



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

*For*  
**SMARTPHONE**

**FCC ID: BCG-3540A  
Model Name: A2398**

**Report Number: 13190901-S6V2  
Issue Date: 9/30/2020**

*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	9/25/2020	Initial Issue	--
V2	9/25/2020	Updated Tables 2-2 and 2-3 with the correct SAR and power	Nathan Sousa

## Table of Contents

<b>1 Introduction</b> .....	<b>4</b>
<b>2 SAR Characterization</b> .....	<b>5</b>
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 13190901-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 mmW 5G NR bands. 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 and power density (PD) are characterized for WWAN radios (2G/3G/4G/5G mmW 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 radio and *PD\_design\_target* (< FCC PD limit) for mmW radio. The SAR characterization and PD characterization are denoted as SAR Char and PD Char.

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

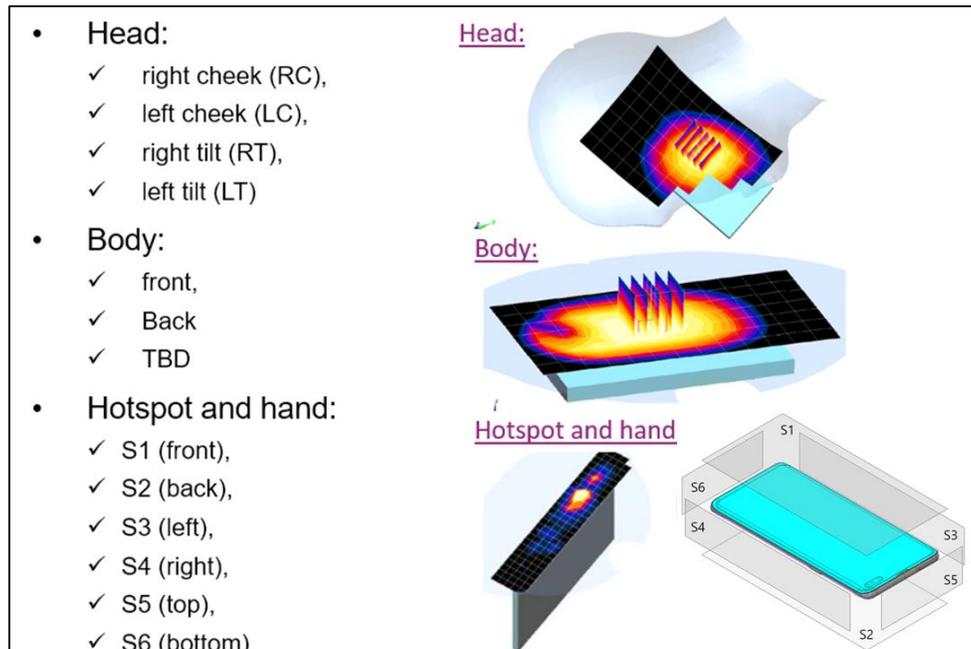
The EUT supports WLAN/BT radio as well but WLAN/BT modem is not enabled with Smart Transmit.

## 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)

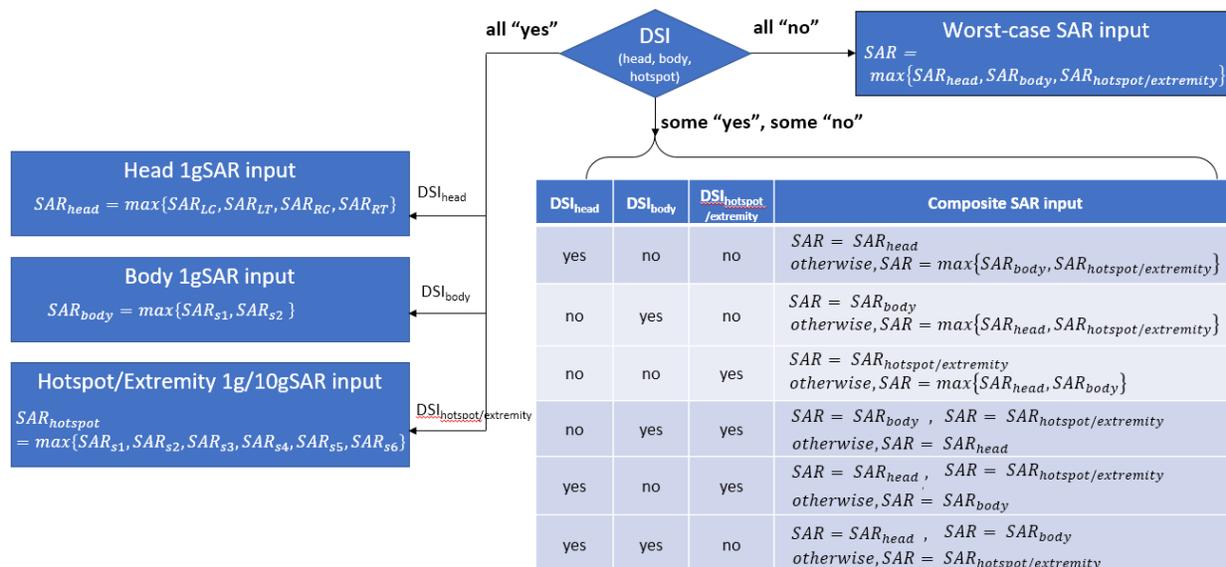


Figure 2-2: Worst-case SAR determination based on DSI

## 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)	<ul style="list-style-type: none"> <li>Device positioned next to head</li> <li>1g SAR evaluated in four positions (left/right cheek/tilt)</li> </ul>	$SAR_{head} = \max\{SAR_{LC}, SAR_{LT}, SAR_{RC}, SAR_{RT}\}$	$SAR_{head}$
Body worn/Hotspot (DSI = 1)	<ul style="list-style-type: none"> <li>Device state is either body worn or Hotspot at 5mm</li> <li>1g SAR evaluated at all surfaces (S<sub>1</sub>-S<sub>6</sub> as shown in Figure 2-1) of the EUT with 5 mm test separation distance relative to the flat phantom for body worn exposure</li> </ul>	$SAR_{body\_DSI=1} = \max\{SAR_{s1\_DSI=1}, SAR_{s2\_DSI=1}, SAR_{s3\_DSI=1}, SAR_{s4\_DSI=1}, SAR_{s5\_DSI=1}, SAR_{s6\_DSI=1}\}$	$SAR_{body\_DSI=1}$

## 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 13190901-S1)**

Tech/Band	Port		Worst-case SAR (W/kg)		P <sub>limit</sub> Max Tune-up Power (dBm)	
	DSI: 0	DSI: 1	DSI: 0	DSI: 1	DSI: 0	DSI: 1
GSM850	B	A	0.741	0.731	31.00	31.50
GSM1900	D	B	0.984	0.990	26.75	25.50
W-CDMA B2	B	C	0.975	0.993	21.50	21.00
W-CDMA B4	D	C	0.995	0.986	20.00	20.75
W-CDMA B5	B	A	0.938	0.794	24.50	25.25
CDMA BC0	B	A	0.923	0.585	24.50	25.25
CDMA BC1	B	A	0.973	0.938	21.50	17.50
CDMA BC10	B	A	0.832	0.647	24.50	25.25
LTE B5	B	A	0.832	0.816	24.50	25.25
LTE B7	B	A	0.996	0.997	19.00	19.00
LTE B12	B	A	0.833	0.536	24.50	25.70
LTE B13	B	A	0.674	0.706	24.50	25.70
LTE B14	B	A	0.477	0.653	24.50	25.70
LTE B25/2	B	D	0.972	0.997	21.50	21.75
LTE B26	B	A	0.880	0.777	24.50	25.25
LTE B30	C	C	0.976	0.995	24.50	20.75
LTE B41	B	A	0.992	0.997	19.75	22.50
LTE B48	B	C	0.983	<b>0.999</b>	20.00	23.00
LTE B66/4	D	B	0.898	0.989	20.00	18.25
LTE B71	B	A	0.741	0.414	24.50	25.70
FR1 n5	B	A	0.653	0.396	24.50	25.25
FR1 n12	B	A	0.419	0.333	24.50	25.70
FR1 n25/n2	D	C	0.749	0.951	20.50	21.25
FR1 n41	B	A	0.760	0.922	17.75	20.50
FR1 n66	D	A	0.840	0.733	20.00	18.50
FR1 n71	B	B	0.375	0.287	24.50	24.50
FR1 n77	A	B	<b>0.999</b>	0.997	25.70	17.00

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		<b><math>P_{max}</math> (dBm) Tune-up power table</b>
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 1.0 W/kg ( $SAR_{design\_target}$ )	$P_{limit}$ (dBm) Tune-up power table	$P_{design}$ (dBm) corresponding to 1.0 W/kg ( $SAR_{design\_target}$ )	$P_{limit}$ (dBm) Tune-up power table	Burst Average
	Transmit Average	Burst Average		Burst Average		
A	GSM 850 2 slots	37.40	32.50	32.86	31.50	32.50
	GSM 1900 2 slots	37.09	31.00	24.02	23.75	31.00
	W-CDMA B2	27.38	25.70	17.84	17.50	25.70
	W-CDMA B4	29.97	25.70	18.57	18.50	25.70
	W-CDMA B5	30.36	25.70	26.25	25.25	25.70
	CDMA BC0	31.84	25.70	27.58	25.25	25.70
	CDMA BC1	28.35	25.70	17.78	17.50	25.70
	CDMA BC10	32.61	25.70	27.14	25.25	25.70
	LTE Band 5	30.85	25.70	26.13	25.25	25.70
	LTE Band 7	26.25	25.25	19.01	19.00	25.70
	LTE Band 12/17	32.91	25.70	28.41	25.70	25.70
	LTE Band 13	32.68	25.70	27.21	25.70	25.70
	LTE Band 14	32.22	25.70	27.55	25.70	25.70
	LTE Band 25/2	30.40	25.70	17.74	17.50	25.70
	LTE Band 26	30.95	25.70	26.35	25.25	25.70
	LTE Band 30	27.77	25.70	22.36	22.25	25.70
	LTE Band 41	26.78	25.70	22.51	22.50	25.70
	LTE Band 48	26.69	25.70	21.51	21.50	22.00
	LTE Band 66/4	29.62	25.70	18.61	18.50	25.70
	LTE Band 71	33.47	25.70	29.53	25.70	25.70
NR n5	32.89	25.70	29.27	25.25	25.70	
NR n12	35.17	25.70	30.48	25.70	25.70	
NR n25/2	31.20	25.70	18.47	17.50	25.70	
NR n41	27.69	25.25	20.85	20.50	24.00	
NR n66	29.86	25.70	19.85	18.50	25.70	
NR n71	36.21	25.70	31.29	25.70	25.70	
NR n77	25.71	25.70	19.78	19.75	25.70	

Exposure Scenario		Head		Body-worn & Hotspot		P <sub>max</sub> (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 <sub>design</sub> (dBm) corresponding to 1.0 W/kg (SAR <sub>design_target</sub> )	P <sub>limit</sub> (dBm) Tune-up power table	P <sub>design</sub> (dBm) corresponding to 1.0 W/kg (SAR <sub>design_target</sub> )	P <sub>limit</sub> (dBm) Tune-up power table	Burst Average
	Transmit Average	Burst Average		Burst Average		
B	GSM 850 2 slots	32.30	31.00	34.70	31.00	31.00
	GSM 1900 2 slots	27.88	27.75	25.55	25.50	28.50
	W-CDMA B2	21.61	21.50	19.58	19.25	23.10
	W-CDMA B4	20.25	20.00	18.47	18.25	23.10
	W-CDMA B5	24.78	24.50	27.34	24.50	24.50
	CDMA BC0	24.85	24.50	27.77	24.50	24.50
	CDMA BC1	21.62	21.50	19.54	19.25	23.10
	CDMA BC10	25.30	24.50	28.54	24.50	24.50
	LTE Band 5	25.30	24.50	28.46	24.50	24.50
	LTE Band 7	19.02	19.00	19.27	19.25	22.80
	LTE Band 12/17	25.29	24.50	28.93	24.50	24.50
	LTE Band 13	26.22	24.50	28.99	24.50	24.50
	LTE Band 14	27.72	24.50	27.80	24.50	24.50
	LTE Band 25/2	21.62	21.50	19.29	19.25	23.10
	LTE Band 26	25.06	24.50	28.10	24.50	24.50
	LTE Band 30	19.00	18.50	19.55	19.50	22.80
	LTE Band 41	19.78	19.75	21.01	21.00	23.70
	LTE Band 48	20.07	20.00	21.52	21.50	22.50
	LTE Band 66/4	20.58	20.00	18.30	18.25	23.10
	LTE Band 71	25.80	24.50	28.60	24.50	24.50
	NR n5	26.35	24.50	28.99	24.50	24.50
	NR n12	28.28	24.50	30.88	24.50	24.50
	NR n25/2	23.84	21.50	20.09	19.25	23.10
NR n41	18.94	17.75	19.73	19.00	26.00	
NR n66	23.15	20.00	19.67	18.25	23.10	
NR n71	28.76	24.50	29.92	24.50	24.50	
NR n77	16.69	16.25	17.01	17.00	22.50	

Exposure Scenario		Head		Body-worn & Hotspot		P <sub>max</sub> (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 <sub>design</sub> (dBm) corresponding to 1.0 W/kg (SAR <sub>design_target</sub> )	P <sub>limit</sub> (dBm) Tune-up power table	P <sub>design</sub> (dBm) corresponding to 1.0 W/kg (SAR <sub>design_target</sub> )	P <sub>limit</sub> (dBm) Tune-up power table	Burst Average
	Transmit Average	Burst Average		Burst Average		
C	GSM 1900 2 slots	32.40	30.00	27.57	27.50	30.00
	W-CDMA B2	25.85	24.70	21.03	21.00	24.70
	W-CDMA B4	26.97	24.70	20.81	20.75	24.70
	LTE Band 7	26.82	24.50	19.05	19.00	25.00
	LTE Band 25/2	25.87	24.70	21.28	21.25	25.00
	LTE Band 30	24.60	24.50	20.77	20.75	25.00
	LTE Band 41	26.34	24.70	21.78	21.75	25.00
	LTE Band 48	29.09	25.70	23.00	23.00	24.60
	LTE Band 66/4	28.20	24.70	21.18	20.75	25.00
	NR n25/2	28.60	24.70	21.47	21.25	25.00
	NR n41	26.99	24.50	21.85	19.75	23.00
	NR n66	30.29	24.70	24.38	20.75	25.00
	NR n77	29.09	25.70	21.11	20.75	26.00
D	GSM 1900 2 slots	26.82	26.75	28.20	28.00	28.00
	W-CDMA B2	20.42	20.25	22.60	22.50	22.70
	W-CDMA B4	20.02	20.00	21.59	21.25	22.70
	LTE Band 7	19.69	19.50	20.33	20.25	22.50
	LTE Band 25/2	20.84	20.50	21.76	21.75	23.00
	LTE Band 30	20.93	20.75	21.44	21.25	22.50
	LTE Band 41	21.29	21.25	22.48	22.20	22.50
	LTE Band 48	20.35	20.25	21.73	21.50	22.80
	LTE Band 66/4	20.47	20.00	21.47	21.25	23.00
	NR n25/2	21.76	20.50	24.28	21.75	23.00
	NR n41	22.27	19.25	23.66	20.25	25.00
	NR n66	20.76	20.00	23.45	21.25	23.00
	NR n77	18.01	18.00	18.53	18.50	22.80