



**Part 0: SAR Characterization
EUT RF Exposure Compliance Test Report**

For
SMARTPHONE

**FCC ID: BCG-E3547A
Model Name: A2407, A2408, & A2409**

**Report Number: 13259319-S6V3
Issue Date: 10/27/2020**

Prepared for
**APPLE INC
1 APPLE PARK WAY
CUPERTINO, CA 95014-2084**

Prepared by
**UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888**

Revision History

Rev.	Date	Revisions	Revised By
V1	9/18/2020	Initial Issue	--
V2	9/23/2020	Updated Tables 2-2 and 2-3 with the correct Tune-up Power	Nathan Sousa
V3	10/27/2020	Removed all mention of millimeter wave support	

Table of Contents

1 Introduction	4
2 SAR Characterization	5
2.1 Worst-case SAR determination	5
2.2 Usage Scenarios in SAR Evaluation	6
2.3 SAR design target	7
2.4 SAR Char of EUT	8

Figures

Figure 2-1: SAR evaluation for smartphone application.....	5
Figure 2-2: Worst-case SAR determination based on DSI.....	6

Tables

Table 2-1: Usage/Exposure Scenario	6
Table 2-2: Worst-case reported SAR (extracted from UL report 13259319-S1)	8
Table 2-3: SAR Char of EUT	9

1 Introduction

The equipment under test (EUT) is a smart phone. It contains the Qualcomm modem supporting 2G/3G/4G WWAN technologies and 5G NR Sub-6 GHz technologies. These WWAN modems enable Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement.

In the Part 0 report, the EUT SAR are characterized for WWAN radios (2G/3G/4G/Sub6 NR) to determine the power limit that corresponds to the exposure design target after accounting for all device design related uncertainties, i.e., SAR_design_target (< FCC SAR limit) for sub-6. The SAR characterization are denoted as SAR Char.

SAR Char will be used as input for Qualcomm Smart Transmit to operate. SAR Char will be loaded and store in the EUT via the Embedded File System (EFS).

The EUT supports WLAN/BT radio as well but WLAN/BT modem is not enabled with Smart Transmit.

2 SAR Characterization

SAR Char is generated to cover all radio configurations and usage scenarios that are reported in the initial FCC submission.

2.1 Worst-case SAR determination

Based on FCC KDBs, in general, for a smartphone, the SAR evaluation is required for the exposure scenarios shown in Figure 2-1.

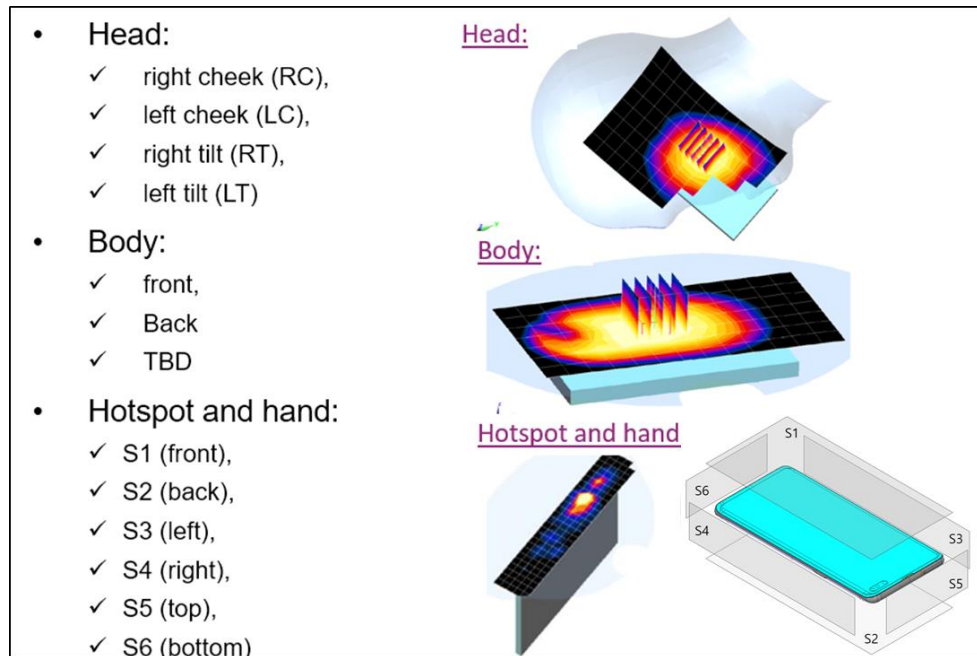


Figure 2-1: SAR evaluation for smartphone application

The device state index (DSI) used in Figure 2-2 represents each exposure scenario. Depending on the detection scheme implemented in the smartphone, the worst-case SAR is further grouped and determined for each or combined exposure scenario(s). Note for the 1g SAR versus 10g SAR exposure scenario, the worst-case is determined in term of exposure ratio (i.e., exposure level relative to the corresponding 1g- or 10g-SAR limit).

- If the device does not have any detection mechanism (**all “no”** in Figure 2-2), then the worst-case SAR is determined by taking the maximum SAR value among all exposure scenarios, i.e., worst-case SAR = $\max\{SAR_{head}, SAR_{body}, SAR_{hotspot/extremity}\}$
- If the device can distinguish each of the above scenarios (**all “yes”** in Figure 2-2), then the worst-case SAR for each individual exposure scenario is given by corresponding SAR_{head} , SAR_{body} , and $SAR_{hotspot/extremity}$
- If the device can only distinguish a subset of the scenarios (**some “yes”, some “no”** in Figure 2-2), then the worst-case SAR is given by:
 - Corresponding SAR for each exposure scenario that can be distinguished (DSI=yes)
 - Worst-case SAR among all other exposure scenario(s) that cannot be distinguished (DSI=no)

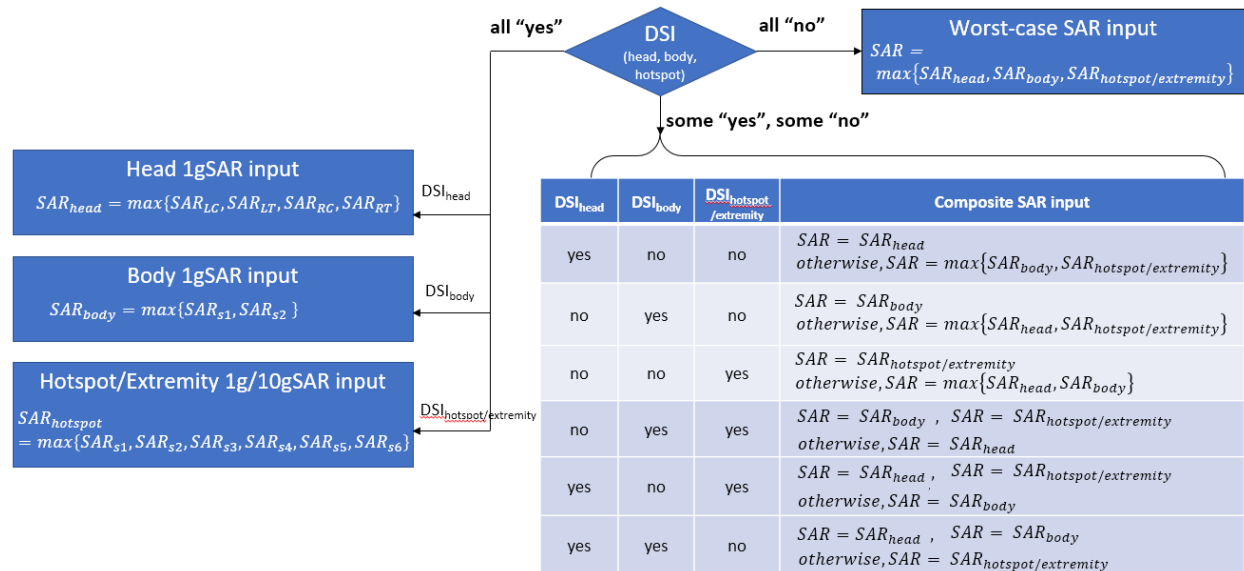


Figure 2-2: Worst-case SAR determination based on DSI

2.2 Usage Scenarios in SAR Evaluation

The EUT has a detection mechanism to distinguish head/body-worn/hotspot exposure, which is represented using DSI = 0 or DSI = 1. These two DSI states were used to determine power limit for Smart Transmit to operate.

The corresponding usage scenarios supported by EUT are summarized in Table 2-1:

Table 2-1: Usage/Exposure Scenario

Scenario	Description	SAR Definition	Worst-case SAR
Head (DSI = 0)	- Device positioned next to head 1g SAR evaluated in four positions (left/right cheek/tilt)	$SAR_{head} = \max\{SAR_{LC}, SAR_{LT}, SAR_{RC}, SAR_{RT}\}$	SAR_{head}
Body worn/Hotspot (DSI = 1)	- Device state is either body worn or Hotspot at 5mm 1g SAR evaluated at all surfaces (S₁-S₆ as shown in Figure 2-1) of the EUT with 5 mm test separation distance relative to the flat phantom for body worn exposure	$SAR_{body_DSI=1} = \max\{SAR_{s1_DSI=1}, SAR_{s2_DSI=1}, SAR_{s3_DSI=1}, SAR_{s4_DSI=1}, SAR_{s5_DSI=1}, SAR_{s6_DSI=1}\}$	$SAR_{body_DSI=1}$

2.3 SAR design target

The total device design related uncertainties of EUT is 1dB (k=2), which includes TxAGC and device to device variation.

To account for the total uncertainty, *SAR_design_target* needs to be:

$$SAR_design_target < SAR_{regulatory_limit} \times 10^{\frac{-total\ uncertainty}{10}}$$

For FCC SAR requirement of 1.6 W/kg for 1g SAR the *SAR_design_target* for EUT is determined as

SAR_design_target = 0.8 W/kg for 1gSAR.

2.4 SAR Char of EUT

Referring to the initial FCC submission, the worst-case *reported* SAR for each antenna/technology/band/DSI is summarized in Table 2-2:

Table 2-2: Worst-case reported SAR (extracted from UL report 13259319-S1)

Tech/Band	Port		Worst-case SAR (W/kg)		P _{limit} Max Tune-up Power (dBm)	
	DSI: 0	DSI: 1	DSI: 0	DSI: 1	DSI: 0	DSI: 1
GSM850	B	A	0.604	0.817	31.00	31.50
GSM1900	D	C	0.975	0.980	24.50	25.50
W-CDMA B2	D	D	0.912	0.968	18.25	19.25
W-CDMA B4	B	B	0.935	0.976	21.00	19.75
W-CDMA B5	B	A	0.711	0.898	23.90	25.70
CDMA BC0	B	A	0.766	0.754	23.90	25.70
CDMA BC1	B	A	0.966	0.977	20.25	17.00
CDMA BC10	B	A	0.773	0.713	23.90	25.70
LTE B5	B	A	0.758	0.837	24.50	25.70
LTE B7	B	B	0.993	0.998	17.00	18.25
LTE B12	B	A	0.653	0.687	23.90	25.70
LTE B13	B	A	0.741	0.754	23.90	25.70
LTE B25/2	D	D	0.926	0.968	18.50	19.25
LTE B26	B	A	0.869	0.782	24.50	25.70
LTE B30	D	C	0.951	0.984	17.50	20.50
LTE B41	B	C	0.988	0.992	19.00	20.00
LTE B48	D	D	0.923	0.998	22.25	19.50
LTE B66	B	D	0.997	0.999	21.00	21.75
FR1 n5	B	A	0.494	0.672	24.50	25.70
FR1 n12	B	A	0.433	0.497	23.90	25.70
FR1 n25/n2	D	A	0.715	0.930	18.50	17.00
FR1 n41	B	C	0.980	0.912	17.00	18.00
FR1 n66	D	D	0.834	0.762	20.00	21.75
FR1 n77	D	A	0.984	0.984	20.50	19.00

Using the reported SAR listed in Table 2-2, and following the procedure described in Section 2.1, the SAR Char of this EUT, i.e., P_{limit} corresponding to SAR_{design_target} , is determined for each supported antenna/technology/band/DSI as:

1. for DSI = 0, P_{limit} is calculated based on 1gSAR head exposure evaluation
2. for DSI = 1, P_{limit} is calculated based on body-worn/hotspot 1gSAR evaluation at 5 mm spacing

$$P_{limit} = \min \{ P_{limit} \text{ corresponding to body worn 1gSAR evaluation at 5mm spacing, } P_{limit} \text{ corresponding to 1g SAR extremity evaluation at 5mm spacing, } P_{max} \text{ maximum RF tuneup power for the case that the SAR test is excluded} \}$$

The SAR Char is listed in Table 2-3.

Table 2-3: SAR Char of EUT

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)		
Antenna	Tech/Band	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average		Burst Average		Burst Average
A	GSM 850 2 slots	38.49	32.50	32.38	31.50	32.50
	GSM 1900 2 slots	39.26	31.00	23.89	23.50	31.00
	W-CDMA B2	31.09	25.70	17.46	17.00	25.70
	W-CDMA B4	32.97	25.70	17.66	17.25	25.70
	W-CDMA B5	32.61	25.70	26.17	25.70	25.70
	CDMA BC0	31.52	25.70	26.93	25.70	25.70
	CDMA BC1	32.28	25.70	17.10	17.00	25.70
	CDMA BC10	31.68	25.70	27.17	25.70	25.70
	LTE Band 5	32.16	25.70	26.47	25.70	25.70
	LTE Band 7	27.60	25.70	19.83	19.75	25.70
	LTE Band 12/17	32.55	25.70	27.33	25.70	25.70
	LTE Band 13	32.67	25.70	26.93	25.70	25.70
	LTE Band 25/2	30.76	25.70	17.26	17.00	25.70
	LTE Band 26	32.02	25.70	26.77	25.70	25.70
	LTE Band 30	26.45	25.70	20.43	20.25	25.70
	LTE Band 41	29.69	25.70	21.89	21.75	25.70
	LTE Band 48	30.14	25.70	22.02	22.00	24.10
	LTE Band 66/4	31.58	25.70	17.61	17.25	25.70
	NR n5	32.91	25.70	27.43	25.70	25.70
	NR n12	34.80	25.70	28.74	25.70	25.70
	NR n25/2	33.42	25.70	17.32	17.00	25.70
	NR n41	34.00	25.70	20.94	19.75	25.70
	NR n66	32.34	25.70	18.87	17.25	25.70
	NR n77	28.66	25.70	19.07	19.00	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)		
Antenna	Tech/Band	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average		Burst Average		Burst Average
B	GSM 850 2 slots	33.19	31.00	34.67	31.00	31.00
	GSM 1900 2 slots	26.75	26.25	26.15	26.00	28.50
	W-CDMA B2	21.08	20.25	20.18	20.00	23.10
	W-CDMA B4	21.29	21.00	19.86	19.75	23.10
	W-CDMA B5	25.38	23.90	26.58	23.90	23.90
	CDMA BC0	25.06	23.90	27.13	23.90	23.90
	CDMA BC1	20.40	20.25	20.58	20.00	23.10
	CDMA BC10	25.02	23.90	27.84	23.90	23.90
	LTE Band 5	25.70	24.50	26.23	24.50	24.50
	LTE Band 7	17.03	17.00	18.26	18.25	22.80
	LTE Band 12/17	25.75	23.90	28.89	23.90	23.90
	LTE Band 13	25.20	23.90	27.27	23.90	23.90
	LTE Band 25/2	20.72	20.25	20.40	20.00	23.10
	LTE Band 26	25.11	24.50	26.85	24.50	24.50
	LTE Band 30	19.00	18.50	20.44	20.00	22.80
	LTE Band 41	19.05	19.00	21.11	21.00	22.80
	LTE Band 48	22.48	21.75	23.26	22.70	22.70
	LTE Band 66/4	21.01	21.00	20.27	20.25	23.10
	NR n5	27.56	24.50	28.21	24.50	24.50
	NR n12	27.54	23.90	30.13	23.90	23.90
	NR n25/2	22.65	20.25	22.57	20.00	23.10
	NR n41	17.09	17.00	20.46	19.00	23.70
	NR n66	22.19	21.00	22.33	20.25	23.10
	NR n77	19.15	19.00	19.65	19.25	22.70

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)		
Antenna	Tech/Band	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	P _{design} (dBm) corresponding to 10 W/kg (SAR _{design_target})	P _{limit} (dBm) Tune-up power table	
	Transmit Average	Burst Average		Burst Average		Burst Average
C	GSM 1900 2 slots	33.78	30.00	25.59	25.50	30.00
	W-CDMA B2	28.09	24.70	19.94	19.50	24.70
	W-CDMA B4	32.16	24.70	20.90	20.25	24.70
	LTE Band 7	25.01	24.70	18.67	18.50	25.00
	LTE Band 25/2	26.90	24.70	20.24	19.50	25.00
	LTE Band 30	25.76	24.70	20.57	20.50	25.00
	LTE Band 41	27.84	24.70	20.04	20.00	25.00
	LTE Band 48	33.73	25.20	22.03	22.00	23.90
	LTE Band 66/4	30.60	24.70	21.08	20.25	25.00
	NR n25/2	27.88	24.70	21.02	19.50	25.00
	NR n41	28.96	25.00	18.40	18.00	25.50
	NR n66	31.44	24.70	23.26	20.25	25.00
	NR n77	34.86	25.20	19.54	19.00	25.50
D	GSM 1900 2 slots	24.61	24.50	26.23	25.50	28.00
	W-CDMA B2	18.65	18.25	19.39	19.25	22.70
	W-CDMA B4	20.33	20.00	22.28	21.75	22.70
	LTE Band 7	17.57	17.50	21.44	21.25	23.00
	LTE Band 25/2	18.83	18.50	19.39	19.25	23.00
	LTE Band 30	17.72	17.50	20.57	20.25	22.50
	LTE Band 41	20.15	20.00	23.09	22.20	22.50
	LTE Band 48	22.60	22.25	19.51	19.50	23.50
	LTE Band 66/4	20.19	20.00	21.75	21.75	23.00
	NR n25/2	19.96	18.50	20.12	19.25	23.00
	NR n41	18.32	18.00	22.72	20.25	23.00
	NR n66	20.79	20.00	22.93	21.75	23.00
	NR n77	20.57	20.50	17.29	17.00	23.50