Part 1: Test Under Static Transmission Scenario

For
SMARTPHONE

FCC ID: BCG-E3539A
Model Name: A2176

Report Number: 13179110-S6V2
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Revision History

Rev.	Date	Revisions	Revised By
V1	9/25/2020	Initial Issue	--
V2	9/25/2020	Updated Table 4-1 with the correct power	Nathan Sousa

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1 Introduction

The equipment under test (EUT) is a smart phone, model A2176 (FCC ID: BCG-E3539A), it contains Qualcomm® modems supporting 2G/3G/4G technologies and 5G mmW NR bands. These WWAN modems enable Qualcomm Smart Transmit features with algorithms to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure from WWAN is in compliance with FCC requirements.

In addition to these WWAN modems, the EUT contains a different modem to support WLAN.

The purpose of this Part 1 report is to demonstrate that this EUT complies with FCC RF exposure limits at maximum time-averaged transmit power limits for WWAN technologies, and at maximum transmit power limits for WLAN technologies.

- SAR and power density (PD) compliance for all WWAN radios (4G + 5G mmW NR) is assessed based on maximum time-averaged transmit power (static transmission condition). Relevant FCC KDBs and exclusion criteria are applied on a time-average power basis for WWAN technologies. The maximum time-averaged transmit power limits for supported WWAN technologies, bands, and antennas in this report are derived in Part 0 report. The validation of the Qualcomm Smart Transmit time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in Part 2 report.
- SAR compliance for WLAN radios is assessed based on maximum transmit power as per relevant FCC KDBs.
- Demonstrate compliance in simultaneous transmission scenarios involving both WWAN and WLAN transmissions, where WWAN exposure is assessed based on time-averaged transmit power limits, and WLAN exposure is assessed separately.

By following the above steps, this report demonstrates that this EUT complies with FCC RF exposure limits for FCC equipment authorization of A2176.

The P_{limit} and *input.power.limit* used in this report are determined and listed in Part 0 report.

Refer to Compliance Summary report for product description and terminology used in this report.

2 Measurement Setup and General Information

The SAR measurement are recorded in UL *FCC SAR Test Report* (Report No. 13179110-S1).

This section provides the details of the test setup used for PD measurement.

2.1 Test environment

Test location	UL Verification Services
Ambient temperature	22±2^{0}C

2.2 Power density measurement system

The power density measurement system is constructed based on the DASY6 platform by SPEAG. The DASY6 with EUmmWV2 and 5G software module can measure the RF exposure (power density) up to 110GHz as close as 2mm from any transmitter.

2.2.1 Power density probe

The EUmmWV2 probe is used in the power density measurement. It is designed for precise near-field measurements in the mm-wave range by Schmid & Partner Engineering AG of Zurich, Switzerland. The specifications are:

- Frequency range: 0.75 ~ 110 GHz
- Dynamic range: <50 – 3000 V/m (up to 10000 V/m with additional PRE-10 voltage divider)
- Linearity: < ± 0.2 dB
- Supports sensor model calibration (SMC)
- ISO17025 accredited calibration

2.2.2 Power density measurement system verification

The power density system verification is performed using the SPEAG verification device. It consists of a ka-band horn antenna with a corresponding gun oscillator packaged within a cube-shaped housing.

The specification of the verification device is:

- Calibrated frequency: 30 GHz at 10 mm from the case surface
- Frequency accuracy: ± 100 MHz
- E-field polarization: linear
- Harmonics: -20 dBc (typ)
- Total radiated power: 14 dBm (typ)
- Power stability: 0.05 dB
- Power consumption: 5 W (max)
- Size: 100 × 100 × 100 mm
- Weight: 1 kg

Table 2-1 shows the verification test results. The measured power density (PD) value is within 0.4dB of target level. Note that the uncertainty of 5G verification source is 1.4dB (k=2).

Table 2-1: System validation results

SAR Lab	Date	Frequency (GHz)	5G Verification Source SN	Source Cal. Due Data	Measured Results for 1cm^2	Target (Ref. Value)	Deviation (dB)	Measured Results for 4cm^2	Target (Ref. Value)	Deviation (dB)	Plot
SAR 1	8/3/2020	30	1003	9/11/2020	41.6	34.9	0.08	37.2	31	0.08	
SAR 1	8/6/2020	30	1003	9/11/2020	42.1	34.9	0.08	37.2	31	0.08	
SAR 1	8/9/2020	30	1003	9/11/2020	46	34.9	0.12	40.5	31	0.12	
SAR 1	8/12/2020	30	1003	9/11/2020	45.2	34.9	0.11	39.4	31	0.10	
SAR 1	8/16/2020	30	1003	9/11/2020	45.3	34.9	0.11	39.1	31	0.10	
SAR 1	8/20/2020	30	1003	9/11/2020	46.6	34.9	0.13	41.5	31	0.13	1,2
SAR 1	8/24/2020	30	1003	9/11/2020	42.5	34.9	0.09	37.9	31	0.09	
SAR 1	8/27/2020	30	1003	9/11/2020	45.8	34.9	0.12	40.7	31	0.12	
SAR 1	8/31/2020	30	1003	9/11/2020	41.6	34.9	0.08	36.6	31	0.07	
SAR 1	9/3/2020	30	1003	9/11/2020	39.7	34.9	0.06	39.7	31	0.11	

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
, 5G Verification Source - 30GHz	100.0 x 100.0 x 100.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G Air	FRONT, 5.55	Validation band	CW, 0--	30000.0, 30000	1.0

Hardware Setup

Medium	Probe, Calibration Date	DAE, Calibration Date
--Air-	EUmmWV4 - SN9437_F1-78GHz, 2020-05-22	DAE4 Sn1257, 2019-10-10

Scan Setup

	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	N/A

Measurement Results

	5G Scan
Date	2020-08-20, 07:17
Avg. Area [cm^2]	4.00
pS_{tot} avg [W/m^2]	42.8
pS_n avg [W/m^2]	41.5
E_{peak} [V/m]	142
Power Drift [dB]	0.25

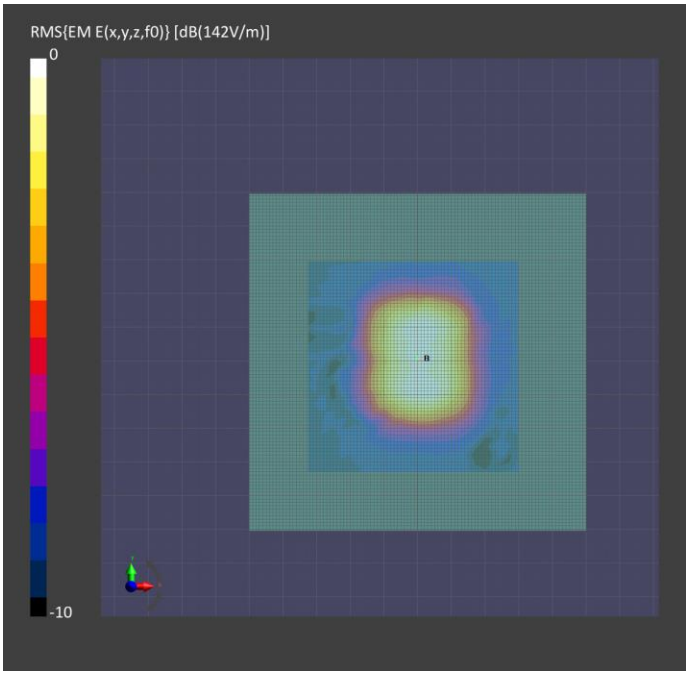

Figure 2-1: *4cm²PD* for source validation on 8/20/2020

3 Test Condition, Configuration, and Assessment
3.1 Qualcomm Smart Transmit parameters

The input parameters described in Section 2.3 of the Compliance Summary report are required for functionality of Qualcomm Smart Transmit algorithm.

These parameters are entered through the *Embedded File System* (EFS) and cannot be accessed by the end-user.

Part 0 report (§2.4) documents determination of P_{limit} for sub-6 WWAN bands, and *input.power.limit* for 5G mmW NR bands using the below design targets and device related uncertainty:

- *SAR_design_target* of 0.8 W/kg 1g SAR and sub-6 WWAN device design related uncertainty of 1.0 dB.
- *PD_design_target* of 7.5 W/m^2 4cm^2 PD and mmW device design related uncertainty of 2.2 dB.

3.1.1 Qualcomm Smart Transmit parameters for the 4G modem

For this EUT, all input parameters determined in Section 2.3 of Part 0 report are populated via the EFS entry.

3.1.2 Qualcomm Smart Transmit parameters for the 5G modem

The *input.power.limit* parameter for 5G mmW NR radio determined in Section 3.7.3 of Part 0 report are populated via EFS entry into the EUT.

3.2 Device Test Configuration for SAR Measurements

In summary, SAR is evaluated on this EUT in below test configurations and test condition:

- Test configurations: Hotspot SAR exposure (1g SAR) from all device surfaces/edges (front, back, left, right, top, bottom) having a transmitting antenna located ≤ 25mm from that device surface/edge when in direct contact with flat section of SAM phantom. Hotspot SAR is evaluated at 5 mm separation distance for all selected device surfaces as per FCC KDB publication 648474 D04.
- Test condition: The SAR measurements on all supported sub-6 WWAN technologies and bands are conducted with the EUT transmitting at maximum time-average transmit power (P_{limit}) or maximum RF tune-up power (P_{max}) if $P_{max} \leq P_{limit}$.

See UL *FCC SAR Test Report* (Report No. 13179110-S1) for details.

3.3 Device test configuration for PD measurements

As can be seen in Section 3 of Part 0 report, the PD exposure for this EUT has been assessed against 6.0 W/m^2 of *PD_design_target* using validated simulation approach for the worst cases of all the beams. To further confirm the compliance, a subset of beams and test cases is selected for PD verification in Section 4.2.

The following beam selection criteria for the PD verification test were used:

- Select one single beam (antenna array config) per polarization (vertical or horizontal) and per mmW antenna module
  - The single beam containing highest number of active antenna ports. For example, the single beam with 4 active patch ports should be selected over the beam with a single active patch port
- Select one beam per mmW antenna module
  - The beam pair containing the highest number of active antenna ports.

Additionally, since the worst-case surface dictates the compliance, the PD measurement is made all channels and all applicable surfaces determined through the validated simulation approach, see Appendix B of Part 0 report.

Based on the aforementioned criteria and the EUT codebook in Section 3.3 of Part 0 report, below Table 3-1 and Table 3-2 lists the selected beams and test cases for PD verification measurement. The definition of the EUT surface is illustrated in Figure 3-1.

Table 3-1: PD verification test cases for n260

Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M1	2254166		159	100	1	Back
	2254166	34	162	100	1	Back
	2229166	23		100	1	Back
	2229166	23		100	1	Left
Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M2	2254166	37		100	1	Right
	2254166	28	156	100	1	Right
	2254166		157	100	1	Right
	2254166		157	100	1	Front
	2254166		157	100	1	Back
Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M0	2254166	9		100	1	Front
	2254166		145	100	1	Front
	2254166		138	100	33	Front
	2254166		138	100	33	Rear
	2254166		138	100	33	Top

Table 3-2: PD verification test cases for n261

Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M1	2077916	21		100	1	Back
	2077916		161	100	1	Back
	2070833	23	151	100	1	Back
	2070833	23	151	100	1	Left
Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M2	2077916	29		100	1	Right
	2077916		163	100	1	Right
	2070833	26	154	100	33	Right
	2070833	26	154	100	33	Front
	2070833	26	154	100	33	Back
Module/Antenna	Ch.	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M0	2077916	9		100	1	Front
	2077916		146	100	1	Front
	2083333 & 2084999	17	145	200	66	Front
	2083333 & 2084999	17	145	200	66	Rear
	2083333 & 2084999	17	145	200	66	Top

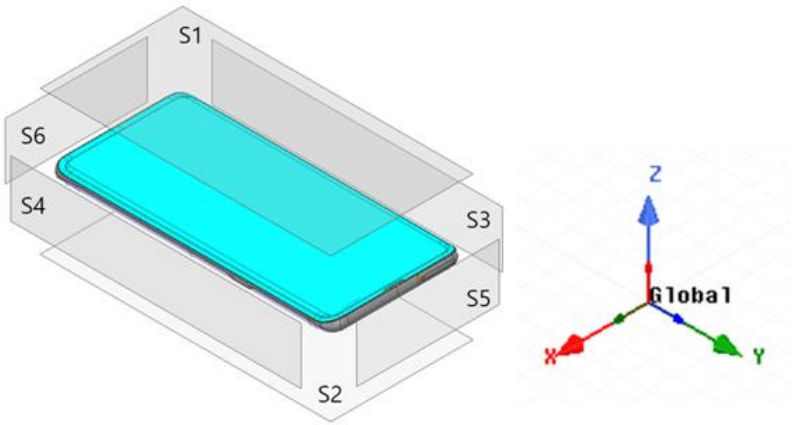

Figure 3-1: EUT surface definition: S1=Front, S2=Rear, S3=Edge 4, S4=Edge 2, S5=Edge 1, S6=Edge 3

4 Summary of Results

4.1 SAR Measurement and Conducted Power Results at P_{limit}

The transmit power limit P_{limit} that corresponds to the *SAR_design_target* of 0.8 W/kg (for 1g SAR) for all technologies and bands were determined through Part 0 report and are listed in EFS entries in Table 2-3. Based on UL *FCC SAR Test Report* (Report No. 13179110-S1), for this EUT, the P_{max} (maximum RF tune-up power) for select Sub-6 GHz technologies is less than, or equal to, the corresponding P_{limit} as summarized and shown in Table 4-1 below.

Table 4-1: Comparison of P_{limit} and P_{max}

Exposure Scenario		Head	Body-worn & Hotspot	P_{max} (dBm) Tune-up power table
Spatial-average		1g	1g	
Test Distance		0 mm	5 mm	
Power Mode (DSI)		Mode A (DSI=0)	Mode B (DSI=1)	
Port	Tech/Band	P_{limit} (dBm) Tune-up power table	P_{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average	Burst Average	Burst Average
A	GSM 850 2 slots	32.50	31.50	32.50
	GSM 1900 2 slots	31.00	23.75	31.00
	W-CDMA B2	25.70	17.50	25.70
	W-CDMA B4	25.70	18.50	25.70
	W-CDMA B5	25.70	25.25	25.70
	CDMA BC0	25.70	25.25	25.70
	CDMA BC1	25.70	17.50	25.70
	LTE Band 5	25.70	25.25	25.70
	LTE Band 7	25.25	19.00	25.70
	LTE Band 12/17	25.70	25.70	25.70
	LTE Band 13	25.70	25.70	25.70
	LTE Band 14	25.70	25.70	25.70
	LTE Band 25/2	25.70	17.50	25.70
	LTE Band 26	25.70	25.25	25.70
	LTE Band 30	25.70	22.25	25.70
	LTE Band 41	25.70	22.50	25.70
	LTE Band 48	25.70	21.50	22.00
	LTE Band 66/4	25.70	18.50	25.70
	LTE Band 71	25.70	25.70	25.70
	NR n5	25.70	25.25	25.70
	NR n12	25.70	25.70	25.70
	NR n25/2	25.70	17.50	25.70
	NR n41	25.25	20.50	24.00
	NR n66	25.70	18.50	25.70
	NR n71	25.70	25.70	25.70
	NR n77	25.70	19.75	25.70

Exposure Scenario		Head	Body-worn & Hotspot	P_{max} (dBm) Tune-up power table
Spatial-average		1g	1g	
Test Distance		0 mm	5 mm	
Power Mode (DSI)		Mode A (DSI=0)	Mode B (DSI=1)	
Port	Tech/Band	P_{limit} (dBm) Tune-up power table	P_{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average	Burst Average	Burst Average
B	GSM 850 2 slots	31.00	31.00	31.00
	GSM 1900 2 slots	27.75	25.50	28.50
	W-CDMA B2	21.50	19.25	23.10
	W-CDMA B4	20.00	18.25	23.10
	W-CDMA B5	24.50	24.50	24.50
	CDMA BC0	24.50	24.50	24.50
	CDMA BC1	21.50	19.25	23.10
	CDMA BC10	24.50	24.50	24.50
	LTE Band 5	24.50	24.50	24.50
	LTE Band 7	19.00	19.25	22.80
	LTE Band 12/17	24.50	24.50	24.50
	LTE Band 13	24.50	24.50	24.50
	LTE Band 14	24.50	24.50	24.50
	LTE Band 25/2	21.50	19.25	23.10
	LTE Band 26	24.50	24.50	24.50
	LTE Band 30	18.50	19.50	22.80
	LTE Band 41	19.75	21.00	23.70
	LTE Band 48	20.00	21.50	22.50
	LTE Band 66/4	20.00	18.25	23.10
	LTE Band 71	24.50	24.50	24.50
	NR n5	24.50	24.50	24.50
	NR n12	24.50	24.50	24.50
	NR n25/2	21.50	19.25	23.10
	NR n41	17.75	19.00	26.00
	NR n66	20.00	18.25	23.10
	NR n71	24.50	24.50	24.50
	NR n77	16.25	17.00	22.50

Exposure Scenario		Head	Body-worn & Hotspot	P_{max} (dBm) Tune-up power table
Spatial-average		1g	1g	
Test Distance		0 mm	5 mm	
Power Mode (DSI)		Mode A (DSI=0)	Mode B (DSI=1)	
Port	Tech/Band	P_{limit} (dBm) Tune-up power table	P_{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average	Burst Average	Burst Average
C	GSM 1900 2 slots	30.00	27.50	30.00
	W-CDMA B2	24.70	21.00	24.70
	W-CDMA B4	24.70	20.75	24.70
	LTE Band 7	24.50	19.00	25.00
	LTE Band 25/2	24.70	21.25	25.00
	LTE Band 30	24.50	20.75	25.00
	LTE Band 41	24.70	21.75	25.00
	LTE Band 48	25.70	23.00	24.60
	LTE Band 66/4	24.70	20.75	25.00
	NR n25/2	24.70	21.25	25.00
	NR n41	24.50	19.75	23.00
	NR n66	24.70	20.75	25.00
	NR n77	25.70	20.75	26.00
D	GSM 1900 2 slots	26.75	28.00	28.00
	W-CDMA B2	20.25	22.50	22.70
	W-CDMA B4	20.00	21.25	22.70
	LTE Band 7	19.50	20.25	22.50
	LTE Band 25/2	20.50	21.75	23.00
	LTE Band 30	20.75	21.25	22.50
	LTE Band 41	21.25	22.20	22.50
	LTE Band 48	20.25	21.50	22.80
	LTE Band 66/4	20.00	21.25	23.00
	NR n25/2	20.50	21.75	23.00
	NR n41	19.25	20.25	25.00
	NR n66	20.00	21.25	23.00
	NR n77	18.00	18.50	22.80

Therefore, for this EUT, SAR and conducted power measurements at P_{limit} will be the same as those performed at P_{max}. Thus, SAR measured at P_{limit} reported in UL *FCC SAR Test Report* (Report No. 13179110-S1) can be leveraged in this section to avoid re-testing. The worst-case reported SAR values from UL *FCC SAR Test Report* (Report No. 13179110-S1) for Sub-6 GHz WWAN bands can be found in Section 2.4 of Part 0. Worst-case reported SAR for WLAN are:

Table 4-2: Worst-case *reported* SAR (extracted from UL *FCC SAR Test Report* (Report No. 13179110-S1)

Techonology	Freq (GHz)	ANT		Reported SAR 1g (W/kg)	Reported SAR 1g (W/kg)	P_{max}	
		DSI: 0	DSI: 1	DSI: 0	DSI: 1	DSI: 0	DSI: 1
WLAN	2.4	4	4	0.379	0.586	14.75	17.75
	5	6	6	0.328	0.494	12.50	14.25

Note that WLAN SAR for each of the bands in the above table lists the worst-case SAR out of both WLAN antennas and WLAN MIMO.

4.2 PD Measurement results at *input.power.limit*

Table 3-1 and Table 3-2 lists the beams selected for PD verification test for this EUT and Table 4-3 lists the corresponding PD measurement results at 2 mm spacing. Qualcomm Smart Transmit algorithm operates based on time-averaged transmit power reported on a per symbol basis, which is independent of modulation, channel and bandwidth (RBs). Therefore, PD measurements in Table 4-3 and Table 4-4 were conducted with the EUT in FTM mode, with CW modulation and in worst-case channel determined through simulations, with EUT transmitting at input.power.limit (listed in Table 3-3 of Part 0) corresponding to the tested beams.

All 4cm^2 PD values for the selected beams are listed in Table 4-3 and Table 4-4. In addition to these selected beams, 4cm^2 PD for few more beams (highlighted in Table 4-3 and Table 4-4) that were used in Part 2 report were also measured.

Table 4-3: PD Measurement results for n260

Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M1	38.5	2254166		159	1 8	1	100	QPSK	1	CW	2mm	Back	0 01	2.310	2.760
	38.5	2254166	34	162	-1 2	1	100	QPSK	1	CW	2mm	Back	-0 21	1.270	1.850
	37	2229166	23		2.4	1	100	QPSK	1	CW	2mm	Back	-0 03	**4.130**	**5.580**
	37	2229166	23		2.4	1	100	QPSK	1	CW	2mm	Left	-0 03	0.518	0.535
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M2	38.5	2254166	37		0 6	1	100	QPSK	1	CW	2mm	Right	-0.18	1.150	1.690
	38.5	2254166	28	156	-0 9	1	100	QPSK	1	CW	2mm	Right	0 05	2.710	3.580
	38.5	2254166		157	2 5	1	100	QPSK	1	CW	2mm	Right	0.14	**3.740**	**4.670**
	38.5	2254166		157	2 5	1	100	QPSK	1	CW	2mm	Front	-0.19	2.310	2.410
	38.5	2254166		157	2 5	1	100	QPSK	1	CW	2mm	Back	-0 09	1.880	2.060
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M0	38.5	2254166	9		11	1	100	QPSK	1	CW	2mm	Front	0 08	2.050	2.600
	38.5	2254166		145	11	1	100	QPSK	1	CW	2mm	Front	0 01	2.110	2.970
	38.5	2254166		138	11	1	100	QPSK	33	CW	2mm	Front	-0 05	**4.000**	**4.870**
	38.5	2254166		138	11	1	100	QPSK	33	CW	2mm	Rear	0 07	1.880	2.600
	38.5	2254166		138	11	1	100	QPSK	33	CW	2mm	Top	-0 07	2.220	2.350

Table 4-4: PD Measurement results for n261

Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M1	27.925	2077916	21		1.9	1	100	QPSK	1	CW	2mm	Back	0.07	2.780	4.120
	27.925	2077916		161	0.8	1	100	QPSK	1	CW	2mm	Back	-0.05	2.820	4.080
	27.5	2070833	23	151	-1.0	1	100	QPSK	1	CW	2mm	Back	0.03	**5.600**	**6.820**
	27.5	2070833	23	151	-1.0	1	100	QPSK	1	CW	2mm	Left	0.52	0.752	0.758
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M2	27.925	2077916	29		1.1	1	100	QPSK	1	CW	2mm	Right	0.21	2.420	3.180
	27.925	2077916		163	0.9	1	100	QPSK	1	CW	2mm	Right	-0.22	2.390	3.610
	27.5	2070833	26	154	-1.8	1	100	QPSK	33	CW	2mm	Right	-0.08	**3.920**	**6.270**
	27.5	2070833	26	154	-1.8	1	100	QPSK	33	CW	2mm	Front	-0.44	1.960	2.090
	27.5	2070833	26	154	-1.8	1	100	QPSK	33	CW	2mm	Back	-0.05	3.540	4.060
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	CC	BW	Modulation	RB	Signal Type	Eval. Distance	DUT Surface	Power Drift	Normal psPD	Total psPD
	GHz	Ch.	V	H	dBm	#	MHz		#				dB	W/m²	W/m²
ANT M0	27.925	2077916	9		10.5	1	100	QPSK	1	CW	2mm	Front	-0.30	0.989	1.000
	27.925	2077916		146	8.7	1	100	QPSK	1	CW	2mm	Front	-0.52	0.583	0.631
	28.350	2083333 & 2084999	17	145	5.0	1	200	QPSK	66	CW	2mm	Front	-0.02	**3.510**	**5.170**
	28.350	2083333 & 2084999	17	145	5.0	1	200	QPSK	66	CW	2mm	Rear	-0.07	1.900	2.160
	28.350	2083333 & 2084999	17	145	5.0	1	200	QPSK	66	CW	2mm	Top	0.08	1.220	1.920

Measurement Report for AA1902, BACK, Custom Band, n260 UID 0 -, Channel 37000000 (37000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
, AA1902	131.0 x 63.0 x 7.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G Air	BACK, 2.00	Custom Band	CW, 0--	37000.0, 37000000	1.0

Hardware Setup

Medium	Probe, Calibration Date	DAE, Calibration Date
--Air-	EUmmWV4 - SN9437_F1-78GHz, 2020-05-22	DAE4 Sn1257, 2019-10-10

Scan Setup

	5G Scan
Grid Extents [mm]	25.0 x 25.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	2.0
MAIA	N/A

Measurement Results

	5G Scan
Date	2020-08-28, 08:34
Avg. Area [cm^2]	4.00
pS_{tot} avg [W/m^2]	5.58
pS_n avg [W/m^2]	4.13
E_{peak} [V/m]	110
Power Drift [dB]	-0.03

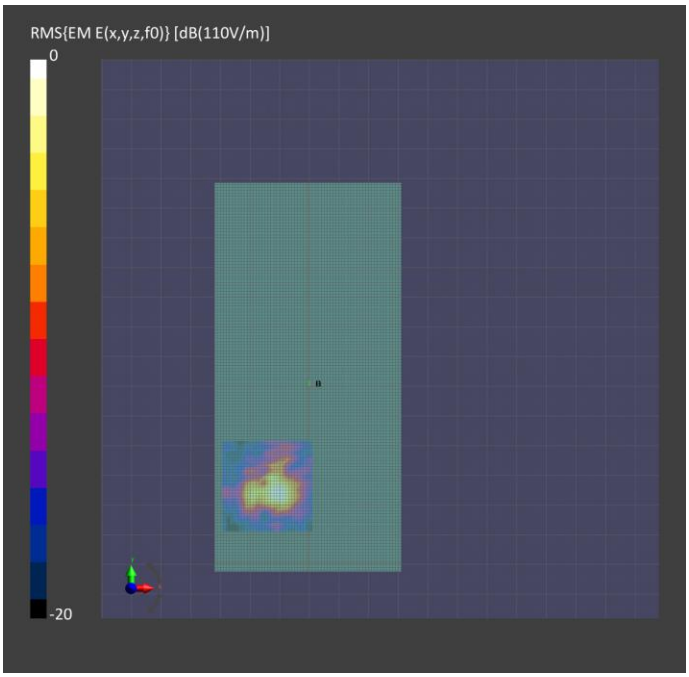

Figure 4-1: Band 260, Beam ID 23, *4cm² PD*, Front

Measurement Report for AA1902, BACK, Custom Band, n261 UID 0 -, Channel 27500000 (27500.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
, AA1902	131.0 x 63.0 x 7.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G Air	BACK, 2.00	Custom Band	CW, 0--	27500.0, 27500000	1.0

Hardware Setup

Medium	Probe, Calibration Date	DAE, Calibration Date
--Air-	EUmmWV4 - SN9437_F1-78GHz, 2020-05-22	DAE4 Sn1257, 2019-10-10

Scan Setup

	5G Scan
Grid Extents [mm]	25.0 x 25.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	2.0
MAIA	N/A

Measurement Results

	5G Scan
Date	2020-08-26, 20:23
Avg. Area [cm^2]	4.00
pS_{tot} avg [W/m^2]	6.82
pS_n avg [W/m^2]	5.60
E_{peak} [V/m]	91.7
Power Drift [dB]	0.03

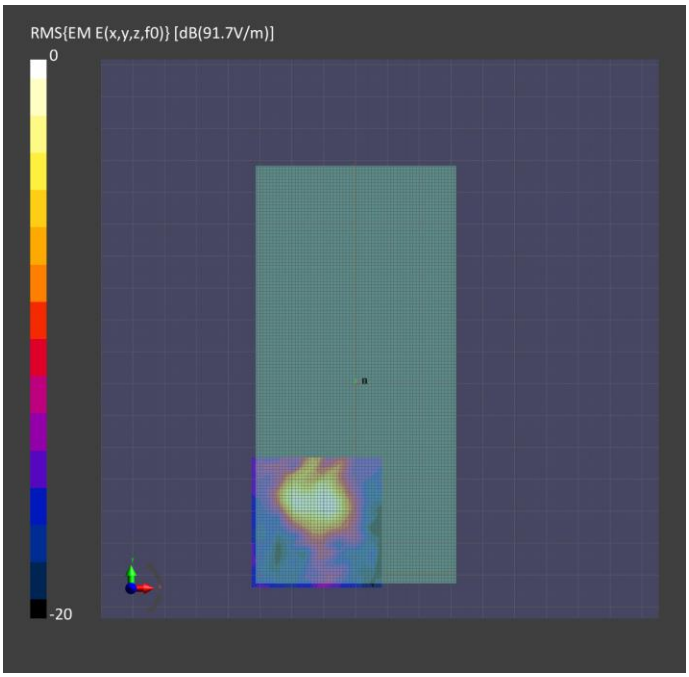

Figure 4-2: Band 261, Beam IDs 23/151, *4cm² PD*, Front

4.3 Simultaneous Transmission Analysis

The EUT supports simultaneous transmission of multiple radios. RF exposure compliance in simultaneous transmission scenarios is evaluated in this section.

It must be noted here that Qualcomm Smart Transmit time-averaging algorithm was applied to only WWAN on this device, where the time-averaged power level is controlled so that RF exposure is ≤ SAR_design_target for sub-6 WWAN and ≤ PD_design_target for 5G mmW NR. Since there is total design-related uncertainty arising from TxAGC and device-to-device variation, the worst-case RF exposure should be determined by accounting for this uncertainty in the corresponding design target, thus, with 1dB of device uncertantiy for sub-6 WWAN and 2.2dB of device uncertainty for 5G mmW NR. Therefore, the worst-case RF exposure for this EUT is:

Table 4-5 Worst-case time-averaged RF exposure for WWAN

	WWAN	
	Sub-6 WWAN	5G mmW NR
Maximum time-averaged power level	P_{limit}	*input.power.limit*
Maximum time-averaged exposure	*SAR_design_target =0.8 W/kg (1gSAR)*	*PD_design_target = 6 W/m²*
Maximum Design-related uncertainty	*1.0 dB*	*2.2 dB*
Worst-case time-averaged RF exposure	*reported* SAR† =1.0W/kg (1gSAR)	*reported PD* =* =75% × *PD_design_target*+2.2dB = 7.5 W/m²

† Highest SAR value obtained from UL *FCC SAR Test Report* (Report No. 13179110-S1). For scenarios where (P_{limit} + 1.0dB uncertainty) ≥ P_{max} (maximum RF tune-up output power), time-averaged SAR exposure from Smart Transmit enabled EUT (at P_{limit}) cannot exceed reported SAR corresponding to P_{max} in Table 4-1.

* Smart Transmit allows only 75% of maximum PD exposure for this EUT using EFS entries listed in 13335182-S6 Part 0. See Section 4.3.1 for details.

WLAN reported 1g SAR at the maximum RF tune-up output power is listed in Table 4-2.

4.3.1 Analysis

RF exposure compliance with WWAN+WLAN simultaneous transmission scenarios is demonstrated for various radio configurations using below equation:

> Total norm. RF exposure = norm. RF exposure from Smart Transmit enabled WWAN (norm. SAR from 4G + norm. PD from 5G mmW NR) + norm. SAR from WLAN ≤ 1.0 normalized limit (1)

Smart Transmit algorithm in WWAN adds directly the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G mmW NR, i.e.,

> norm. RF exposure from Smart Transmit enabled WWAN: (normalized SAR exposure from 4G) + (normalized PD exposure from 5G mmW NR) ≤ 1.0 normalized limit (2)

In other words, Smart Transmit algorithm controls the total RF exposure from both 4G radio and 5G mmW NR to not exceed FCC limit. Smart transmit algorithm assumes hotspots are collocated (i.e., ignoring spatial distribution of hotspots) and directly adds normalized RF exposures from 4G and from 5G mmW NR, i.e.,

If A = max normalized time-averaged SAR exposure from 4G,
B = max normalized time-averaged PD exposure from 5G mmW NR,

Then, equation (2) can be re-written as below because Smart Transmit assumes 4G hotspots are collocated with 5G mmW NR hotspot:

Smart Transmit enabled WWAN: x(t) * A + (1-x(t)) * B ≤ 1.0 normalized limit (3)

Here, "*x(t)*A*" represents percentage of normalized time-averaged RF exposure from 4G, and x(t) ranges between [0,1]; "*(1-x(t))*B*" is remaining percentage of RF exposure contribution from 5G mmW NR. Smart Transmit controls '*x*' in real time such that the sum of these exposures never exceeds 1.0 normalized limit.

Note that mathematically:

$$x(t) * A + (1 - x(t)) * B \leq max(A, B) \leq 1.0\ normalized\ limit \text{ for x(t) } \in [0,1] \quad (4)$$

Therefore, if below equations (5a) and (5b) are proven:

$$A + norm.SAR\ from\ WLAN \leq 1.0\ norm.limit \quad (5a),$$

$$B + norm.SAR\ from\ WLAN \leq 1.0\ norm.limit \quad (5b),$$

Then, based on equation (4), below condition is also proved:

$$[x(t) * A + (1 - x(t)) * B] + norm.SAR\ from\ WLAN \leq 1.0\ norm.limit \quad (5c)$$

which is same as equation (1), to demonstrate compliance for simultaneous transmission.

Additionally, it should be noted that in the absence of 5G mmW NR, Smart Transmit limits the maximum RF exposure contributed from 4G to 100% normalized exposure (i.e., *x*=1.0 in equation 3), while with 5G mmW NR active, Smart Transmit limits the maximum RF exposure contributed from 5G mmW NR to 75% normalized exposure to guarantee at least 25% margin allocated to 4G LTE anchor to maintain the link (i.e., *x*=0.25 in equation 3). Therefore:

Smart Transmit enabled WWAN: A=max (normalized SAR exposure from 4G) ≤ 1.0 normalized limit (6a)

Smart Transmit enabled WWAN: B=max (normalized PD exposure from 5G mmW NR) ≤ 0.75 normalized limit (6b)

Thus, for compliance demonstration given by equation (1), below equation (7) obtained by combining equations (5a & 5b) and (6a & 6b), should be proven to guarantee simultaneous transmission compliance:

Total normalized RF exposure = norm. SAR from 4G WWAN + norm. SAR from WLAN < 1.0 normalized FCC limit (7a)
*Total normalized RF exposure = 0.75*norm. PD from 5G mmW NR WWAN + norm. SAR from WLAN < 1.0 normalized FCC limit* (7b)

The compliance for simultaneous transmission scenarios of WWAN (4G/5G mmW NR) radio enabled with Smart Transmit and WLAN without Smart Transmit is re-evaluated for all transmission scenarios supported by this EUT.

As described in equation (7), simultaneous transmission analysis for WWAN + WLAN is performed in two parts:

1. 4G WWAN + WLAN (i.e., Eq. (7a) with compliance demonstration in Section 4.3.2)
2. 5G mmW NR WWAN + WLAN (i.e., Eq. (7b) with compliance demonstration in Section 4.3.3)

By combining above a. and b., the FCC requirement expressed in Eq. (1), re-written below, is met:

Total norm. RF exposure = norm. RF exposure from Smart Transmit enabled WWAN (norm. SAR from 4G + norm. PD from 5G mmW NR) + norm. SAR from WLAN ≤ 1.0 normalized limit (1)

4.3.2 Simultaneous Transmission Compliance demonstration for Sub-6 WWAN + WLAN

Simultaneous transmission analysis for Sub-6 WWAN + WLAN is shown in UL *FCC SAR Test Report* (Report No. 13179110-S1).

4.3.3 Simultaneous Transmission Compliance demonstration for 5G mmW NR WWAN + WLAN

Simultaneous transmission analysis is performed in this section using worst-case PD values listed in Table 4-3 for compliance demonstration of 5G mmW NR WWAN + WLAN, along with all worst-case reported SAR values for WLAN listed in Table 4-2 extracted from UL *FCC SAR Test Report* (Report No. 13179110-S1). For bodyworn/hotspot analysis the 2 mm PD results were scaled to 5 mm based upon the simulation results.

Simultaneous transmission analysis on all 5G mmW NR WWAN + WLAN scenarios are listed below:

Table 4-6: Simultaneous transmission analysis scenarios for 5G mmW NR WWAN + WLAN

1	2.4GHz WLAN* + 5G mmW NR
2	5GHz WLAN* + 5G mmW NR
3	5GHz WLAN* + BT + 5G mmW NR

* For each of the WLAN bands, worst-case SAR out of both WLAN antennas and WLAN MIMO scenarios is used during simultaneous transmission analysis. Additionally, note that WLAN 2.4GHz cannot transmit simultaneously with WLAN 5GHz or BT.

The total exposure ratio (TER) is calculated using the equation below, followed by the calculated TER for this EUT:

$$TER = \sum_{n=1}^{N} \frac{\mathrm{SAR}_n}{\mathrm{SAR}_{n,limit}} + \sum_{n=1}^{N} \frac{\mathrm{S}_{m,avg}}{\mathrm{S}_{m,limit}} < 1$$

Table 4-7: 5G mmW NR Simulation PD Surface Ratio n261

n261						
Surface	PD Magnitude Ratio		Head	Body[1]	Meas. Total PD	Measured Total PD x 0.75 (W/m^2)
	2mm (W/m^2)	5mm (W/m^2)	PD x 0.75 @ 2mm (W/m^2)	PD x 0.75 @ 5mm (W/m^2)	(W/m^2)	
S1	10.0	6.3	**7.5**	**5.5**	-	-
S2	10.0	7.3	-	**5.5**	-	-
S3	2.6	-	-	**1.4**	0.535	0.401
S4	10.0	6.7	-	**5.5**	-	-
S5	4.9	-	-	**2.7**	2.350	1.76
S6	0.1	-	-	**0.1**	-	-

[1] Results for Body were calculated using the most conservative ratio between the PD Magnitudes for 2mm and 5mm.

Table 4-8: 5G mmW NR Simulation PD Surface Ratio n260

n260						
Surface	PD Magnitude Ratio		Head	Body[1]	Meas. Total PD	Measured Total PD x 0.75 (W/m^2)
	2mm (W/m^2)	5mm (W/m^2)	PD x 0.75 @ 2mm (W/m^2)	PD x 0.75 @ 5mm (W/m^2)	(W/m^2)	
S1	10.0	6.3	**7.5**	**5.0**	-	-
S2	10.0	6.7	-	**5.0**	-	-
S3	3.0	-	-	**1.5**	0.758	0.569
S4	10.0	5.3	-	**5.0**	-	-
S5	4.7	-	-	**2.4**	1.920	1.440
S6	0.2	-	-	**0.1**	-	-

[1] Results for Body were calculated using the most conservative ratio between the PD Magnitudes for 2mm and 5mm.

Table 4-9: Head TER for Worst-Case WLAN + 5G mmW NR n261 and n260

Head TER	psPD	2.4 GHz WiFi	5 GHz WiFi	BT P_{low}	psPD + 2.4 GHz WLAN	psPD + 5 GHz WLAN	psPD + 5 GHz WLAN + BT
	W/m^2	W/kg	W/kg	W/kg			
TER Combinations	1	2	3	4	1+2	1+3	1+3+4
Applicable limit	10	1.6	1.6	1.6	1	1	1
Reported Exposure	7.5	0.379	0.328	0.069	-	-	-
Ratio to Limit	0.750	0.237	0.205	0.043	0.987	0.955	0.998

Table 4-10: Body/Hotspot TER for Worst-Case WLAN + 5G mmW NR n261

n261								
Body/Hotspot TER		psPD	2.4 GHz WiFi	5 GHz WiFi	BT P_{low}	psPD + 2.4 GHz WLAN	psPD + 5 GHz WLAN	psPD + 5 GHz WLAN + BT
		W/m²	W/kg	W/kg	W/kg			
Scenario		1	2	3	4	1+2	1+3	1+3+4
Applicable limit		10	1.6	1.6	1.6	1	1	1
S1 @ 5mm	Reported Exposure	5.500	0.475	0.266	0.042	-	-	-
	Ratio to Limit	0.550	0.297	0.166	0.026	0.847	0.716	0.743
S2 @ 5mm	Reported Exposure	5.500	0.475	0.411	0.082	-	-	-
	Ratio to Limit	0.550	0.297	0.257	0.051	0.847	0.807	0.858
S3 @ 5mm	Reported Exposure	1.400	0.475	0.494	0.084	-	-	-
	Ratio to Limit	0.140	0.297	0.309	0.052	0.437	0.449	0.501
S4 @ 5mm	Reported Exposure	5.500	0.586	-	0.076	-	-	-
	Ratio to Limit	0.550	0.366	-	0.047	0.916	-	0.597
S5 @ 5mm	Reported Exposure	2.700	0.441	0.494	0.014	-	-	-
	Ratio to Limit	0.270	0.276	0.309	0.009	0.546	0.579	0.588
S6 @ 5mm	Reported Exposure	0.100	0.475	0.198	0.013	-	-	-
	Ratio to Limit	0.010	0.297	0.124	0.008	0.307	0.134	0.142

Table 4-11: Body/Hotspot TER for Worst-Case WLAN + 5G mmW NR n260

n260								
Body/Hotspot TER		psPD	2.4 GHz WiFi	5 GHz WiFi	BT P_{low}	psPD + 2.4 GHz WLAN	psPD + 5 GHz WLAN	psPD + 5 GHz WLAN + BT
		W/m²	W/kg	W/kg	W/kg			
Scenario		1	2	3	4	1+2	1+3	1+3+4
Applicable limit		10	1.6	1.6	1.6	1	1	1
S1 @ 5mm	Reported Exposure	5.000	0.475	0.266	0.042	-	-	-
	Ratio to Limit	0.500	0.297	0.166	0.026	0.797	0.666	0.693
S2 @ 5mm	Reported Exposure	5.000	0.475	0.411	0.082	-	-	-
	Ratio to Limit	0.500	0.297	0.257	0.051	0.797	0.757	0.808
S3 @ 5mm	Reported Exposure	1.500	0.475	0.494	0.084	-	-	-
	Ratio to Limit	0.150	0.297	0.309	0.052	0.447	0.459	0.511
S4 @ 5mm	Reported Exposure	5.000	0.586	-	0.076	-	-	-
	Ratio to Limit	0.500	0.366	-	0.047	0.866	-	0.547
S5 @ 5mm	Reported Exposure	2.400	0.441	0.494	0.014	-	-	-
	Ratio to Limit	0.240	0.276	0.309	0.009	0.516	0.549	0.558
S6 @ 5mm	Reported Exposure	0.100	0.475	0.198	0.013	-	-	-
	Ratio to Limit	0.010	0.297	0.124	0.008	0.307	0.134	0.142

5 Conclusions

Table 5-1 shows the worst-case 1g SAR at P_{limit} and worst-case 4cm^2-avg PD at *input.power.limit.*

Table 5-1: Reported RF exposure level

Reported RF Exposure Level		Notes
Highest 1g SAR at P_{limit} (W/kg)	0.999	UL Verification Services 13179110-S1
Highest 4cm^2-avg PD at *input.power.limit* (W/m^2)	6.82	Section 4.2
Highest 1g SAR (W/kg) for simultaneous Tx (Sub-6 WWAN + WLAN)	1.585	UL Verification Services 13179110-S1
Highest Total Exposure Ratio for simultaneous Tx (5G mmW NR + WLAN)	0.998	Section 4.3

Qualcomm Smart Transmit feature employed in A2176 (FCC ID: BCG-E3539A) meets the *SAR_design_target* and *PD_design_target* (within the design uncertainties) when operating in the static transmission condition at P_{limit} and *input.power.limit*, respectively, and is compliant with the FCC RF exposure limits.

Appendices

Refer to separated files for the following appendixes.

Appendix A: Probe Certificates

Appendix B: Verification Source Certificate