Part 1: Test Under Static Transmission Scenario

For
SMARTPHONE

FCC ID: BCG-E3542A
Model Name: A2172

Report Number: 13179116-S6V3
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Revision History

Rev.	Date	Revisions	Revised By
V1	9/11/2020	Initial Issue	--
V2	9/13/2020	Various updates besed upon TCB comments	Dave Weaver
V3	9/14/2020	Section 4.3 – Updated note under Table 4-5	Dave Weaver

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1 Introduction

The equipment under test (EUT) is a smart phone, model A2172 (FCC ID: BCG-E3542A), it contains Qualcomm® modems supporting 2G/3G/4G technologies and mmW 5G 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 A2172.

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. 13179116-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	10/11/2021	41.6	34.9	0.08	37.2	31	0.08	
SAR 1	8/6/2020	30	1003	10/11/2021	42.1	34.9	0.08	37.2	31	0.08	
SAR 1	8/9/2020	30	1003	10/11/2021	46	34.9	0.12	40.5	31	0.12	
SAR 1	8/12/2020	30	1003	10/11/2021	45.2	34.9	0.11	39.4	31	0.10	
SAR 1	8/16/2020	30	1003	10/11/2021	45.3	34.9	0.11	39.1	31	0.10	
SAR 1	8/20/2020	30	1003	10/11/2021	46.6	34.9	0.13	41.5	31	0.13	1,2

Measurement Report for 5G Verification Source - 30GHz, FRONT, Validation band, UID 0 -, Channel 30000 (30000.0MHz)

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

Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave- xxxx	--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

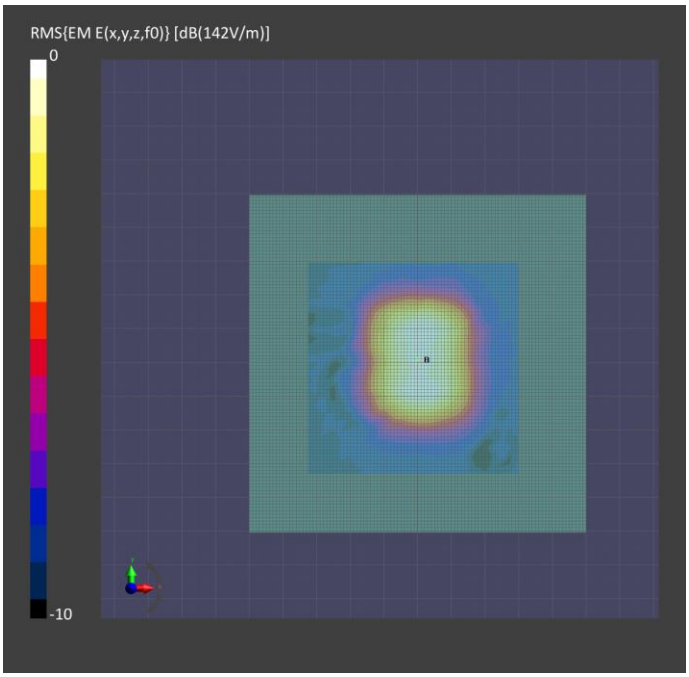

Figure 2-1: *4cm²PD* for source validation on 8/20/2020

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. 13179116-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	Channel	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M1	Mid	28		100	1	Back
	Mid	28	156	100	1	Back
	Mid		147	100	1	Back
	Mid		147	50	1	Back
	Mid		147	100	1	Left
Module/Antenna	**Channel**	**Beam ID1**	**Beam ID2**	**BW**	**RB**	**DUT**
		V	**H**	**MHz**	**#**	**Surface**
ANT M2	Mid	34		100	1	Right
	Mid	25	153	100	1	Right
	Mid		154	100	1	Right
	Low		154	50	66	Right
	Low		154	50	66	Front
	Low		154	50	66	Back
Module/Antenna	**Channel**	**Beam ID1**	**Beam ID2**	**BW**	**RB**	**DUT**
		V	**H**	**MHz**	**#**	**Surface**
ANT M0	Mid	6		100	1	Front
	Mid		142	100	1	Front
	Mid	7	135	100	1	Front
	Mid	7	135	50	66	Front
	Mid	7	135	50	66	Back
	Mid	7	135	50	66	Top

Table 3-2: PD verification test cases for n261

Module/Antenna	Channel	Beam ID1	Beam ID2	BW	RB	DUT
		V	H	MHz	#	Surface
ANT M1	Mid	31		100	1	Back
	Mid	21	149	100	1	Back
	Mid		150	100	1	Back
	Mid		150	50	1	Back
	Mid		150	50	1	Left
Module/Antenna	**Channel**	**Beam ID1**	**Beam ID2**	**BW**	**RB**	**DUT**
		V	**H**	**MHz**	**#**	**Surface**
ANT M2	Mid	35		100	1	Right
	Mid		160	100	1	Right
	Mid	32	160	100	1	Right
	Mid	35		50	1	Right
	Mid	35		100	1	Front
	Mid	35		100	1	Back
Module/Antenna	**Channel**	**Beam ID1**	**Beam ID2**	**BW**	**RB**	**DUT**
		V	**H**	**MHz**	**#**	**Surface**
ANT M0	Mid	6		100	1	Front
	Mid	6	134	100	1	Front
	Mid		143	100	1	Front
	Dual		143	200	66	Front
	Dual		143	200	66	Back
	Dual		143	200	66	Top

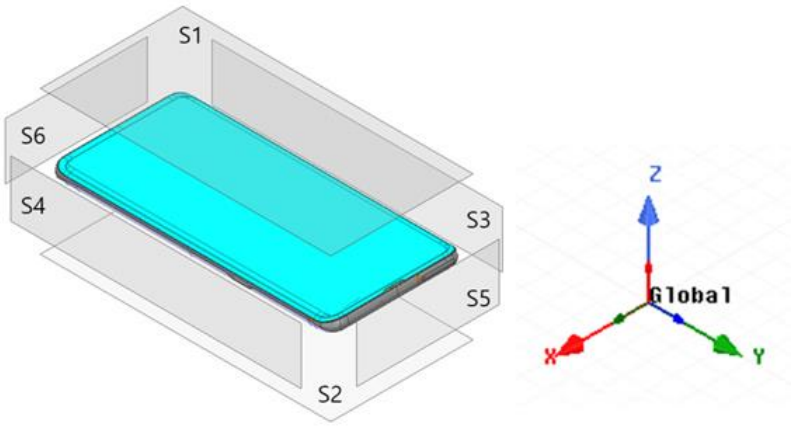

Figure 3-1: EUT surface definition: S1=Front, S2=Rear, S3=Edge 4, S4=Edge 2, S5=Edge 1, S6=Edge 3

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 1gSAR) 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. 13179116-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) Duty-cycle corrected	P_{limit} (dBm) Duty-cycle corrected	
	Transmit Average	Burst Average	Burst Average	Burst Average
A	GSM 850 2 slots	32.50	32.50	32.50
	GSM 1900 2 slots	31.00	22.50	31.00
	W-CDMA B2	25.70	16.50	25.70
	W-CDMA B4	25.70	17.00	25.70
	W-CDMA B5	25.70	25.70	25.70
	CDMA BC0	25.70	25.70	25.70
	CDMA BC1	25.70	16.50	25.70
	CDMA BC10	25.70	25.70	25.70
	LTE Band 5	25.70	25.70	25.70
	LTE Band 7	25.70	19.50	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	16.50	25.70
	LTE Band 26	25.70	25.70	25.70
	LTE Band 30	25.70	21.00	25.70
	LTE Band 41	25.70	22.25	25.70
	LTE Band 48	25.70	21.00	22.80
	LTE Band 66/4	25.70	17.00	25.70
	LTE Band 71	25.70	25.70	25.70
	NR n5	25.70	25.70	25.70
	NR n12	25.70	25.70	25.70
	NR n25/2	25.70	16.50	25.70
	NR n41	25.70	20.25	25.70
	NR n66	25.70	17.00	25.70
	NR n71	25.70	25.70	25.70
	NR n77	25.70	18.25	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	Max Tx Power	P_{limit} (dBm) Tune-up power table	Max Tx Power	P_{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average		Burst Average		Burst Average
B	GSM 850 2 slots	25.00	31.00	25.75	31.00	31.00
	W-CDMA B5	24.00	23.90	25.75	23.90	23.90
	CDMA BC0	24.00	23.90	24.75	23.90	23.90
	CDMA BC10	24.00	23.90	26.00	23.90	23.90
	LTE Band 5	24.25	24.50	24.50	24.50	24.50
	LTE Band 12/17	24.75	23.90	26.00	23.90	23.90
	LTE Band 13	24.75	23.90	26.75	23.90	23.90
	LTE Band 14	19.25	23.90	25.00	23.90	23.90
	LTE Band 26	19.00	24.50	24.50	24.50	24.50
	LTE Band 71	31.25	24.50	26.25	24.50	24.50
	NR n5	24.25	24.50	24.50	24.50	24.50
	NR n12	24.75	23.90	26.00	23.90	23.90
	NR n71	24.50	24.50	26.25	24.50	24.50
C	GSM 1900 2 slots	27.50	30.00	18.50	25.50	30.00
	W-CDMA B2	27.00	24.70	18.75	19.50	24.70
	W-CDMA B4	27.50	24.70	20.50	21.25	24.70
	LTE Band 48	24.50	25.20	19.50	22.50	23.70

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. 13179116-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. 13179116-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. 13179116-S1)

Techonology	Freq (GHz)	ANT	Reported SAR 1g (W/kg) DSI: 0	Reported SAR 1g (W/kg) DSI: 1	Pmax	
					DSI: 0	DSI: 1
WLAN	2.4	4	0.384	0.565	16.00	18.25
	5	6	0.248	0.449	12.50	12.50

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	Signal Type	DUT Surface	Normal psPD	Total psPD
	Channel	Ch. Number	V	H	dBm			W/cm^2	W/cm^2
ANT M1	Mid	2254166	28		1.4	CW	Back	2.39	2.99
	Mid	2254166	28	156	-1.9	CW	Back	2.44	3.14
	Mid	2254166		147	2.3	CW	Back	4.41	5.12
	Mid	2254166		147	2.3	CW	Back	4.39	5.06
	Mid	2254166		147	2.3	CW	Left	0.402	0.415
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	Signal Type	DUT Surface	Normal psPD	Total psPD
	MHz	Ch. number	V	H	dBm			W/cm^2	W/cm^2
ANT M2	Mid	2254166	34		0.9	CW	Right	2.4	3.11
	Mid	2254166	25	153	-1.1	CW	Right	2.96	3.56
	Mid	2254166		154	1.8	CW	Right	3.63	4.31
	Low	2229167		154	1.8	CW	Right	3.99	4.7
	Low	2229167		154	1.8	CW	Front	0.884	0.985
	Low	2229167		154	1.8	CW	Back	0.483	0.547
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	Signal Type	DUT Surface	Normal psPD	Total psPD
	MHz	Ch. Number	V	H	dBm			W/cm^2	W/cm^2
ANT M0	Mid	2254166	6		8.5	CW	Front	1.76	2.24
	Mid	2254166		142	8.8	CW	Front	2.49	2.93
	Mid	2254166	7	135	9.5	CW	Front	5.44	7.04
	Mid	2254166	7	135	9.5	CW	Front	5.69	7.14
	Mid	2254166	7	135	9.5	CW	Back	1.53	2.17
	Mid	2254166	7	135	9.5	CW	Top	1.46	2.61

Table 4-4: PD Measurement results for n261

Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	Signal Type	DUT Surface	Normal psPD	Total psPD
	Channel	Ch. number	V	H	dBm			W/cm^2	W/cm^2
ANT M1	Mid	2077916	31		1.2	CW	Back	3.63	4.57
	Mid	2077916	21	149	-3.7	CW	Back	3.73	4.18
	Mid	2077916		150	0.5	CW	Back	2.74	6.17
	Mid	2077916		150	0.5	CW	Back	3.89	6.9
	Mid	2077916		150	0.5	CW	Left	1.2	1.36
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	Signal Type	DUT Surface	Normal psPD	Total psPD
	Channel	Ch. number	V	H	dBm			W/cm^2	W/cm^2
ANT M2	Mid	2077916	35		0.9	CW	Right	5.18	7.50
	Mid	2077916		160	0.9	CW	Right	3.56	5.15
	Mid	2077916	32	160	-2	CW	Right	2.58	4.04
	Mid	2077916	35		0.9	CW	Right	5.17	7.42
	Mid	2077916	35		0.9	CW	Front	1.87	3.26
	Mid	2077916	35		0.9	CW	Back	1.16	2.19
Module/Antenna	Frequency		Beam ID1	Beam ID2	input.power.limit	Signal Type	DUT Surface	Normal psPD	Total psPD
	Channel	Ch. number	V	H	dBm			W/cm^2	W/cm^2
ANT M0	Mid	2077916	6		11.3	CW	Front	2.36	3
	Mid	2077916	6	134	4.4	CW	Front	1.76	2.57
	Mid	2077916		143	10.5	CW	Front	3.23	4.67
	Dual	2077916 & 2079582		143	10.5	CW	Front	4.49	5.9
	Dual	2077916 & 2079582		143	10.5	CW	Back	1.03	1.48
	Dual	2077916 & 2079582		143	10.5	CW	Top	1.15	2.06

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	DUT Type
A2172	147.0 x 71.0 x 7.0	Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G Air	FRONT, 2.00	Custom Band	CW, 0--	38500.0, 38500000	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	2020-08-04, 21:24
Avg. Area [cm^2]	4.00
pS_{tot} avg [W/m^2]	7.14
pS_n avg [W/m^2]	5.69
E_{peak} [V/m]	166
Power Drift [dB]	-0.03

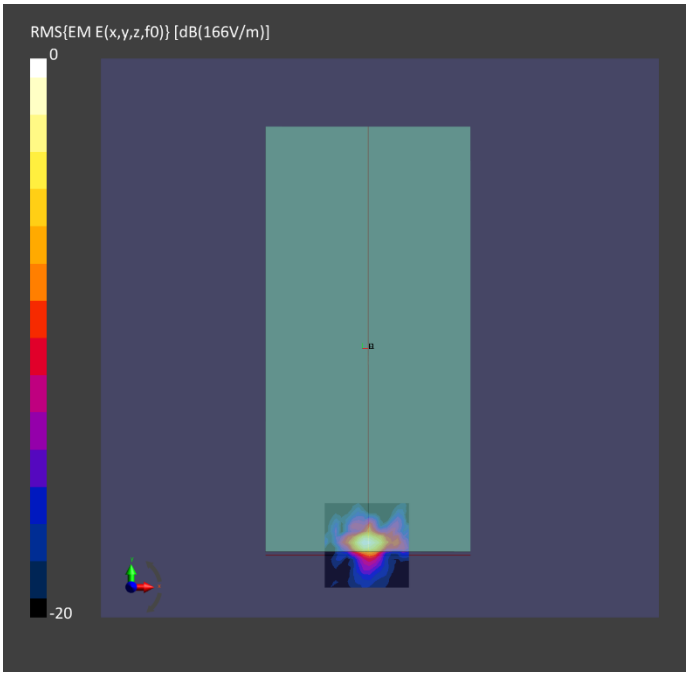

Figure 4-1: Band 260, beam ID 6, *4cm² PD*, Front

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	DUT Type
A2172	147.0 x 71.0 x 7.0	Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G Air	EDGE RIGHT, 2.00	Custom Band	CW, 0--	27925.0, 27925000	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	2020-08-02, 14:03
Avg. Area [cm^2]	4.00
pS_{tot} avg [W/m^2]	7.50
pS_n avg [W/m^2]	5.18
E_{peak} [V/m]	127
Power Drift [dB]	-0.31

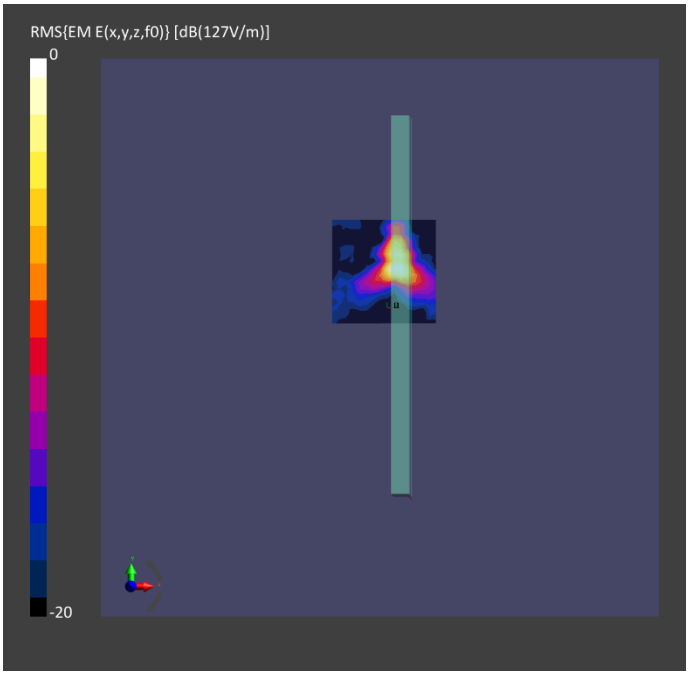

Figure 4-2: Band 261, beam ID 6, *4cm² PD*, Edge Right

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. 13179116-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 13179116-S6V2 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 4G WWAN + WLAN

Simultaneous transmission analysis for 4G WWAN + WLAN is shown in UL *FCC SAR Test Report* (Report No. 13179116-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. 13179116-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	PD Magnitude Ratio		Head	Body	Measured Total PD (W/m^2)	Measured Total PD x 0.75
Surface	2mm (W/m^2)	5mm (W/m^2)	PD x 0.75 @ 2mm (W/m^2)	PD x 0.75 @ 5mm (W/m^2)		
S1	10	6.3	**7.5**	**5.0**	-	-
S2	10	6.6	-	**5.0**	-	-
S3	2.1	-	-	**1.1**	1.36	1.02
S4	10	6.7	-	**5.0**	-	-
S5	4.9	-	-	**2.5**	2.06	1.55
S6	0.1	-	-	**0.1**	-	-

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

N260	PD Magnitude Ratio		Head	Body	Measured Total PD (W/m^2)	Measured Total PD x 0.75 2mm (W/m^2)
Surface	2mm (W/m^2)	5mm (W/m^2)	PD x 0.75 @ 2mm (W/m^2)	PD x 0.75 @ 5mm (W/m^2)		
S1	10	6.3	**7.5**	**4.7**	-	-
S2	10	6.1	-	**4.7**	-	-
S3	1.6	-	-	**0.8**	0.42	0.31
S4	10	5.3	-	**4.7**	-	-
S5	4.7	-	-	**2.2**	2.61	1.96
S6	0.2	-	-	**0.1**	-	-

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

	psPD	2.4GHz WiFi	5GHz 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			
	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	0.384	0.248	0.076	-	-	-
Ratio to Limit	0.75	0.24	0.155	0.048	0.990	0.905	0.900

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

		psPD	2.4 WiFi	5GHz WiFi	BT P_{low}	psPD + 2.4 WLAN ANT 4	psPD + 5 WLAN ANT 6	psPD + 5 WLAN ANT 6 + BT
		W/m^2	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	0.479	0.167	0.084	-	-	-
	Ratio to Limit	0.5	0.299	0.104	0.053	0.799	0.604	0.657
S2 @ 5mm	Reported Exposure	5	0.565	0.434	0.068	-	-	-
	Ratio to Limit	0.5	0.353	0.271	0.043	0.853	0.771	0.814
S3 @ 5mm	Reported Exposure	1.1	0.479	0.449	0.004	-	-	-
	Ratio to Limit	0.11	0.299	0.281	0.003	0.409	0.391	0.393
S4 @ 5mm	Reported Exposure	5	0.299	-	0.067	-	-	-
	Ratio to Limit	0.5	0.187	-	0.042	0.687	0.500	0.542
S5 @ 5mm	Reported Exposure	2.5	0.299	0.401	0.003	-	-	-
	Ratio to Limit	0.25	0.187	0.251	0.002	0.437	0.501	0.503
S6 @ 5mm	Reported Exposure	0.1	0.479	0.144	0.01	-	-	-
	Ratio to Limit	0.01	0.299	0.090	0.006	0.309	0.100	0.106

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

		psPD	2.4 WiFi	5GHz WiFi	BT P_{low}	psPD + 2.4 WLAN ANT 4	psPD + 5 WLAN ANT 6	psPD + 5 WLAN ANT 6 + BT
		W/m^2	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	4.7	0.479	0.167	0.084	-	-	-
	Ratio to Limit	0.47	0.299	0.104	0.053	0.769	0.574	0.627
S2 @ 5mm	Reported Exposure	4.7	0.565	0.434	0.068	-	-	-
	Ratio to Limit	0.47	0.353	0.271	0.043	0.823	0.741	0.784
S3 @ 5mm	Reported Exposure	0.80	0.479	0.449	0.004	-	-	-
	Ratio to Limit	0.08	0.299	0.281	0.003	0.379	0.361	0.363
S4 @ 5mm	Reported Exposure	4.7	0.299	-	0.067	-	-	-
	Ratio to Limit	0.47	0.187	-	0.042	0.657	0.470	0.512
S5 @ 5mm	Reported Exposure	2.2	0.299	0.401	0.003	-	-	-
	Ratio to Limit	0.22	0.187	0.251	0.002	0.407	0.471	0.473
S6 @ 5mm	Reported Exposure	0.10	0.479	0.144	0.01	-	-	-
	Ratio to Limit	0.01	0.299	0.090	0.006	0.309	0.100	0.106

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)	.999	UL Verification Services 13179116-S1
Highest 4cm^2-avg PD at *input.power.limit* (W/m^2)	7.5	Section 4.3
Highest 1g SAR (W/kg) for simultaneous Tx (4G WWAN + WLAN)	1.554	UL Verification Services 13179116-S1
Highest Total Exposure Ratio for simultaneous Tx (LTE+5G mmW NR + WLAN)	0.990	Section 4.3

Qualcomm Smart Transmit feature employed in A2172 (FCC ID: BCG-E3542A) 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