n260 beam 4

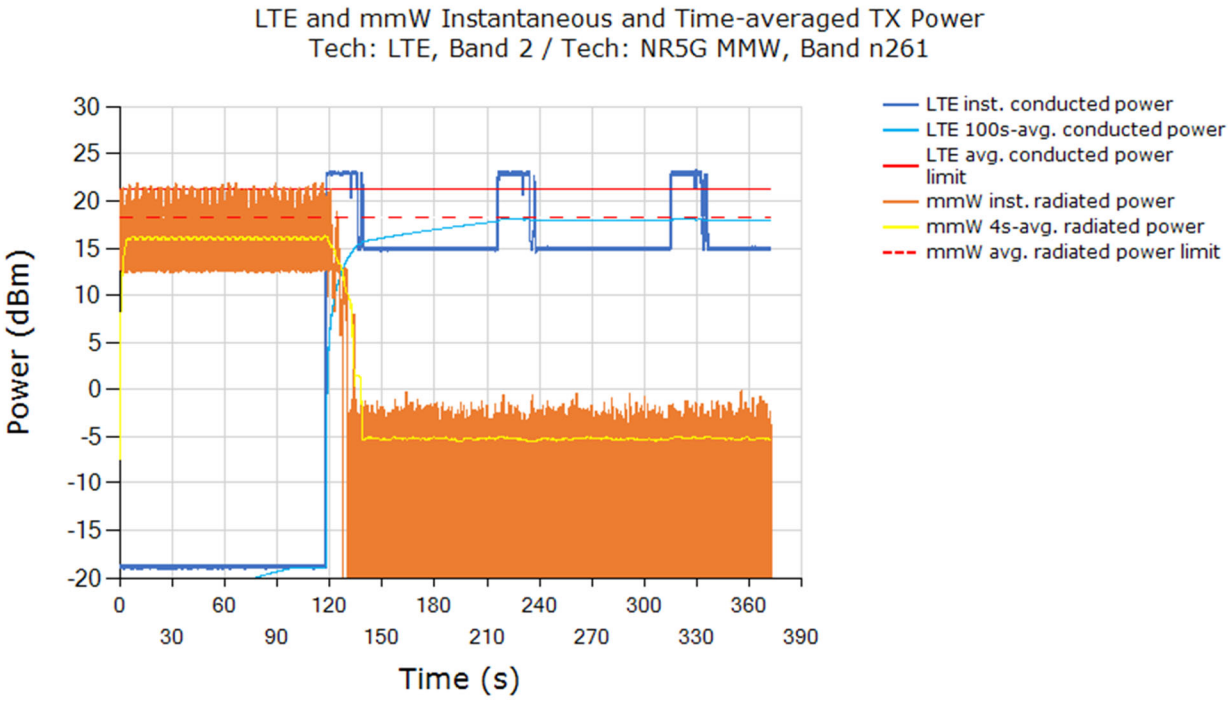


13 RADIATED POWER TX CASES (FREQ > 6 GHZ)

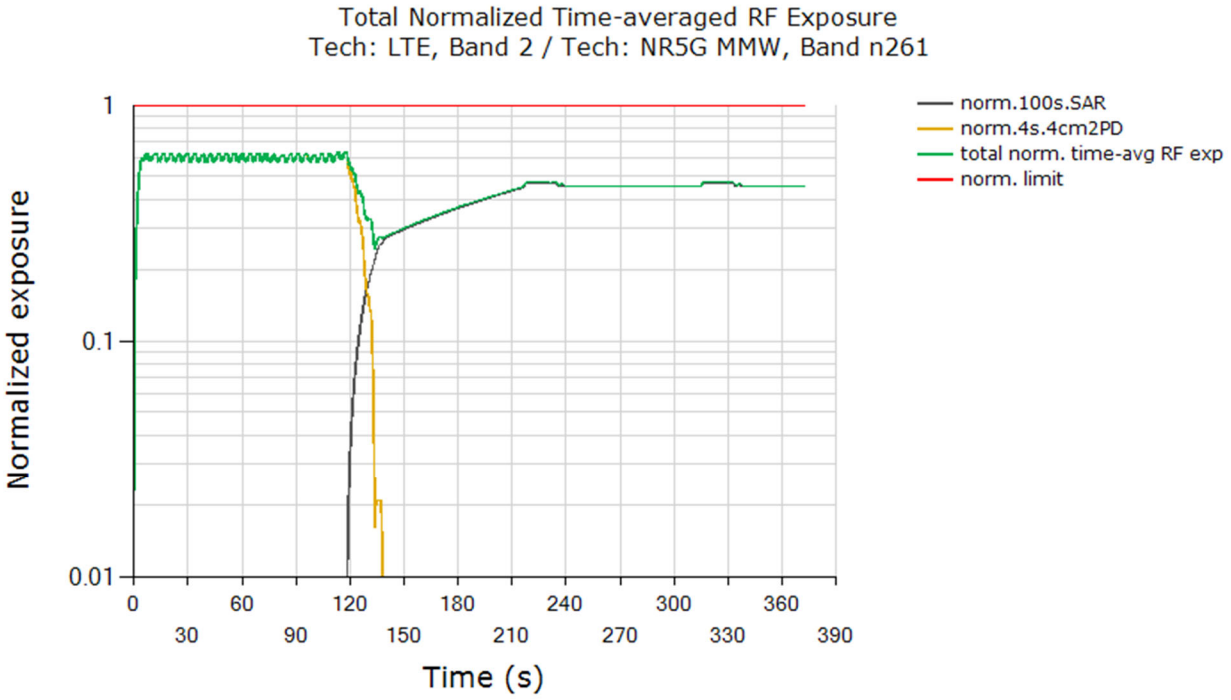
13.1 Maximum Tx power test results for n261

This test was measured with LTE Band 2 and mmW Band n261 Beam ID 21, by following the detailed test procedure described in Section 5.3.1.

Instantaneous and 100s-averaged conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged conducted LTE Tx power limit and time-averaged radiated mmW Tx power limit:



Above time-averaged conducted Tx power for LTE Band 2 and radiated Tx power for mmW NR n261 beam 21 are converted into time-averaged 10gSAR and time-averaged 4cm^{2}PD using Equation (2a) and (2b), which are divided by FCC 10gSAR limit of 4.0 W/kg and 4cm^{2}PD limit of 10 W/m^2, respectively, to obtain normalized exposures versus time. Below plot shows (a) normalized time-averaged 10gSAR versus time, (b) normalized time-averaged 4cm2-avg.PD versus time, (c) sum of normalized time-averaged 10gSAR and normalized time-averaged 4cm^2-avg.PD:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.639
Validated	

Plot notes: As soon as 5G mmW NR call was established, LTE was placed in all-down bits immediately. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW (based on the 3dB reserve setting in Part 1 report). At ~120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually and towards the end of the test, LTE is the dominant contributor towards RF exposure. Table 13-1 shows the calculations for the normalized 4cm^2 PD exposure values and the normalized 10g SAR exposure value.

Table 13-1

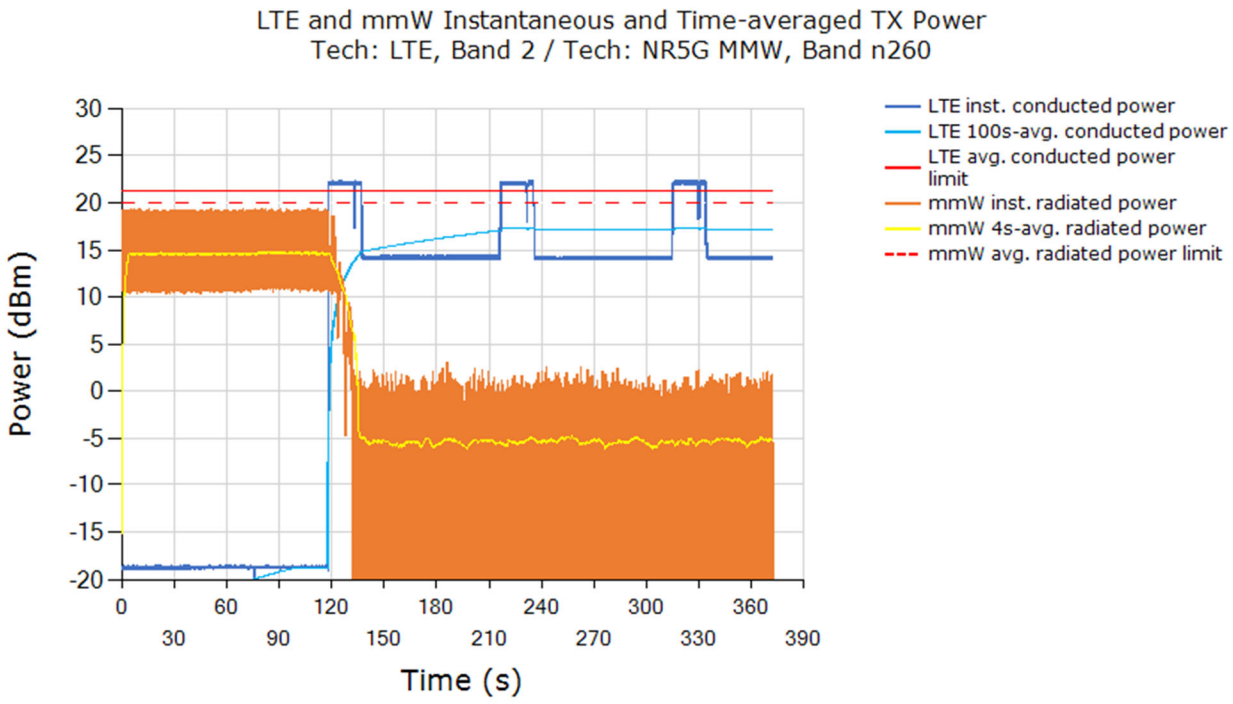
	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncertainty [dB]
0s~120s: NR Green/Orange Curve	5.02	50.2%	2.1
After ~120s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

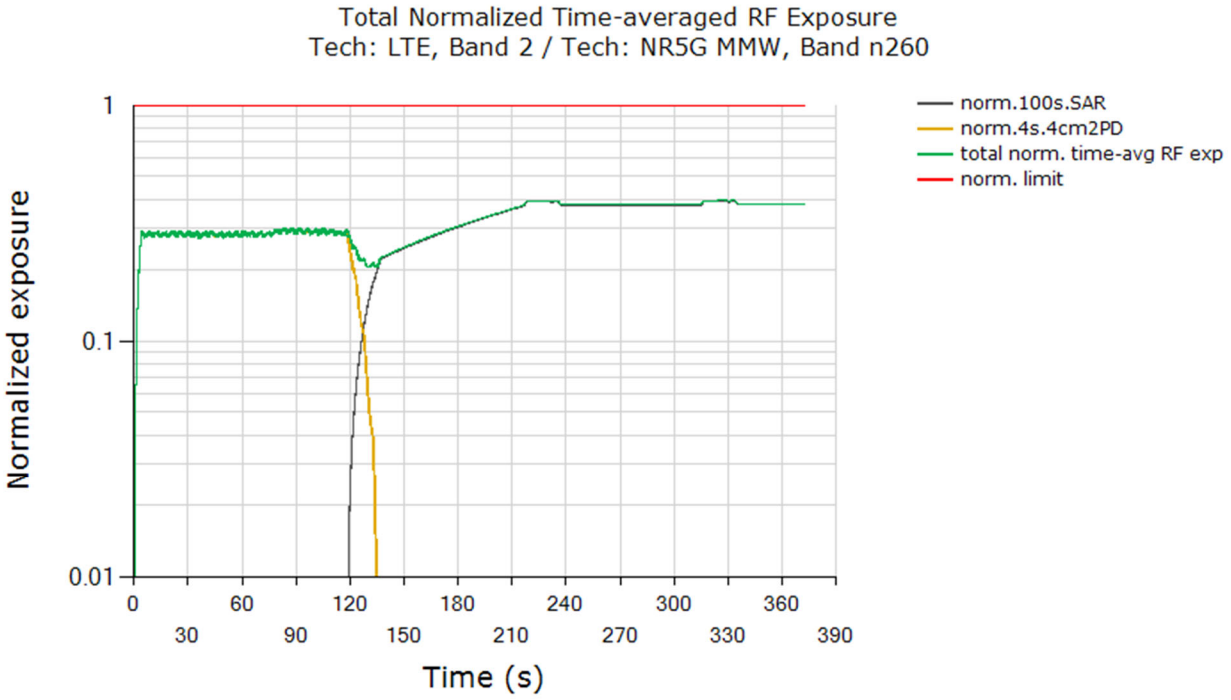
13.2 Maximum Tx power test results for n260

This test was measured with LTE Band 2 and mmW Band n260 Beam ID 24, by following the detailed test procedure described in Section 5.3.1.

Instantaneous and 100s-averaged conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged conducted LTE Tx power limit and time-averaged radiated mmW Tx power limit:



Above time-averaged conducted Tx power for LTE Band 2 and radiated Tx power for mmW NR n260 beam 24 are converted into time-averaged 10gSAR and time-averaged 4cm^{2}PD using Equation (2a) and (2b), which are divided by FCC 10gSAR limit of 4.0 W/kg and 4cm^{2}PD limit of 10 W/m^2, respectively, to obtain normalized exposures versus time. Below plot shows (a) normalized time-averaged 10gSAR versus time, (b) normalized time-averaged 4cm2-avg.PD versus time, (c) sum of normalized time-averaged 10gSAR and normalized time-averaged 4cm^2-avg.PD:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.396
Validated	

Plot notes: As soon as 5G mmW NR call was established, LTE was placed in all-down bits immediately. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW (based on the 3dB reserve setting in Part 1 report). At ~120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually and towards the end of the test, LTE is the dominant contributor towards RF exposure. Table 13-2 shows the calculations for the normalized 4cm^2 PD exposure values and the normalized 10g SAR exposure value.

Table 13-2

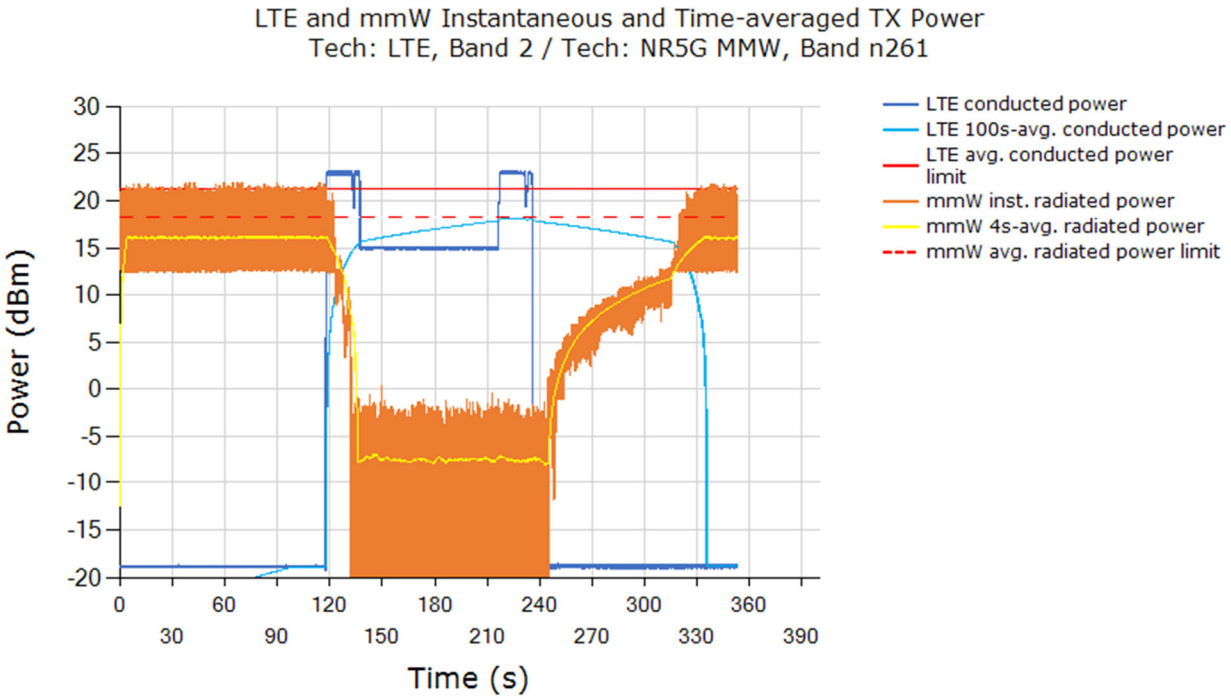
	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncertainty [dB]
0s~120s: NR Green/Orange Curve	2.24	22.4%	2.1
After ~120s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

13.3 Switch in SAR vs. PD exposure test results for n261

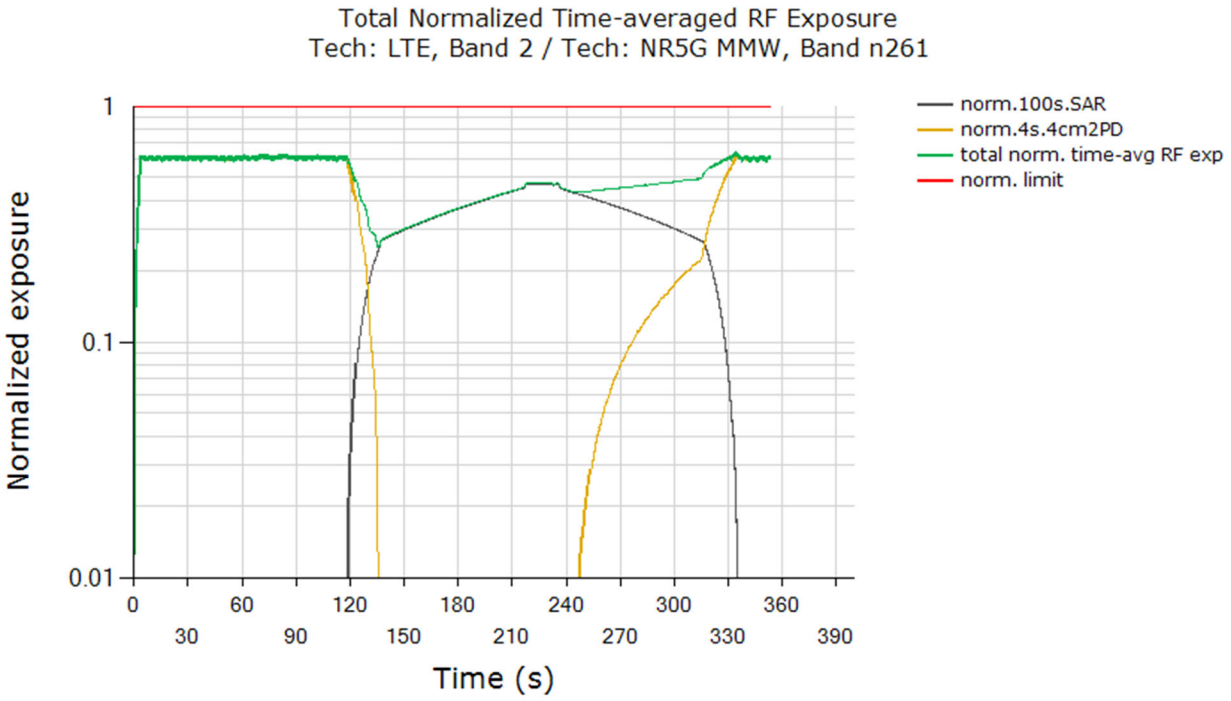
This test was measured with LTE Band 2 (DSI =1) and mmW Band n261 Beam ID 24, by following the detailed test procedure is described in Section 5.3.2.

Instantaneous and 100s-averaged conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged conducted LTE Tx power limit and time-averaged radiated mmW Tx power limit:



From the above plot, it is predominantly instantaneous PD exposure between 0s ~ 120s, it is instantaneous SAR+PD exposure between 120s ~ 140s, it is predominantly instantaneous SAR exposure between 140s ~ 200s, and above 200s, it is predominantly instantaneous PD exposure.

Normalized time-averaged exposures for LTE (10gSAR) and mmW (4cm^{2}PD), as well as total normalized time-averaged exposure versus time:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.643
Validated	

Plot notes: As soon as 5G mmW NR call was established, LTE was placed in all-down bits immediately. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW). At ~120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually (orange curve for mmW exposure goes down while black curve for LTE exposure goes up). At ~240s time mark, LTE is set to all-down bits, which results in mmW getting back RF margin slowly as seen by gradual increase in mmW exposure (orange curve for mmW exposure goes up while black curve for LTE exposure goes down). Table 13-3 shows the calculations for the normalized 4cm^2 PD exposure value and the normalized 10g SAR exposure value.

Table 13-3

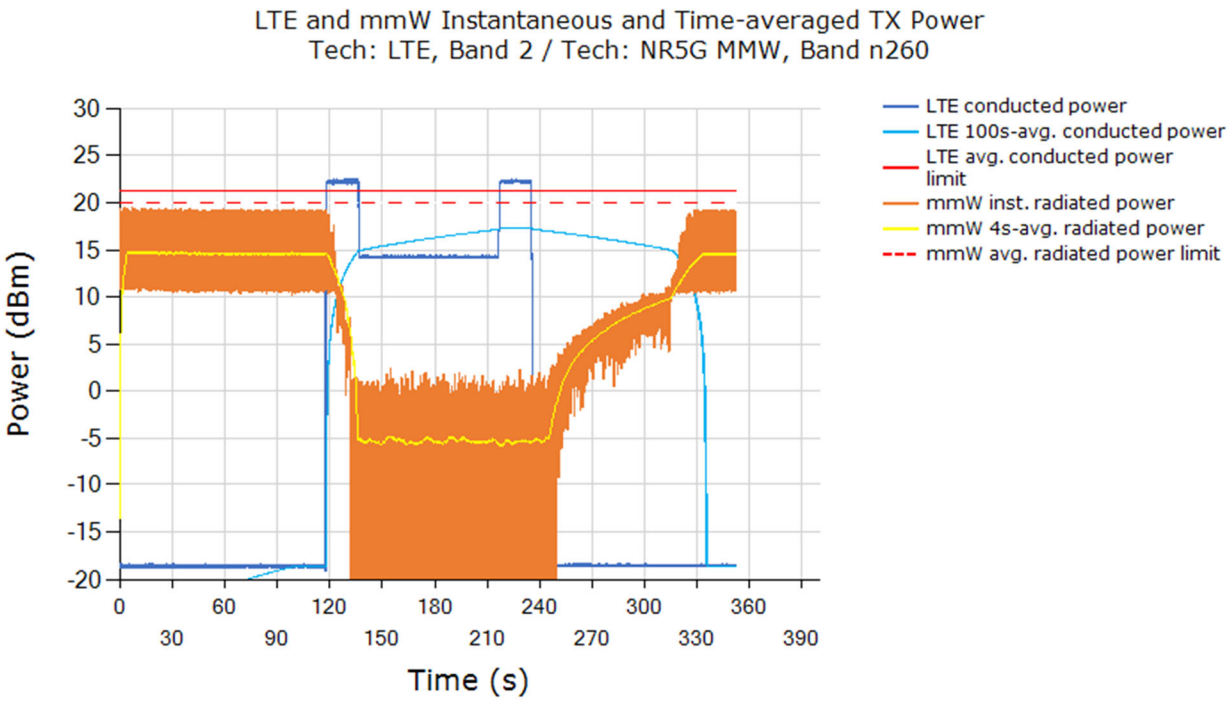
	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncert [dB]
0s~120s + After 240s: NR Green/Orange Curve	5.02	50.2%	2.1
120s - 240s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective during transmission when SAR and PD exposures are switched, and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

13.4 Switch in SAR vs. PD exposure test results for n260

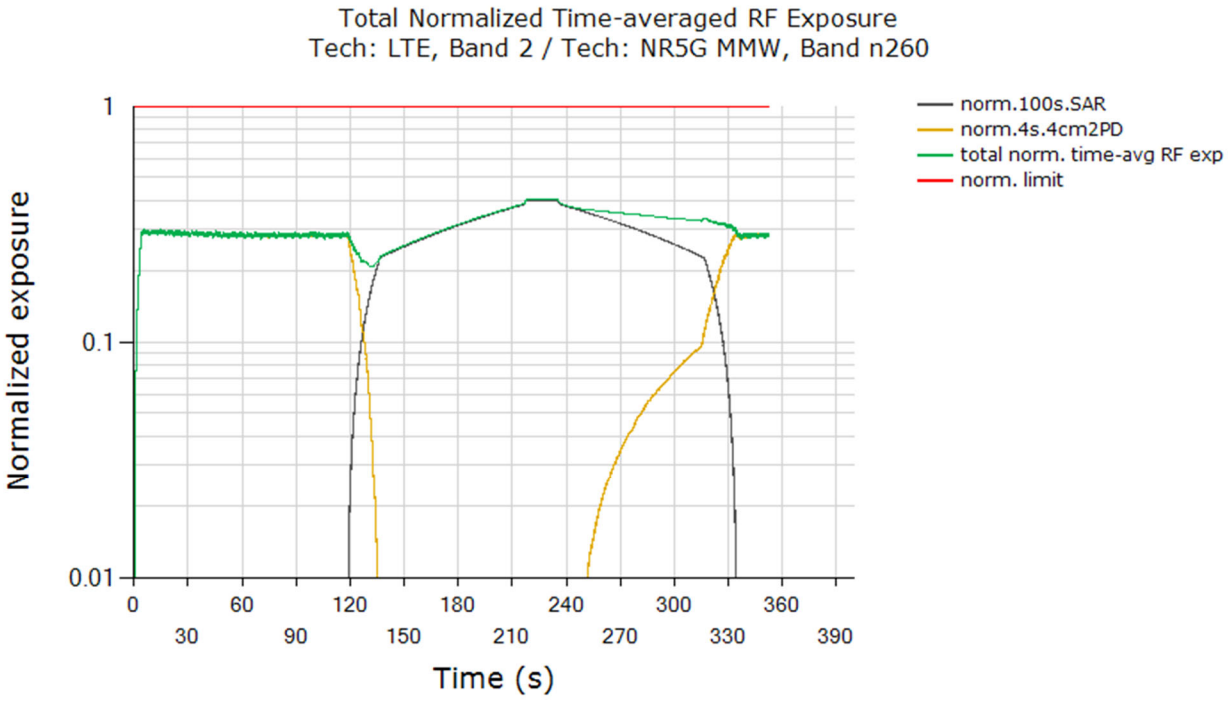
This test was measured with LTE Band 2 (DSI =1) and mmW Band n260 Beam ID 21, by following the detailed test procedure is described in Section 5.3.2.

Instantaneous and 100s-averaged conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged conducted LTE Tx power limit and time-averaged radiated mmW Tx power limit:



From the above plot, it is predominantly instantaneous PD exposure between 0s ~ 120s, it is instantaneous SAR+PD exposure between 120s ~ 140s, it is predominantly instantaneous SAR exposure between 140s ~ 200s, and above 200s, it is predominantly instantaneous PD exposure.

Normalized time-averaged exposures for LTE (10gSAR) and mmW (4cm^{2}PD), as well as total normalized time-averaged exposure versus time:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.404
Validated	

Plot notes: As soon as 5G mmW NR call was established, LTE was placed in all-down bits immediately. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW). At ~120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually (orange curve for mmW exposure goes down while black curve for LTE exposure goes up). At ~240s time mark, LTE is set to all-down bits, which results in mmW getting back RF margin slowly as seen by gradual increase in mmW exposure (orange curve for mmW exposure goes up while black curve for LTE exposure goes down). Table 13-4 shows the calculations for the normalized 4cm^2 PD exposure value and the normalized 10g SAR exposure value.

Table 13-4

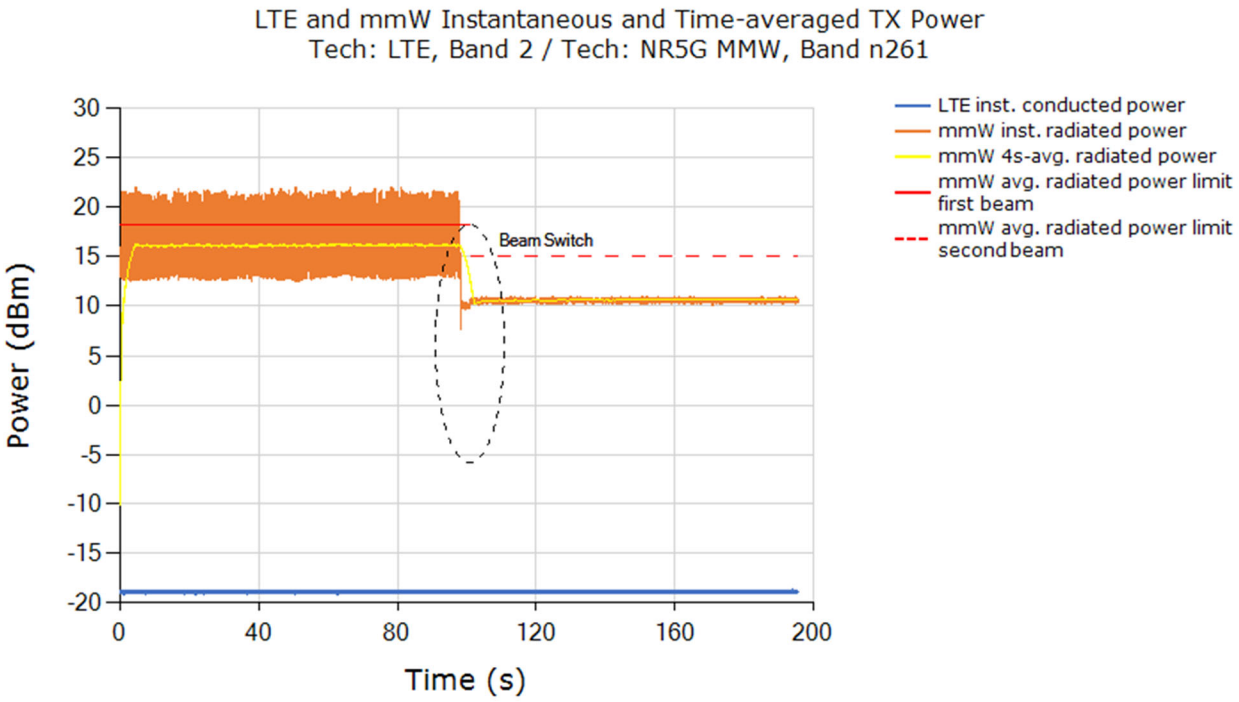
	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncert [dB]
0s~120s + After 240s: NR Green/Orange Curve	2.24	22.4%	2.1
120s - 240s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective during transmission when SAR and PD exposures are switched, and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

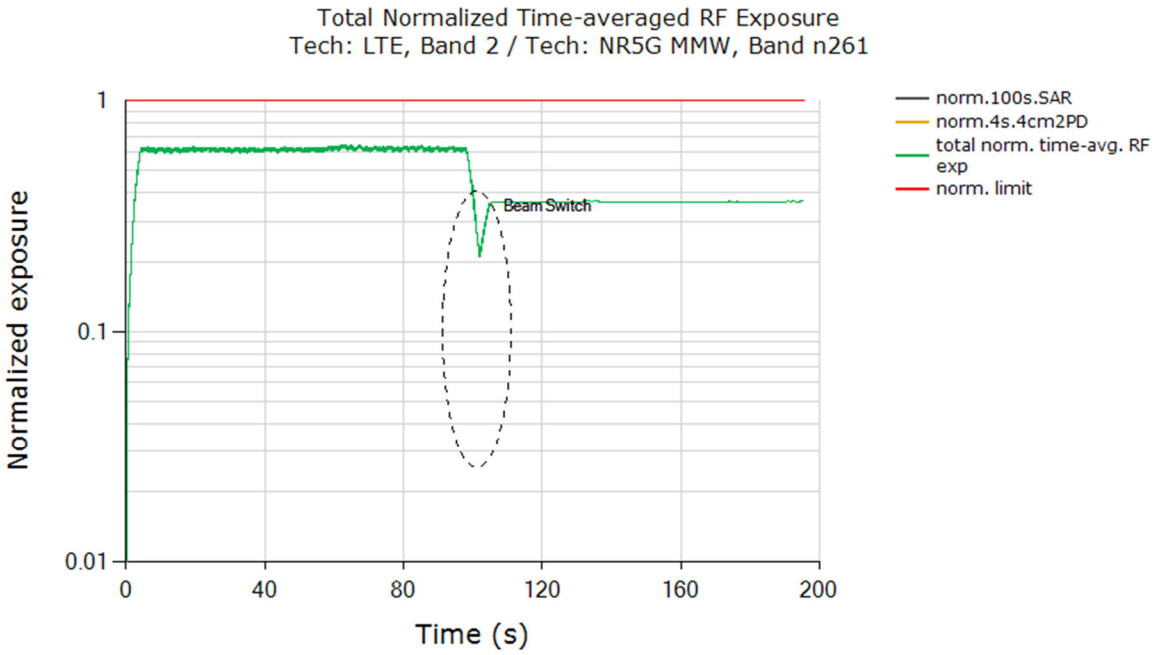
13.5 Change in Beam test results for n261

This test was measured with LTE Band 2 (DSI = 1) and mmW Band n261, with beam switch from Beam ID 21 to Beam ID 2, by following the test procedure is described in Section 5.3.3.

Instantaneous conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged radiated mmW Tx power limits for beam 21 and beam 2:



Normalized time-averaged exposures for LTE and mmW (4cm^{2}PD), as well as total normalized time-averaged exposure versus time:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.642
Validated	

Plot notes: 5G mmW NR call was established at ~1s time mark and LTE was placed in all-down bits immediately after 5G mmW NR call was established. For the rest of this test, mmW exposure is the dominant contributor as LTE is left in all-down bits. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW for the first beam (based on 3dB reserve setting in Part 1 report). At ~100s time mark (shown in black dotted ellipse), beam switch takes place and mmW starts transmission from the second beam. Second beam transmits at *input.power.limit* with active power limiting. During the switch, the ratio between the averaged radiated powers of the two beams (yellow curve) should correspond to the difference in EIRPs measured at each corresponding *input.power.limit* for these beams listed in Table 13-5. Table 13-5 shows the calculations for the normalized 4cm^2 PD exposure values and the difference in EIRPs between two beams.

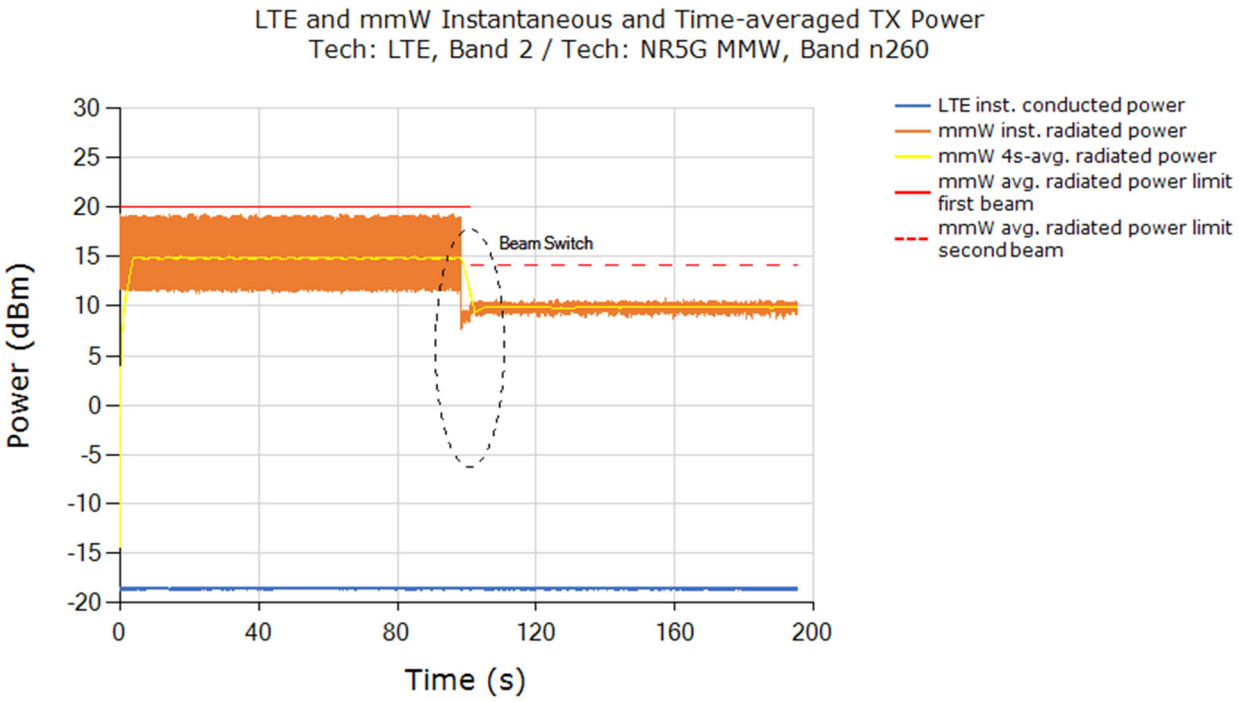
Table 13-5

	Beam ID 21 (0 - 100 sec, before ellipse)	Beam ID 2 (100 - 200 sec, after ellipse)
Static psPD [W/m^2]	5.02	3.93
Input.power.limit [dBm]	1.7	7.7
Maximum Power [dBm]	10.5	
Normalized 4cm^{2}PD exposure value [% ± 2.1 dB uncertainty]	50.2%	39.3%
EIRP Difference [dB ± 2.1 dB uncertainty]	4.34 dB	

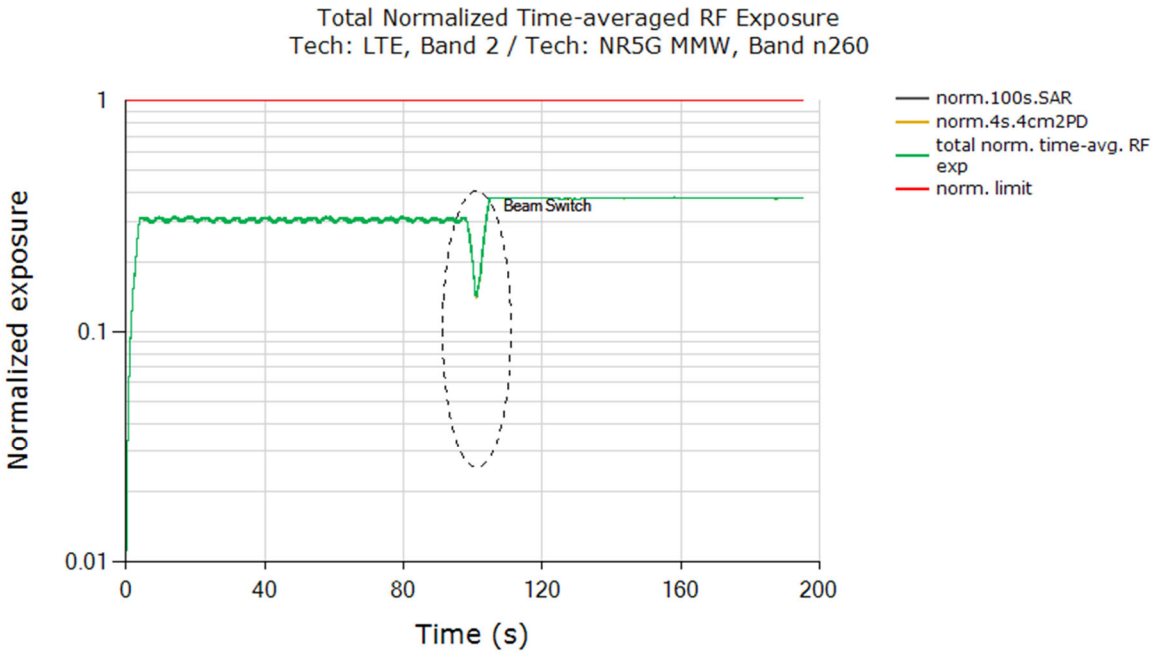
13.6 Change in Beam test results for n260

This test was measured with LTE Band 2 (DSI = 1) and mmW Band n260, with beam switch from Beam ID 24 to Beam ID 4, by following the test procedure is described in Section 5.3.3.

Instantaneous conducted LTE Tx power versus time, instantaneous and 4s-averaged radiated mmW Tx power versus time, time-averaged radiated mmW Tx power limits for beam 24 and beam 4:



Normalized time-averaged exposures for LTE and mmW (4cm^{2}PD), as well as total normalized time-averaged exposure versus time:



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.380
Validated	

Plot notes: 5G mmW NR call was established at ~1s time mark and LTE was placed in all-down bits immediately after 5G mmW NR call was established. For the rest of this test, mmW exposure is the dominant contributor as LTE is left in all-down bits. Here, Smart Transmit feature allocates a maximum of 1.0 for mmW for the first beam (based on 3dB reserve setting in Part 1 report). At ~100s time mark (shown in black dotted ellipse), beam switch takes place and mmW starts transmission from the second beam. Second beam transmits at *input.power.limit* with active power limiting. During the switch, the ratio between the averaged radiated powers of the two beams (yellow curve) should correspond to the difference in EIRPs measured at each corresponding *input.power.limit* for these beams listed in Table 13-6. Table 13-6 shows the calculations for the normalized 4cm^2 PD exposure values and the difference in EIRPs between two beams.

Table 13-6

	Beam ID 24 (0 - 100 sec, before ellipse)	Beam ID 4 (100 - 200 sec, after ellipse)
Static psPD [W/m^2]	2.24	2.66
Input.power.limit [dBm]	1.5	6.9
Maximum Power [dBm]	9.5	
Normalized 4cm^{2}PD exposure value [% ± 2.1 dB uncertainty]	22.4%	26.6%
EIRP Difference [dB ± 2.1 dB uncertainty]	5.19 dB	

14 SYSTEM VERIFICATION (FREQ > 6 GHZ)

The system was verified to be within ±0.66 dB of the power density targets on the calibration certificate according to the test system specification in the user's manual and calibration facility recommendation. The 0.66 dB deviation threshold represents the expanded uncertainty for system performance checks using SPEAG's mmWave verification sources. The same spatial resolution and measurement region used in the source calibration was applied during the system check.

The measured power density distribution of verification source was also confirmed through visual inspection to have no noticeable differences, both spatially (shape) and numerically (level) from the distribution provided by the manufacturer, per November 2017 TCBC Workshop Notes.

Table 14-1
System Verification Results

System Verification										
Syst.	Freq. (GHz)	Date	Source SN	Probe SN	Normal psPD (W/m^2 over 4 cm^2)		Deviation (dB)	Total psPD (W/m^2 over 4 cm^2)		Deviation (dB)
					measured	target		measured	target	
R	30.00	6/4/2021	1045	9523	31.20	32.70	-0.20	31.60	33.20	-0.21
Q	30.00	6/4/2021	1035	9389	31.40	31.00	0.06	31.70	31.00	0.10
N	30.00	6/4/2021	1035	9364	31.70	31.00	0.10	32.00	31.00	0.14

Note: A **10 mm distance spacing** was used from the reference horn antenna aperture to the probe element. This includes 4.45 mm from the reference antenna horn aperture to the surface of the verification source plus 5.55 mm from the surface to the probe. The SPEAG software requires a setting of "5.55 mm" for the correct set up.

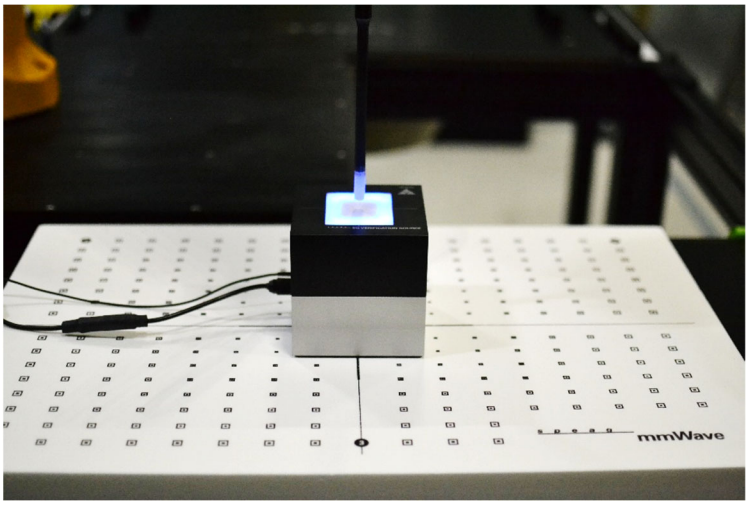


Figure 14-1
System Verification Setup Photo

15 POWER DENSITY TEST RESULTS (FREQ > 6 GHZ)

15.1 PD measurement results for maximum power transmission scenario

The following configurations were measured by following the detailed test procedure is described in Section 5.4:

1. LTE Band 2 (DSI = 1) and mmW Band n261 Beam ID 21
2. LTE Band 2 (DSI = 1) and mmW Band n260 Beam ID 24

The measured conducted Tx power of LTE and ratio of $\frac{[pointE(t)]^2}{[pointE\_input.power.limit]^2}$ of mmW is converted into 10gSAR and 4cm^{2}PD value, respectively, using Eq. (4a) and (4b), rewritten below:

$$1g\_or\_10gSAR(t) = \frac{conducted\_Tx\_power(t)}{conducted\_Tx\_power\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (4a)$$

$$4cm^2PD(t) = \frac{[pointE(t)]^2}{[pointE\_input.power.limit]^2} * 4cm^2PD\_input.power.limit \quad (4b)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR(t)dt}{FCC\ SAR\ limit} + \frac{\frac{1}{T_{PD}}\int_{t-T_{PD}}^{t} 4cm^2PD(t)dt}{FCC\ 4cm^2PD\ limit} \leq 1 \quad (4c)$$

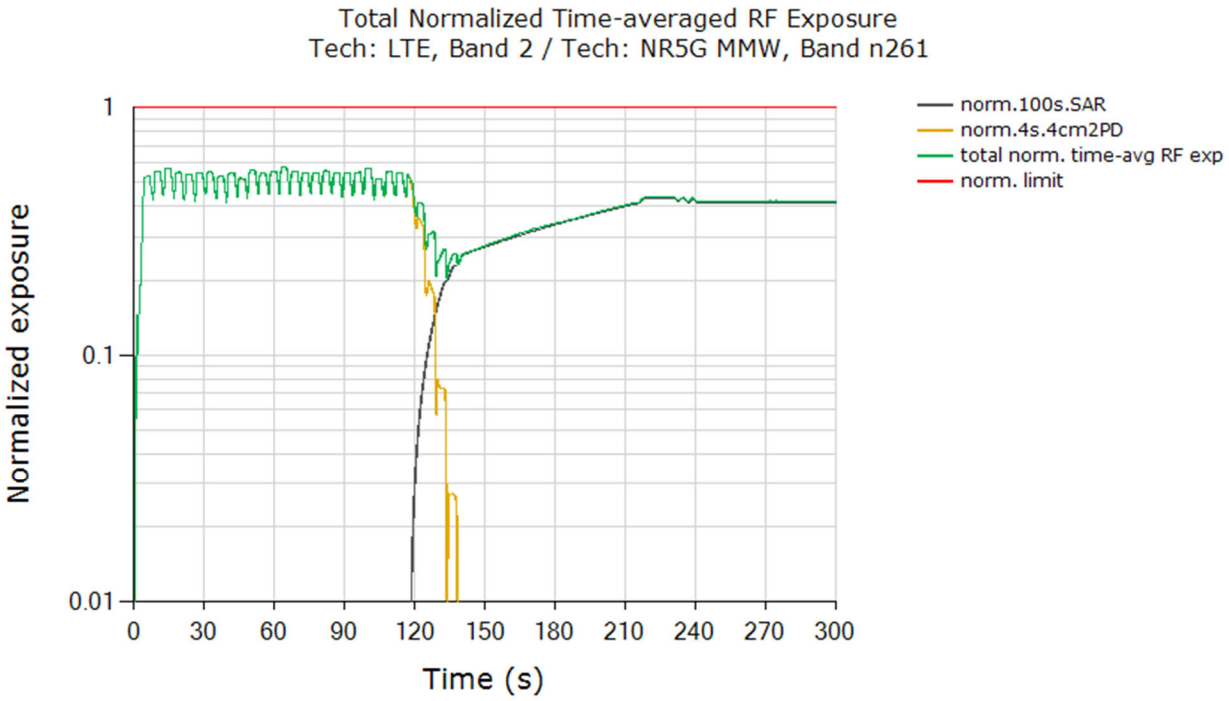
where, $conducted\_Tx\_power(t)$, $conducted\_Tx\_power\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at P_{limit}, and measured 1gSAR or 10gSAR values at P_{limit} corresponding to LTE transmission. Similarly, $pointE(t)$, $pointE\_input.power.limit$, and $4cm^2PD@input.power.limit$ correspond to the measured instantaneous E-field, E-field at *input.power.limit*, and 4cm^{2}PD value at *input.power.limit*. corresponding to mmW transmission.

NOTE: cDASY6 system measures relative E-field, and provides ratio of $\frac{[pointE(t)]^2}{[pointE\_input.power.limit]^2}$ versus time.

The radio configurations tested are described in Table 12-1 and Table 12-2. The 10gSAR at P_{limit} for LTE 2 DSI = 1, the measured 4cm^{2}PD at *input.power.limit* of mmW n261 beam 21 and n260 beam 24, are all listed in Table 12-3.

15.1.1 PD test results for n261

Step 2.e plot (in Section 5.4) for normalized instantaneous and time-averaged exposures for LTE and mmW n261 beam 21.



FCC limit for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure (green curve)	0.571
Validated	

Plot notes: LTE was placed in all-down bits immediately after 5G mmW NR call was established. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 100% for mmW (based on the 3dB reserve setting in Part 1 report). Around the 120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually. Towards the end of the test, LTE is the dominant contributor towards RF exposure. Table 15-1 shows the calculations for the normalized 4cm^2 PD exposure values and the normalized 10g SAR exposure value.

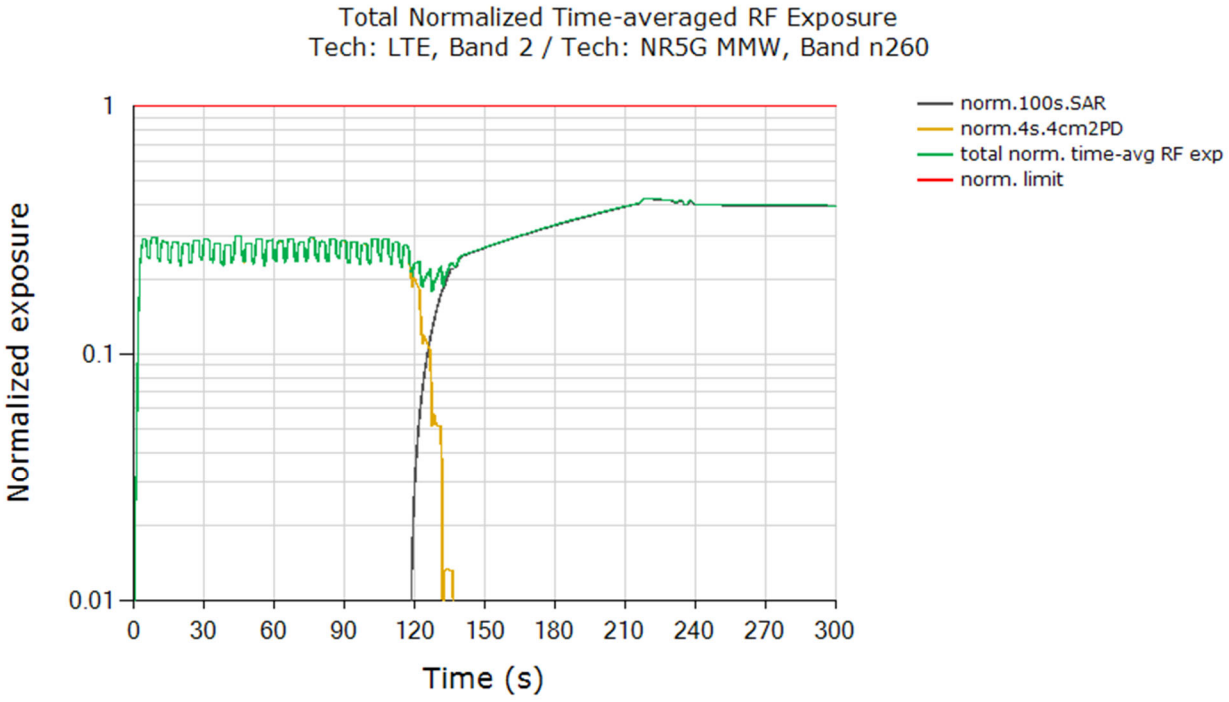
Table 15-1

	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncertainty [dB]
0s~120s: NR Green/Orange Curve	5.02	50.2%	2.1
After ~120s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

15.1.2 PD test results for n260

Step 2.e plot (in Section 5.4) for normalized instantaneous and time-averaged exposures for LTE and mmW n260 beam 24.



FCC limit for total RF exposure	1.0
Max total normalized time-averaged RF exposure (green curve)	0.429
Validated	

Plot notes: LTE was placed in all-down bits immediately after 5G mmW NR call was established. Between 0s~120s, mmW exposure is the dominant contributor. Here, Smart Transmit feature allocates a maximum of 100% for mmW (based on the 3dB reserve setting in Part 1 report). Around the 120s time mark, LTE is set to all-up bits, taking away margin from mmW exposure gradually. Towards the end of the test, LTE is the dominant contributor towards RF exposure. Table 15-2 shows the calculations for the normalized 4cm^2 PD exposure values and the normalized 10g SAR exposure value.

Table 15-2

	Static 4cm^2 PD or 10g SAR [W/m^2 or W/kg]	Normalized Exposure	Uncertainty [dB]
0s~120s: NR Green/Orange Curve	2.24	22.4%	2.1
After ~120s: LTE Black Curve	1.75	43.8%	1

As can be seen, the power limiting enforcement is effective and the total normalized time-averaged RF exposure does not exceed 1.0. Therefore, Qualcomm® Smart Transmit time averaging feature is validated.

16 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8594A	(9kHz-2.9GHz) Spectrum Analyzer	N/A	N/A	N/A	3051A00187
Agilent	E4438C	ESG Vector Signal Generator	1/15/2020	Triennial	1/15/2023	MY45090479
Agilent	N9020A	MXA Signal Analyzer	9/22/2020	Annual	9/22/2021	MY54500644
Agilent	N5182A	MXG Vector Signal Generator	5/13/2020	Annual	5/13/2021	MY47420603
Agilent	8753ES	S-Parameter Network Analyzer	2/2/2021	Annual	2/2/2022	US39170122
Agilent	N5183A	MXG Analog Signal Generator	1/21/2021	Annual	1/21/2022	MY50141900
Agilent	E4438C	ESG Vector Signal Generator	12/14/2020	Biennial	12/14/2022	MY42082385
Agilent	E4438C	ESG Vector Signal Generator	9/8/2020	Biennial	9/8/2022	MY45090700
Agilent	E4438C	ESG Vector Signal Generator	1/16/2020	Triennial	1/16/2023	MY49070496
Agilent	8753ES	S-Parameter Vector Network Analyzer	12/15/2020	Annual	12/15/2021	MY40003841
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433974
Anritsu	MT8000A	Radio Communication Test Station	2/6/2021	Annual	2/6/2022	6262036828
Anritsu	ML2495A	Power Meter	3/4/2021	Annual	3/4/2022	1328004
Anritsu	MA24106A	USB Power Sensor	2/25/2021	Annual	2/25/2022	1520501
Anritsu	MA24106A	USB Power Sensor	7/24/2020	Annual	7/24/2021	1231538
Anritsu	ML2496A	Power Meter	3/3/2021	Annual	3/3/2022	1306009
Anritsu	MA2411B	Pulse Power Sensor	7/28/2020	Annual	7/28/2021	1339018
Anritsu	MA2411B	Pulse Power Sensor	10/19/2020	Annual	10/19/2021	1339026
COMTECH	AR85729-5/5759B	Solid State Amplifier	CBT	N/A	CBT	M3W1A00-1002
COMTech	AR85729-5	Solid State Amplifier	CBT	N/A	CBT	M1S5A00-009
Control Company	4352	Long Stem Thermometer	5/16/2020	Biennial	5/16/2022	200294416
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/6/2020	Biennial	3/6/2022	200170289
Control Company	4352	Long Stem Thermometer	5/16/2020	Biennial	5/16/2022	200294604
K & L	11SH10-1300/U4000	High Pass Filter	N/A	N/A	N/A	11SH10-1300/U4000 - 2
Keysight Technologies	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	E7515B	UXM 5G Wireless Test Platform	6/11/2019	Biennial	6/11/2021	MY59150289
Keysight Technologies	M1740A	mmWave Transceiver	2/20/2020	Biennial	2/20/2022	MY59291989
Keysight Technologies	M1740A	mmWave Transceiver	2/20/2020	Biennial	2/20/2022	MY59291982
Keysight Technologies	E7770A	Common Interface Unit	N/A	N/A	N/A	MY58290483
Krytar	110067006	Directional Coupler, 10 - 67 GHz	N/A	N/A	N/A	200391
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Mini Circuits	ZA2PD2-63-S+	Power Splitter	CBT	N/A	CBT	SUU64901930
Mini Circuits	ZAPD-2-272-S+	Power Splitter	CBT	N/A	CBT	SF702001405
MIniCircuits	NLP-1200+	Low Pass Filter	N/A	N/A	N/A	VUU78201318
MiniCircuits	SLP-2400+	Low Pass Filter	CBT	N/A	CBT	R8979500903
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter DC to 1000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	CBT	N/A	CBT	01492
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	CBT	N/A	CBT	01493
Narda	4772-3	Attenuator	CBT	N/A	CBT	9406
Narda	BW-S3W2	Attenuator	CBT	N/A	CBT	120
Narda	BW-S10W2+	Attenuator	CBT	N/A	CBT	831
Narda	4014C-6	4 - 8 GHz SMA 6 dB Directional Coupler	CBT	N/A	CBT	N/A
Newmark System	NSC-G2	Motion Controller	CBT	N/A	CBT	1007-D
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	11/4/2020	Annual	11/4/2021	100976
Rohde & Schwarz	CMW500	Radio Communication Tester	11/4/2020	Annual	11/4/2021	100976
Rohde & Schwarz	NRP8S	3 Path Dipole Power Sensor	3/24/2021	Annual	3/24/2022	108168
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	5/13/2021	Annual	5/13/2022	109322
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	5/13/2021	Annual	5/13/2022	109052
Rohde & Schwarz	NRP50S	3-Path Dipole Power Sensor	3/24/2021	Annual	3/24/2022	101164
SPEAG	5G Verification Source 30GHz	30GHz System Verification Antenna	2/10/2021	Annual	2/10/2022	1035
SPEAG	5G Verification Source 30GHz	30GHz System Verification Antenna	12/10/2020	Annual	12/10/2021	1045
SPEAG	EUmmWV4	E-field Probes	1/11/2021	Annual	1/11/2022	9523
SPEAG	EUmmWV3	E-field Probe	11/16/2020	Annual	11/16/2021	9389
SPEAG	EUmmWV3	E-field Probe	6/24/2020	Annual	6/24/2021	9364
SPEAG	DAK-3.5	Dielectric Assessment Kit	10/14/2020	Annual	10/14/2021	1091
SPEAG	D1750V2	1750 MHz SAR Dipole	5/12/2020	Biennial	5/12/2022	1148
SPEAG	D1900V2	1900 MHz SAR Dipole	2/21/2019	Triennial	2/21/2022	5d148
SPEAG	D2300V2	2300 MHz SAR Dipole	8/13/2018	Triennial	8/13/2021	1073
SPEAG	D2600V2	2600 MHz SAR Dipole	11/12/2019	Biennial	11/12/2021	1071
SPEAG	EX3DV4	SAR Probe	12/15/2020	Annual	12/15/2021	7570
SPEAG	EX3DV4	SAR Probe	2/16/2021	Annual	2/16/2022	7417
SPEAG	DAE4	Dasy Data Acquisition Electronics	12/7/2020	Annual	12/7/2021	859
SPEAG	DAE4ip	Intergrated Power Supply	11/17/2020	Annual	11/17/2021	1639
SPEAG	DAE4ip	Intergrated Power Supply	11/17/2020	Annual	11/17/2021	1638
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/12/2021	Annual	2/12/2022	665
Zhuhai Bojay Electronics	BJ8827	Shielded Test Enclosure	N/A	N/A	N/A	F229647

Notes:

1. CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler, or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.
2. Each equipment item is used solely within its respective calibration period.
3. Due to the worldwide pandemic caused by the novel SAR-CoV-2 virus (COVID-19), special calibration extensions have been permitted by A2LA. Some equipment had its calibration period extended accordingly and will be calibrated when possible.

17 MEASUREMENT UNCERTAINTIES

For SAR Measurements

a	c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Uncertainty Component	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i 1gm**	**c_i 10 gms**	**1gm u_i (± %)**	**10gms u_i (± %)**	**v_i**
Measurement System								
Probe Calibration	6.55	N	1	1.0	1.0	6.6	6.6	∞
Axial Isotropy	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	2.0	R	1.73	1.0	1.0	1.2	1.2	∞
Linearity	0.3	N	1	1.0	1.0	0.3	0.3	∞
System Detection Limits	0.25	R	1.73	1.0	1.0	0.1	0.1	∞
Readout Electronics	0.3	N	1	1.0	1.0	0.3	0.3	∞
Response Time	0.8	R	1.73	1.0	1.0	0.5	0.5	∞
Integration Time	2.6	R	1.73	1.0	1.0	1.5	1.5	∞
RF Ambient Conditions - Noise	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
RF Ambient Conditions - Reflections	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	0.4	R	1.73	1.0	1.0	0.2	0.2	∞
Probe Positioning w/ respect to Phantom	6.7	R	1.73	1.0	1.0	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	4.0	R	1.73	1.0	1.0	2.3	2.3	∞
Test Sample Related								
Test Sample Positioning	2.7	N	1	1.0	1.0	2.7	2.7	35
Device Holder Uncertainty	1.67	N	1	1.0	1.0	1.7	1.7	5
Output Power Variation - SAR drift measurement	5.0	R	1.73	1.0	1.0	2.9	2.9	∞
SAR Scaling	0.0	R	1.73	1.0	1.0	0.0	0.0	∞
Phantom & Tissue Parameters								
Phantom Uncertainty (Shape & Thickness tolerances)	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	4.2	N	1	0.78	0.71	3.3	3.0	10
Liquid Permittivity - measurement uncertainty	4.1	N	1	0.23	0.26	1.0	1.1	10
Liquid Conductivity - Temperature Uncertainty	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)		RSS				11.5	11.3	60
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2				23.0	22.6	

For PD Measurements

a	b	c	d	e	f = c x f/e	g
Uncertainty Component	Unc. (± dB)	Prob. Dist.	Div.	c_i	u_i (± dB)	v_i
Measurement System						
Calibration	0.49	N	1	1	0.49	∞
Probe Correction	0.00	R	1.73	1	0.00	∞
Frequency Response	0.20	R	1.73	1	0.12	∞
Sensor Cross Coupling	0.00	R	1.73	1	0.00	∞
Isotropy	0.50	R	1.73	1	0.29	∞
Linearity	0.20	R	1.73	1	0.12	∞
Probe Scattering	0.00	R	1.73	1	0.00	∞
Probe Positioning offset	0.30	R	1.73	1	0.17	∞
Probe Positioning Repeatability	0.04	R	1.73	1	0.02	∞
Sensor MechanicalOffset	0.00	R	1.73	1	0.00	∞
Probe Spatial Resolution	0.00	R	1.73	1	0.00	∞
Field Impedence Dependance	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Drift	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Noise	0.04	R	1.73	1	0.02	∞
Measurement Area Truncation	0.00	R	1.73	1	0.00	∞
Data Acquisition	0.03	N	1	1	0.03	∞
Sampling	0.00	R	1.73	1	0.00	∞
Field Reconstruction	0.60	R	1.73	1	0.35	∞
Forward Transformation	0.00	R	1.73	1	0.00	∞
Power Density Scaling	0.00	R	1.73	1	0.00	∞
Spatial Averaging	0.10	R	1.73	1	0.06	∞
System Detection Limit	0.04	R	1.73	1	0.02	∞
Test Sample Related						
Probe Coupling with DUT	0.00	R	1.73	1	0.00	∞
Modulation Response	0.40	R	1.73	1	0.23	∞
Integration Time	0.00	R	1.73	1	0.00	∞
Response Time	0.00	R	1.73	1	0.00	∞
Device Holder Influence	0.10	R	1.73	1	0.06	∞
DUT alignment	0.00	R	1.73	1	0.00	∞
RF Ambient Conditions	0.04	R	1.73	1	0.02	∞
Ambient Reflections	0.04	R	1.73	1	0.02	∞
Immunity/Secondary Reception	0.00	R	1.73	1	0.00	∞
Drift of DUT	0.21	R	1.73	1	0.12	∞
Combined Standard Uncertainty (k=1)		RSS			0.76	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2			1.52	

18 CONCLUSION

18.1 Measurement Conclusion

The SAR evaluation indicates that the DUT complies with the RF radiation exposure limits of the FCC and Innovation, Science, and Economic Development Canada, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables. [3]

19 REFERENCES

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.

[2] ANSI/IEEE C95.1-2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.

[3] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.

[4] ANSI/IEEE C95.3-2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, December 2002.

[5] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528-2013, IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

[6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.

[7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.

[8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 1 -124.

[9] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.

[10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.

[11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.

[12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.

[13] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.

[14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.

[15] W. Gander, Computermathematick, Birkhaeuser, Basel, 1992.

[16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.

[17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.

[18] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.

[19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hoschschule Zürich, Dosimetric Evaluation of the Cellular Phone.

[20] IEC 62209-1, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz), July 2016.

[21] Innovation, Science, Economic Development Canada RSS-102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) Issue 5, March 2015.

[22] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2015

[23] FCC SAR Test Procedures for 2G-3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225, D01-D07

[24] SAR Measurement Guidance for IEEE 802.11 Transmitters, KDB Publication 248227 D01

[25] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474 D03-D04

[26] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04

[27] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01-D02

[28] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01-D02

[29] Anexo à Resolução No. 533, de 10 de Septembro de 2009.

[30] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), Mar. 2010.