



## PART 2 RF EXPOSURE EVALUATION REPORT

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08/24/2020 - 08/28/2020  
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**FCC ID:** A3LSMN986JPN

**APPLICANT:** SAMSUNG ELECTRONICS CO., LTD.

**DUT Type:** Portable Handset  
**Application Type:** Certification  
**FCC Rule Part(s):** CFR §2.1093  
**Model:** SCG06, SC-53A  
**Device Serial Number:** Pre-Production Sample [SN: TGS0706M]



Note: This revised Test Report (S/N: 1M2006240100-15-R1.A3L) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.



\_\_\_\_\_  
Randy Ortanez  
President





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APPENDIX A: TEST SETUP PHOTOGRAPHS

APPENDIX B: TEST SEQUENCES

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# 1 DEVICE UNDER TEST

## 1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
GSM/GPRS/EDGE 850	Voice/Data	824.20 - 848.80 MHz
GSM/GPRS/EDGE 1900	Voice/Data	1850.20 - 1909.80 MHz
UMTS 850	Voice/Data	826.40 - 846.60 MHz
LTE Band 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 5 (Cell)	Voice/Data	824.7 - 848.3 MHz
LTE Band 4 (AWS)	Voice/Data	1710.7 - 1754.3 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
2.4 GHz WLAN	Voice/Data	2412 - 2472 MHz
U-NII-1	Voice/Data	5180 - 5240 MHz
U-NII-2A	Voice/Data	5260 - 5320 MHz
U-NII-2C	Voice/Data	5500 - 5720 MHz
U-NII-3	Voice/Data	5745 - 5825 MHz
Bluetooth	Data	2402 - 2480 MHz
NFC	Data	13.56 MHz
MST	Data	555 Hz - 8.33 kHz

## 1.2 Time-Averaging Algorithm for RF Exposure Compliance

The device under test (DUT) contains:

- a. Qualcomm® SDX55M modems supporting 2G/3G/4G WWAN technologies



Qualcomm® SDX55M modem is enabled with Qualcomm® Smart Transmit feature. This feature performs time averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements all the time.

The Smart Transmit algorithm maintains the time-averaged transmit power, in turn, time-averaged RF exposure of SAR\_design\_target or PD\_design\_target, below the predefined time-averaged power limit (i.e.,  $P_{limit}$  for sub-6 radio, and input.power.limit for 5G mmW NR), for each characterized technology and band.

Smart Transmit allows the device to transmit at higher power instantaneously, as high as  $P_{max}$ , when needed, but enforces power limiting to maintain time-averaged transmit power to  $P_{limit}$  for frequencies < 6 GHz.

Note that the device uncertainty for sub-6GHz WWAN is 1.0dB for this DUT, and the reserve power margin is 3 dB.

This purpose of the Part 2 report is to demonstrate the DUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Qualcomm® Smart Transmit feature implementation in this device. It serves to compliment the Part 0 and Part 1 Test Reports to justify compliance per FCC.




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### 1.3 Part 2 Test Reduction for Multiple Filings

Per FCC guidance, number of test cases for Part 2 evaluation can be reduced in the case of multiple filings using the same chipset after full part 2 testing on the first filing. While the same chipset and Smart Transmit algorithm are used in this model, DUT with the final SW was tested for power measurements to verify the integration. The essential test cases in power measurement are required to ensure the Smart Transmit performs as expected in the new design, but the RF exposure measurement can be excluded per FCC guidance.

### 1.4 Bibliography

Report Type	Report Serial Number
Part 0 SAR Test Report	1M2006240100-17-R1.A3L
Part 1 SAR Test Report	1M2006240100-01-R1.A3L
RF Exposure Compliance Summary	1M2006240100-18.A3L

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## 2 RF EXPOSURE LIMITS

### 2.1 Uncontrolled Environment

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

### 2.2 Controlled Environment




CONTROLLED ENVIRONMENTS are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

### 2.3 RF Exposure Limits for Frequencies Below 6 GHz

**Table 2-1**  
**SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6**

HUMAN EXPOSURE LIMITS		
	UNCONTROLLED ENVIRONMENT <i>General Population</i> (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT <i>Occupational</i> (W/kg) or (mW/g)
Peak Spatial Average SAR Head	1.6	8.0
Whole Body SAR	0.08	0.4
Peak Spatial Average SAR Hands, Feet, Ankle, Wrists, etc.	4.0	20




1. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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## 2.4 Time Averaging Windows for FCC Compliance

Per October 2018 TCB Workshop Notes, the below time-averaging windows can be used for assessing time-averaged exposures for devices that are capable of actively monitoring and adjusting power output over time to comply with exposure limits.

Interim Guidance	Frequency (GHz)	Maximum Averaging Time (sec)
SAR	< 3	100
	3 – 6	60
MPE	6 - 10	30
	10 - 16	14
	16 – 24	8
	24 – 42	4
	42 – 95	2

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### 3 TIME VARYING TRANSMISSION TEST CASES

To validate the time averaging feature and demonstrate the compliance in Tx varying transmission conditions, the following transmission scenarios are covered in the Part 2 test:

1. During a time-varying Tx power transmission: To prove that the Smart Transmit feature accounts for Tx power variations in time accurately.
2. During a call disconnect and re-establish scenario: To prove that the Smart Transmit feature accounts for history of past Tx power transmissions accurately.
3. During a technology/band handover: To prove that the Smart Transmit feature functions correctly during transitions in technology/band.
4. During a DSI (Device State Index) change: To prove that the Smart Transmit feature functions correctly during transition from one device state (DSI) to another.
5. During an antenna switch: To prove that the Smart Transmit feature functions correctly during transitions in antenna (such as AsDiv scenario) or beams (different antenna array configurations) or beams (different antenna array configurations).
6. During time window switch: To prove that the Smart Transmit feature correctly handles the transition from one time window to another specified by FCC, and maintains the normalized time-averaged RF exposure to be less than normalized FCC limit of 1.0 at all times.
7. SAR exposure switching between two active radios (radio1 and radio2): To prove that the Smart Transmit feature functions correctly and ensures total RF exposure compliance when exposure varies among SAR\_radio1 only, SAR\_radio1 + SAR\_radio2, and SAR\_radio2 only scenarios.

As described in Part 0 report, the RF exposure is proportional to the Tx power for a SAR characterized wireless device. Thus, feature validation in Part 2 can be effectively performed through conducted (for  $f < 6\text{GHz}$ ) power measurement. Therefore, the compliance demonstration under dynamic transmission conditions and feature validation are done in conducted/radiated power measurement setup for transmission scenario 1 through 8.

To add confidence in the feature validation, the time-averaged SAR measurements are also performed but only performed for transmission scenario 1 to avoid the complexity in SAR measurement (such as, for scenario 3 requiring change in SAR probe calibration file to accommodate different bands and/or tissue simulating liquid).




The strategy for testing in Tx varying transmission condition is outlined as follows:

- Demonstrate the total RF exposure averaged over FCC defined time windows does not exceed FCC's SAR limits, through time-averaged power measurements
  - Measure conducted Tx power (for  $f < 6\text{GHz}$ ) versus time.
  - Convert it into RF exposure and divide by respective FCC limits to get normalized exposure versus time.
  - Perform running time-averaging over FCC defined time windows.
  - Demonstrate that the total normalized time-averaged RF exposure is less than 1 for all transmission scenarios (i.e., transmission scenarios 1, 2, 3, 4, 5, 6, 7, and 8) at all times.

Mathematical expression:

For  $< 6\text{ GHz}$  transmission only:

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

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$$\frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^t 1g\_or\_10gSAR(t) dt}{FCC\ SAR\ limit} \leq 1 \quad (1b)$$

For sub-6+mmW transmission:

$$1g\_or\_10gSAR(t) = \frac{conducted\_Tx\_power(t)}{conducted\_Tx\_power\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (2a)$$

where, *conducted\_Tx\_power(t)*, *conducted\_Tx\_power\_P<sub>limit</sub>*, and *1g\_or\_10gSAR\_P<sub>limit</sub>* correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at *P<sub>limit</sub>*, and measured 1gSAR or 10gSAR values at *P<sub>limit</sub>* corresponding to sub-6 transmission. *P<sub>limit</sub>* are the parameters pre-defined in Part 0 and loaded via Embedded File System (EFS) onto the EUT. *T<sub>SAR</sub>* is the FCC defined time window for sub-6 radio; *T<sub>PD</sub>* is the FCC defined time window for mmW radio.

- Demonstrate the total RF exposure averaged over FCC defined time windows does not exceed FCC's SAR limits, through time-averaged SAR measurements. Note as mentioned earlier, this measurement is performed for transmission scenario 1 only.
  - Convert it into RF exposure and divide by respective FCC limits to obtain normalized exposure versus time.
  - Perform time averaging over FCC defined time window.
  - Demonstrate that the total normalized time-averaged RF exposure is less than 1 for transmission scenario 1 at all times.

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This chapter provides the test plan and test procedure for validating Qualcomm Smart Transmit feature for sub-6 transmission. The 100 seconds time window for operating  $f < 3\text{GHz}$  is used as an example to detail the test procedures in this chapter. The same test plan and test procedures described in this chapter apply to 60 seconds time window for operating  $f \geq 3\text{GHz}$ .

#### 4.1 Test sequence determination for validation

Following the FCC recommendation, two test sequences having time-variation in Tx power are predefined for sub-6 ( $f < 6\text{GHz}$ ) validation:

- Test sequence 1: request DUT's Tx power to be at maximum power, measured  $P_{max}^\dagger$ , for 80s, then requesting for half of the maximum power, i.e., measured  $P_{max}/2$ , for the rest of the time.
- Test sequence 2: request DUT's Tx power to vary with time. This sequence is generated relative to measured  $P_{max}$ , measured  $P_{limit}$  and calculated  $P_{reserve}$  (= measured  $P_{limit}$  in dBm - Reserve\_power\_margin in dB) of DUT based on measured  $P_{limit}$ .

The details for generating these two test sequences is described and listed in Appendix E.

NOTE: For test sequence generation, "measured  $P_{limit}$ " and "measured  $P_{max}$ " are used instead of the " $P_{limit}$ " specified in EFS entry and " $P_{max}$ " specified for the device, because the Smart Transmit feature operates against the actual power level of the " $P_{limit}$ " that was calibrated for the DUT. The "measured  $P_{limit}$ " accurately reflects what the feature is referencing to, therefore, it should be used during feature validation testing. The RF tune up and device-to-device variation are already considered in Part 0 report prior to determining  $P_{limit}$ .

#### 4.2 Test configuration selection criteria for validating Smart Transmit feature

For validating the Smart Transmit feature, this section provides the general guidance to select test cases.

##### 4.2.1 Test configuration selection for time-varying Tx power transmission




The Smart Transmit time averaging feature operation is independent of bands, modes, and channels for a given technology. Hence, validation of Smart Transmit in one band/mode/channel per technology is sufficient. Two bands per technology are proposed and selected for this testing to provide high confidence in this validation.

The criteria for the selection are based on the  $P_{limit}$  values determined in Part 0 report. Select two bands\* in each supported technology that correspond to least\*\* and highest\*\*\*  $P_{limit}$  values that are less than  $P_{max}$  for validating Smart Transmit.

\* If one  $P_{limit}$  level applies to all the bands within a technology, then only one band needs to be tested. In this case, within the bands having the same  $P_{limit}$ , the radio configuration (e.g., # of RBs, channel#) and device position that correspond to the highest measured 1gSAR at  $P_{limit}$  shown in Part 1 report is selected.

\*\* In case of multiple bands having the same least  $P_{limit}$  within the technology, then select the band having the highest measured 1gSAR at  $P_{limit}$ .

\*\*\* The band having a higher  $P_{limit}$  needs to be properly selected so that the power limiting enforced by Smart Transmit can be validated using the pre-defined test sequences. If the highest  $P_{limit}$  in a technology is too high where the power limiting enforcement is not needed when testing with the pre-defined test sequences, then the

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next highest level is checked. This process is continued within the technology until the second band for validation testing is determined.

#### 4.2.2 Test configuration selection for change in call

The criteria to select a test configuration for call-drop measurement is:

- Select technology/band with least  $P_{limit}$  among all supported technologies/bands, and select the radio configuration (e.g., # of RBs, channel#) in this technology/band that corresponds to the highest *measured* 1gSAR at  $P_{limit}$  listed in Part 1 report.
- In case of multiple bands having same least  $P_{limit}$ , then select the band having the highest *measured* 1gSAR at  $P_{limit}$  in Part 1 report.

This test is performed with the DUT's Tx power requested to be at maximum power, the above band selection will result in Tx power enforcement (i.e., DUT forced to have Tx power at  $P_{reserve}$ ) for longest duration in one FCC defined time window. The call change (call drop/reestablish) is performed during the Tx power enforcement duration (i.e., during the time when DUT is forced to have Tx power at  $P_{reserve}$ ). One test is sufficient as the feature operation is independent of technology and band.

#### 4.2.3 Test configuration selection for change in technology/band

The selection criteria for this measurement is, for a given antenna, to have DUT switch from a technology/band with lowest  $P_{limit}$  within the technology group (in case of multiple bands having the same  $P_{limit}$ , then select the band with highest *measured* 1gSAR at  $P_{limit}$ ) to a technology/band with highest  $P_{limit}$  within the technology group, in case of multiple bands having the same  $P_{limit}$ , then select the band with lowest *measured* 1gSAR at  $P_{limit}$  in Part 1 report, or vice versa.

This test is performed with the DUT's Tx power requested to be at maximum power, the technology/band switch is performed during Tx power enforcement duration (i.e., during the time when DUT is forced to have Tx power at  $P_{reserve}$ ).

#### 4.2.4 Test configuration selection for change in antenna

The criteria to select a test configuration for antenna switch measurement is:

- Whenever possible and supported by the DUT, first select antenna switch configuration within the same technology/band (i.e., same technology and band combination).
- Then, select any technology/band that supports multiple Tx antennas, and has the highest difference in  $P_{limit}$  among all supported antennas.
- In case of multiple bands having same difference in  $P_{limit}$  among supported antennas, then select the band having the highest *measured* 1gSAR at  $P_{limit}$  in Part 1 report.




This test is performed with the DUT's Tx power requested to be at maximum power in selected technology/band, and antenna change is conducted during Tx power enforcement duration (i.e., during the time when DUT is forced to have Tx power at  $P_{reserve}$ ).

#### 4.2.5 Test configuration selection for change in DSI

The criteria to select a test configuration for DSI change test is

- Select a technology/band having the  $P_{limit} < P_{max}$  within any technology and DSI group, and for the same technology/band having a different  $P_{limit}$  in any other DSI group. Note that the selected DSI transition need to be supported by the device.

This test is performed with the DUT's Tx power requested to be at maximum power in selected technology/band, and DSI change is conducted during Tx power enforcement duration (i.e., during the time when DUT is forced to have Tx power at  $P_{reserve}$ ).

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## 4.2.6 Test configuration selection for change in time window

FCC specifies different time window for time averaging based on operation frequency. The criteria to select a test configuration for validating Smart Transmit feature and demonstrating the compliance during the change in time window is

- Select any technology/band that has operation frequency classified in one time window defined by FCC (such as 100-seconds time window), and its corresponding  $P_{limit}$  is less than  $P_{max}$  if possible.
- Select the 2<sup>nd</sup> technology/band that has operation frequency classified in a different time window defined by FCC (such as 60-seconds time window), and its corresponding  $P_{limit}$  is less than  $P_{max}$  if possible.
- Note it is preferred both  $P_{limit}$  values of two selected technology/band less than corresponding  $P_{max}$ , but if not possible, at least one of technologies/bands has its  $P_{limit}$  less than  $P_{max}$ .

This test is performed with the EUT's Tx power requested to be at maximum power in selected technology/band. Test for one pair of time windows selected is sufficient as the feature operation is the same.

## 4.3 Test procedures for conducted power measurements

This section provides general conducted power measurement procedures to perform compliance test under dynamic transmission scenarios described in Section 3. In practice, an adjustment can be made in these procedures. The justification/clarification may be provided.




### 4.3.1 Time-varying Tx power transmission scenario

This test is performed with the two pre-defined test sequences described in Section 4.1 for all the technologies and bands selected in Section 4.2.1. The purpose of the test is to demonstrate the effectiveness of power limiting enforcement and that the time-averaged SAR (corresponding time-averaged Tx power) does not exceed the FCC limit at all times (see Eq. (1a) and (1b)).

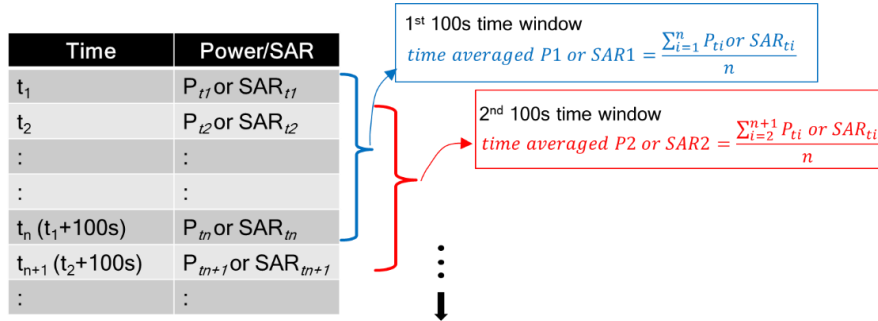
### Test procedure

1. Measure  $P_{max}$ , measure  $P_{limit}$  and calculate  $P_{reserve}$  (= measured  $P_{limit}$  in dBm – *Reserve\_power\_margin* in dB) and follow Section 4.1 to generate the test sequences for all the technologies and bands selected in Section 4.2.1. Both test sequence 1 and test sequence 2 are created based on measured  $P_{max}$  and measured  $P_{limit}$  of the DUT. Test condition to measure  $P_{max}$  and  $P_{limit}$  is:
  - a. Measure  $P_{max}$  with Smart Transmit disabled and callbox set to request maximum power.
  - b. Measure  $P_{limit}$  with Smart Transmit enabled and *Reserve\_power\_margin* set to 0 dB, callbox set to request maximum power.
2. Set *Reserve\_power\_margin* to actual (intended) value (3dB for this DUT based on Part 1 report) and reset power on DUT to enable Smart Transmit, establish radio link in desired radio configuration, with callbox requesting the DUT's Tx power to be at pre-defined test sequence 1, measure and record Tx power versus time, and then convert the conducted Tx power into 1gSAR or 10gSAR value (see Eq. (1a)) using measured  $P_{limit}$  from above Step 1. Perform running time average to determine time-averaged power and 1gSAR or 10gSAR versus time as illustrated in Figure 4-1 where using 100-seconds time window as an example.

Note: In Eq.(1a), instantaneous Tx power is converted into instantaneous 1gSAR or 10gSAR value by applying the measured worst-case 1gSAR or 10gSAR value at  $P_{limit}$  for the corresponding technology/band/antenna/DSI reported in Part 1 report.

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Note: For an easier computation of the running time average, 0 dBm can be added at the beginning of the test sequences the length of the responding time window, for example, add 0dBm for 100-seconds so the running time average can be directly performed starting with the first 100-seconds data using excel spreadsheet. This technique applies to all tests performed in this Part 2 report for easier time-averaged computation using excel spreadsheet.



**Figure 4-1**  
**Running Average Illustration**

3. Make one plot containing:
  - a. Instantaneous Tx power versus time measured in Step 2,
  - b. Requested Tx power used in Step 2 (test sequence 1),
  - c. Computed time-averaged power versus time determined in Step 2,
  - d. Time-averaged power limit (corresponding to FCC SAR limit of 1.6 W/kg for 1gSAR or 4.0W/kg for 10gSAR) given by

$$\text{Time avearged power limit} = \text{meas. } P_{limit} + 10 \times \log\left(\frac{\text{FCC SAR limit}}{\text{meas.SAR\_Plimit}}\right) \quad (5a)$$

where *meas. P<sub>limit</sub>* and *meas. SAR\_Plimit* correspond to measured power at *P<sub>limit</sub>* and measured SAR at *P<sub>limit</sub>*.

4. Make another plot containing:
  - a. Computed time-averaged 1gSAR or 10gSAR versus time determined in Step 2
  - b. FCC 1gSAR<sub>limit</sub> of 1.6W/kg or FCC 10gSAR<sub>limit</sub> of 4.0W/kg.
5. Repeat Steps 2 ~ 4 for pre-defined test sequence 2 and replace the requested Tx power (test sequence 1) in Step 2 with test sequence 2.
6. Repeat Steps 2 ~ 5 for all the selected technologies and bands.
7. The validation criteria are, at all times, the time-averaged power versus time shown in Step 3 plot shall not exceed the time-averaged power limit (defined in Eq. (5a)), in turn, the time-averaged 1gSAR or 10gSAR versus time shown in Step 4 plot shall not exceed the FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR (i.e., Eq. (1b)).

### 4.3.2 Change in call scenario

This test is to demonstrate that Smart Transmit feature accurately accounts for the past Tx powers during time-averaging when a new call is established.

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The call disconnect and re-establishment needs to be performed during power limit enforcement, i.e., when the DUT's Tx power is at  $P_{reserve}$  level, to demonstrate the continuity of RF exposure management and limiting in call change scenario. In other words, the RF exposure averaged over any FCC defined time window (including the time windows containing the call change) doesn't exceed FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

## Test procedure

1. Measure  $P_{limit}$  for the technology/band selected in Section 4.2.2. Measure  $P_{limit}$  with Smart Transmit enabled and *Reserve\_power\_margin* set to 0 dB, callbox set to request maximum power.
2. Set *Reserve\_power\_margin* to actual (intended) value and reset power on DUT to enable Smart Transmit.
3. Establish radio link with callbox in the selected technology/band.
4. Request DUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, followed by requesting DUT's Tx power to be at maximum power for about ~60 seconds, and then drop the call for ~10 seconds. Afterwards, re-establish another call in the same radio configuration (i.e., same technology/band/channel) and continue callbox requesting DUT's Tx power to be at maximum power for the remaining time of at least another full duration of the specified time window. Measure and record Tx power versus time. Once the measurement is done, extract instantaneous Tx power versus time, convert the measured conducted Tx power into 1gSAR or 10gSAR value using Eq. (1a), and then perform the running time average to determine time-averaged power and 1gSAR or 10gSAR versus time.

NOTE: In Eq.(1a), instantaneous Tx power is converted into instantaneous 1gSAR or 10gSAR value by applying the measured worst-case 1gSAR or 10gSAR value at  $P_{limit}$  for the corresponding technology/band/antenna/DSI reported in Part 1 report.

5. Make one plot containing: (a) instantaneous Tx power versus time, (b) requested power, (c) computed time-averaged power, (d) time-averaged power limit calculated using Eq.(5a).
6. Make another plot containing: (a) computed time-averaged 1gSAR or 10gSAR versus time, and (b) FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

The validation criteria are, at all times, the time-averaged power versus time shall not exceed the time-averaged power limit (defined in Eq.(5a)), in turn, the time-averaged 1gSAR or 10gSAR versus time shall not exceed the FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR (i.e., Eq. (1b)).




### 4.3.3 Change in technology and band

This test is to demonstrate the correct power control by Smart Transmit during technology switches and/or band handovers.

Similar to the change in call test in Section 4.3.2, to validate the continuity of RF exposure limiting during the transition, the technology and band handover needs to be performed when DUT's Tx power is at  $P_{reserve}$  level (i.e., during Tx power enforcement) to make sure that the DUT's Tx power from previous  $P_{reserve}$  level to the new  $P_{reserve}$  level (corresponding to new technology/band). Since the  $P_{limit}$  could vary with technology and band, Eq. (1a) can be written as follows to convert the instantaneous Tx power in 1gSAR or 10gSAR exposure for the two given radios, respectively:

$$1g\_or\_10gSAR_1(t) = \frac{conducted\_Tx\_power\_1(t)}{conducted\_Tx\_power\_P_{limit\_1}} * 1g\_or\_10gSAR\_P_{limit\_1} \quad (6a)$$

$$1g\_or\_10gSAR_2(t) = \frac{conducted\_Tx\_power\_2(t)}{conducted\_Tx\_power\_P_{limit\_2}} * 1g\_or\_10gSAR\_P_{limit\_2} \quad (6b)$$

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$$\frac{1}{T_{SAR}} \left[ \int_{t-T_{SAR}}^{t_1} \frac{1g\_or\_10gSAR_1(t)}{FCC\ SAR\ limit} dt + \int_{t-T_{SAR}}^t \frac{1g\_or\_10gSAR_2(t)}{FCC\ SAR\ limit} dt \right] \leq 1 \quad (6c)$$

where, *conducted\_Tx\_power\_1(t)*, *conducted\_Tx\_power\_Plimit\_1*, and *1g\_or\_10gSAR\_Plimit\_1* correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at  $P_{limit}$ , and measured 1gSAR or 10gSAR value at  $P_{limit}$  of technology1/band1; *conducted\_Tx\_power\_2(t)*, *conducted\_Tx\_power\_Plimit\_2(t)*, and *1g\_or\_10gSAR\_Plimit\_2* correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at  $P_{limit}$ , and measured 1gSAR or 10gSAR value at  $P_{limit}$  of technology2/band2. Transition from technology1/band1 to the technology2/band2 happens at time-instant ' $t_1$ '.

## Test procedure

1. Measure  $P_{limit}$  for both the technologies and bands selected in Section 4.2.3. Measure  $P_{limit}$  with Smart Transmit enabled and *Reserve\_power\_margin* set to 0 dB, callbox set to request maximum power.
2. Set *Reserve\_power\_margin* to actual (intended) value and reset power on DUT to enable Smart Transmit
3. Establish radio link with callbox in first technology/band selected.
4. Request DUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, followed by requesting DUT's Tx power to be at maximum power for about ~60 seconds, and then switch to second technology/band selected. Continue with callbox requesting DUT's Tx power to be at maximum power for the remaining time of at least another full duration of the specified time window. Measure and record Tx power versus time for the full duration of the test.
5. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1gSAR or 10gSAR value using Eq. (6a) and (6b) and corresponding measured  $P_{limit}$  values from Step 1 of this section. Perform the running time average to determine time-averaged power and 1gSAR or 10gSAR versus time.

**NOTE:** In Eq.(6a) & (6b), instantaneous Tx power is converted into instantaneous 1gSAR or 10gSAR value by applying the measured worst-case 1gSAR or 10gSAR value at  $P_{limit}$  for the corresponding technology/band/antenna/DSI reported in Part 1 report.




6. Make one plot containing: (a) instantaneous Tx power versus time, (b) requested power, (c) computed time-averaged power, (d) time-averaged power limit calculated using Eq.(5a).
7. Make another plot containing: (a) computed time-averaged 1gSAR or 10gSAR versus time, and (b) FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

The validation criteria are, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed the FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR (i.e., Eq. (6c)).

### 4.3.4 Change in antenna

This test is to demonstrate the correct power control by Smart Transmit during antenna switches from one antenna to another. The test procedure is identical to Section 4.3.3, by replacing technology/band switch operation with antenna switch. The validation criteria are, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

**NOTE:** If the DUT does not support antenna switch within the same technology/band, but has multiple antennas to support different frequency bands, then the antenna switch test is included as part of change in technology and band (Section 4.3.3) test.

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### 4.3.5 Change in DSI

This test is to demonstrate the correct power control by Smart Transmit during DSI switches from one DSI to another. The test procedure is identical to Section 4.3.3, by replacing technology/band switch operation with DSI switch. The validation criteria are, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

### 4.3.6 Change in time window

This test is to demonstrate the correct power control by Smart Transmit during the change in averaging time window when a specific band handover occurs. FCC specifies time-averaging windows of 100s for Tx frequency < 3GHz, and 60s for Tx frequency between 3GHz and 6GHz.

To validate the continuity of RF exposure limiting during the transition, the band handover test needs to be performed when EUT handovers from operation band less than 3GHz to greater than 3GHz and vice versa. The equations (3a) and (3b) in Section 2 can be written as follows for transmission scenario having change in time window,

$$1gSAR_1(t) = \frac{\text{conducted\_Tx\_power\_1}(t)}{\text{conducted\_Tx\_power\_P}_{limit\_1}} * 1g\_or\ 10g\_SAR\_P_{limit\_1} \quad (7a)$$

$$1gSAR_2(t) = \frac{\text{conducted\_Tx\_power\_2}(t)}{\text{conducted\_Tx\_power\_P}_{limit\_2}} * 1g\_or\ 10g\_SAR\_P_{limit\_2} \quad (7b)$$

$$\frac{1}{T_{1SAR}} \left[ \int_{t-T_{1SAR}}^{t_1} \frac{1g\_or\ 10g\_SAR_1(t)}{FCC\ SAR\ limit} dt \right] + \frac{1}{T_{2SAR}} \left[ \int_{t-T_{2SAR}}^t \frac{1g\_or\ 10g\_SAR_2(t)}{FCC\ SAR\ limit} dt \right] \leq 1 \quad (7c)$$




where, *conducted\_Tx\_power\_1(t)*, *conducted\_Tx\_power\_P<sub>limit\_1</sub>(t)*, and *1g\_ or 10g\_SAR\_P<sub>limit\_1</sub>* correspond to the instantaneous Tx power, conducted Tx power at *P<sub>limit</sub>*, and compliance *1g\_ or 10g\_SAR* values at *P<sub>limit\_1</sub>* of band1 with time-averaging window '*T<sub>1SAR</sub>*'; *conducted\_Tx\_power\_2(t)*, *conducted\_Tx\_power\_P<sub>limit\_2</sub>(t)*, and *1g\_ or 10g\_SAR\_P<sub>limit\_2</sub>* correspond to the instantaneous Tx power, conducted Tx power at *P<sub>limit</sub>*, and compliance *1g\_ or 10g\_SAR* values at *P<sub>limit\_2</sub>* of band2 with time-averaging window '*T<sub>2SAR</sub>*'. One of the two bands is less than 3GHz, another is greater than 3GHz. Transition from first band with time-averaging window '*T<sub>1SAR</sub>*' to the second band with time-averaging window '*T<sub>2SAR</sub>*' happens at time-instant '*t<sub>1</sub>*'.

### Test procedure

1. Measure *P<sub>limit</sub>* for both the technologies and bands selected in Section 4.2.6. Measure *P<sub>limit</sub>* with Smart Transmit enabled and *Reserve\_power\_margin* set to 0 dB, callbox set to request maximum power.
2. Set *Reserve\_power\_margin* to actual (intended) value and enable Smart Transmit

### Transition from 100s time window to 60s time window, and vice versa

3. Establish radio link with callbox in the technology/band having 100s time window selected in Section 4.2.6.
4. Request EUT's Tx power to be at 0 dBm for at least 100 seconds, followed by requesting EUT's Tx power to be at maximum power for about ~140 seconds, and then switch to second technology/band (having 60s time window) selected in Section 4.2.6. Continue with callbox requesting EUT's Tx power to be at maximum power for about ~60s in this second technology/band, and then switch back to the first technology/band. Continue with callbox requesting EUT's Tx power to be at maximum power for at least another 100s. Measure and record Tx power versus time for the entire duration of the test.
5. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1gSAR or 10gSAR value (see Eq. (7a) and (7b)) using corresponding technology/band Step 1 result, and then perform 100s running average to determine time-averaged 1gSAR or 10gSAR versus time. Note that in Eq.(7a) & (7b), instantaneous Tx power is converted into

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instantaneous 1gSAR or 10gSAR value by applying the worst-case 1gSAR or 10gSAR value tested in Part 1 for the selected technologies/bands at  $P_{limit}$ .

6. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 4.
7. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 5, (b) computed time-averaged 1gSAR versus time determined in Step 5, and (c) corresponding regulatory  $1gSAR_{limit}$  of 1.6W/kg or  $10gSAR_{limit}$  of 4.0W/kg.

### Transition from 60s time window to 100s time window, and vice versa

8. Establish radio link with callbox in the technology/band having 60s time window selected in Section 4.2.6.
9. Request EUT's Tx power to be at 0 dBm for at least 60 seconds, followed by requesting EUT's Tx power to be at maximum power for about ~80 seconds, and then switch to second technology/band (having 100s time window) selected in Section 4.2.6. Continue with callbox requesting EUT's Tx power to be at maximum power for about ~100s in this second technology/band, and then switch back to the first technology/band. Continue with callbox requesting EUT's Tx power to be at maximum power for the remaining time for a total test time of 500 seconds. Measure and record Tx power versus time for the entire duration of the test.
10. Repeat above Step 5~7 to generate the plots

The validation criteria is, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed the regulatory  $1gSAR_{limit}$  of 1.6W/kg or  $10gSAR_{limit}$  of 4.0W/kg.

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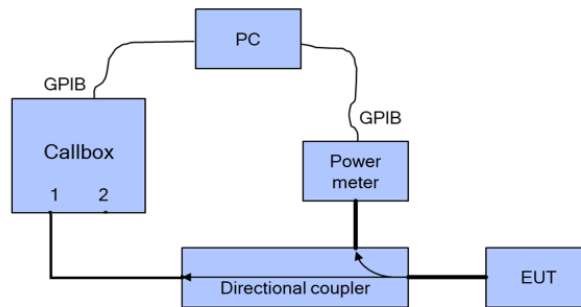


5.1 Conducted Measurement Test setup

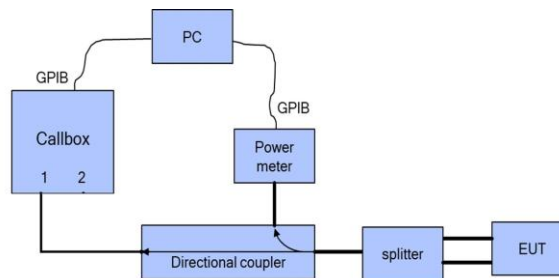
Legacy Test Setup

The Rohde & Schwarz CMW500 callbox was used in this test. The test setup schematic is shown in Figure 5-1a (Appendix A – Test Setup Photo 1) for measurements with a single antenna of DUT, and in Figure 5-2b (Appendix A – Test Setup Photo 2) for measurements involving antenna switch. For single antenna measurement, one port (RF1 COM) of the callbox is connected to the RF port of the DUT using a directional coupler. For technology/band switch measurement, one port (RF1 COM) of the callbox used for signaling two different technologies is connected to a combiner, which is in turn connected to a directional coupler. The other end of the directional coupler is connected to a splitter to connect to two RF ports of the DUT corresponding to the two antennas of interest. In the setups, power meter is used to tap the directional coupler for measuring the conducted output power of the DUT. For all legacy conducted tests, only RF1 COM port of the callbox is used to communicate with the DUT.

All the path losses from RF port of DUT to the callbox RF COM port and to the power meter are calibrated and automatically entered as offsets in the callbox and the power meter via test scripts on the PC used to control callbox and power meter.



(a) Appendix A – Test Setup Photo 1



(b) Appendix A – Test Setup Photo 2

Figure 5-1

Conducted power measurement setup

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Both the callbox and power meter are connected to the PC using GPIB cables. Two test scripts are custom made for automation, and the test duration set in the test scripts is 500 seconds.

For time-varying Tx power measurement, the PC runs the 1<sup>st</sup> test script to send GPIB commands to control the callbox's requested power versus time, while at the same time to record the conducted power measured at DUT RF port using the power meter. The commands sent to the callbox to request power are:

- 0dBm for 100 seconds
- test sequence 1 or test sequence 2 (defined in Section 4.1 and generated in Section 4.2.1), for 360 seconds
- stay at the last power level of test sequence 1 or test sequence 2 for the remaining time.

Power meter readings are periodically recorded every 100ms. A running average of this measured Tx power over 100 seconds is performed in the post-data processing to determine the 100s-time averaged power.

For call drop, technology/band/antenna switch, and DSI switch tests, after the call is established, the callbox is set to request the DUT's Tx power at 0dBm for 100 seconds while simultaneously starting the 2<sup>nd</sup> test script runs at the same time to start recording the Tx power measured at DUT RF port using the power meter. After the initial 100 seconds since starting the Tx power recording, the callbox is set to request maximum power from the DUT for the rest of the test. Note that the call drop/re-establish, or technology/band/antenna switch or DSI switch is manually performed when the Tx power of DUT is at  $P_{reserve}$  level. See Section 4.3 for detailed test procedure of call drop test, technology/band/antenna switch test and DSI switch test.

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### 6.1 WWAN (sub-6) transmission

The  $P_{limit}$  values, corresponding to 1.0 W/kg (1gSAR) and 2.5 W/kg (10gSAR) of  $SAR_{design\_target}$ , for technologies and bands supported by DUT are derived in Part 0 report and summarized in Table 6-1. Note all  $P_{limit}$  power levels entered in Table 6-1 correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes.

**Table 6-1**  
 **$P_{limit}$  for supported technologies and bands ( $P_{limit}$  in EFS file)**




Exposure Scenario:	Body-Worn	Phablet	Phablet	Head	Hotspot	Earjack	Maximum Tune-up Output Power*
Averaging Volume:	1g	10g	10g	1g	1g	10g	
Spacing:	15 mm	10, 6, 13	0 mm	0 mm	10 mm	0 mm	
DSI:	0	0	1	2	3	4	
Technology/Band	P <sub>limit</sub> corresponding to 1mW/g ( $SAR_{design\_target}$ )						P <sub>max</sub>
GSM/GPRS/EDGE 850 MHz	29.2		26.3	33.0	26.3	26.3	24.8
GSM/GPRS/EDGE 1900 MHz	26.9		18.9	33.3	18.9	18.9	21.8
UMTS B5	30.1		26.7	32.0	26.7	26.7	24.0
LTE FDD B12	28.7		26.8	35.8	27.5	26.8	23.0
LTE FDD B13	29.4		27.3	32.5	27.3	27.3	23.0
LTE FDD B5	27.8		24.6	32.4	24.6	24.6	23.0
LTE FDD B4	26.8		18.5	33.9	18.5	18.5	22.5
LTE TDD B41	26.6		19.8	34.2	19.8	19.8	22.0

\* Maximum tune up target power,  $P_{max}$ , is configured in NV settings in DUT to limit maximum transmitting power. This power is converted into peak power in NV settings for TDD schemes. The DUT maximum allowed output power is equal to  $P_{max} + 1$  dB device uncertainty.

Based on selection criteria described in Section 4.2.1, the selected technologies/bands for testing time-varying test sequences are highlighted in yellow in Table 6-1. Per the manufacturer, the  $Reserve\_power\_margin$  (dB) is set to 3dB in EFS and is used in Part 2 test.

The radio configurations used in Part 2 test for selected technologies, bands, DSIs and antennas are listed in Table 6-2. The corresponding worst-case radio configuration 1gSAR or 10gSAR values for selected technology/band/DSI are extracted from Part 1 report and are listed in the last column of Table 6-2.

Based on equations (1a), (2a), (3a) and (4a), it is clear that Part 2 testing outcome is normalized quantity, which implies that it can be applied to any radio configuration within a selected technology/band/DSI. Thus, as long as applying the worst-case SAR obtained from the worst radio configuration in Part 1 testing to calculate time-varying SAR exposure in equations (1a), (2a), (3a) and (4a), the accuracy in compliance demonstration remains the same. Therefore, there may be some differences between the radio configuration selected for Part 2 testing and the radio configuration associated with worst-case SAR obtained in the Part 1 evaluation.

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**Table 6-2**  
**Radio configurations selected for Part 2 test**




Test Case #	Test Scenario	Tech	Band	Antenna	DSI	Channel	Frequency [MHz]	RB/RB Offset/Bandwidth (MHz)	Mode	SAR Exposure Scenario	Part 1 Worst Case Measured SAR at P <sub>limit</sub> (W/kg)
1	Test Sequence 1	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	bottom edge, 10 mm	0.579
	20175					1732.5	1/50/20 MHz BW	QPSK			
2	Test Sequence 1	GSM	1900	A	3	661	1880	-	GPRS, 4 Tx	bottom edge, 10 mm	0.779
	661					1880	-	GPRS, 4 Tx			
3	Change in Call	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	bottom edge, 10 mm	0.579
4	Tech/Band Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	bottom edge, 10 mm	0.579
		GSM	1900	A	3	661	1880	-	GPRS, 4 Tx	bottom edge, 10 mm	0.779
5	DSI Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	bottom edge, 10 mm	0.579
					2	20175	1732.5	1/50/20 MHz BW	QPSK	Head, Right Cheek	0.072
6	Antenna Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	bottom edge, 10 mm	0.579
			B41	B	3	40620	2593	1/0/20 MHz BW	QPSK	bottom edge, 10 mm	1.040

**Table 6-3**  
**DSI and Corresponding Exposure Scenarios**

Scenario	Description	SAR Test Cases
Head (DSI = 2)	<ul style="list-style-type: none"> <li>Device positioned next to head</li> <li>Receiver Active</li> </ul>	Head SAR per KDB Publication 648474 D04
Hotspot mode (DSI = 3)	<ul style="list-style-type: none"> <li>Device transmits in hotspot mode near body</li> <li>Hotspot Mode Active</li> </ul>	Hotspot SAR per KDB Publication 941225 D06
Phablet Grip (DSI=1 or 4)	<ul style="list-style-type: none"> <li>Device is held with hand and grip sensor is triggered</li> <li>Grip sensor triggered or earjack is active</li> </ul>	Phablet SAR per KDB Publication 648474 D04 & KDB Publication 616217 D04
Phablet (DSI = 0)	<ul style="list-style-type: none"> <li>Device is held with hand and grip sensor is not triggered</li> <li>Distance grip sensor not triggered</li> </ul>	Phablet SAR per KDB Publication 648474 D04 & KDB Publication 616217 D04
Body-worn (DSI = 0)	<ul style="list-style-type: none"> <li>Device being used with a body-worn accessory</li> </ul>	Body-worn SAR per KDB Publication 648474 D04

Based on the selection criteria described in Section 4.2, the radio configurations for the Tx varying transmission test cases listed in Section 3 are:

- Technologies and bands for time-varying Tx power transmission: The test case 1-2 listed in Table 6-2 are selected to test with the test sequences defined in Section 4.1 in both time-varying conducted power measurement and time-varying SAR measurement.
- Technology and band for change in call test: LTE Band 4, having the lowest  $P_{limit}$  among all technologies and bands (test case 3 in Table 6-2), is selected for performing the call drop test in conducted power setup.
- Technologies and bands for change in technology/band test: Following the guidelines in Section 4.2.3, test case 4 in Table 6-2 is selected for handover test from a technology/band within one technology group (LTE Band 4, DSI=3, antenna A), to a technology/band in the same DSI within another technology group (GSM 1900, DSI=3, antenna A) in conducted power setup.
- Technologies and bands for change in DSI: Based on selection criteria in Section 4.2.5, for a given technology and band, test case 5 in Table 6-2 is selected for DSI switch test by establishing a call in LTE Band 4 in DSI=3, and then handing over to DSI = 2 exposure scenario in conducted power setup.

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5. Technologies and bands for antenna switch: Based on selection criteria in Section 4.2.6, for a given DSI=3, test case 6 in Table 6-2 is selected for antenna switch between antenna A (LTE Band 4) and antenna B (LTE Band 41) in conducted power setup.

## 6.2 $P_{limit}$ and $P_{max}$ measurement results




The measured  $P_{limit}$  for all the selected radio configurations given in Table 6-2 are listed in below Table 6-4.  $P_{max}$  was also measured for radio configurations selected for testing time-varying Tx power transmission scenarios in order to generate test sequences following the test procedures in Section 4.1.

**Table 6-4**  
**Measured  $P_{limit}$  and  $P_{max}$  of selected radio configurations**

Test Case #	Test Scenario	Tech	Band	Antenna	DSI	Channel	Frequency [MHz]	RB/RB Offset/Bandwidth (MHz)	Mode	SAR Exposure Scenario	EFS P <sub>limit</sub> [dBm]	Tune-up P <sub>max</sub> [dBm]	Measured P <sub>limit</sub> [dBm]	Measured P <sub>max</sub> [dBm]
1	Test Sequence 1	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	Hotspot	18.50	22.50	17.89	23.17
	20175					1732.5	1/50/20 MHz BW	QPSK	18.50		22.50	17.89	23.17	
2	Test Sequence 1	GSM	1900	A	3	661	1880	-	GPRS, 4 Tx	Hotspot	18.90	20.80	18.44	20.88
	661					1880	-	GPRS, 4 Tx	18.90		20.80	18.44	20.88	
3	Change in Call	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	Hotspot	18.50	22.50	17.89	23.17
4	Tech/Band Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	Hotspot	18.50	22.50	17.89	23.17
		GSM	1900	A	3	661	1880	-	GPRS, 4 Tx	Hotspot	18.90	20.80	18.44	20.88
5	DSI Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	Hotspot	18.50	22.50	17.89	23.17
						2	20175	1732.5	1/50/20 MHz BW	QPSK	Head	33.90	22.50	23.17
6	Antenna Switch	LTE	B4	A	3	20175	1732.5	1/50/20 MHz BW	QPSK	Hotspot	18.50	22.50	17.89	23.17
			B41	B	3	40620	2593	1/0/20 MHz BW	QPSK	Hotspot	19.80	22.00	19.58	21.71

Note: The device uncertainty of  $P_{max}$  is +/- 1 dB as provided by manufacturer.

Note: The above  $P_{max}$  value for GSM1900 is GPRS for 4 Tx Slots

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# 7 CONDUCTED TX CASES (FREQ < 6 GHZ)

## 7.1 Time-varying Tx Power Case

The measurement setup is shown in Figure 5-1. The purpose of the time-varying Tx power measurement is to demonstrate the effectiveness of power limiting enforcement and that the time-averaged Tx power when represented in time-averaged 1gSAR or 10gSAR values does not exceed FCC limit as shown in Eq. (1a) and (1b), rewritten below:

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




$$\frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^t 1g\_or\_10gSAR(t) dt}{FCC\ SAR\ limit} \leq 1 \quad (1b)$$

where, *conducted\_Tx\_power(t)*, *conducted\_Tx\_power\_P<sub>limit</sub>*, and *1g\_or\_10gSAR\_P<sub>limit</sub>* correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at *P<sub>limit</sub>*, and measured 1gSAR and 10gSAR values at *P<sub>limit</sub>* reported in Part 1 test (listed in Table 6-2 of this report as well).

Following the test procedure in Section 4.3, the conducted Tx power measurement for all selected configurations are reported in this section. In all the conducted Tx power plots, the dotted line represents the requested power by callbox (test sequence 1 or test sequence 2), the blue curve represents the instantaneous conducted Tx power measured using power meter, the green curve represents time-averaged power and red line represents the conducted power limit that corresponds to FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

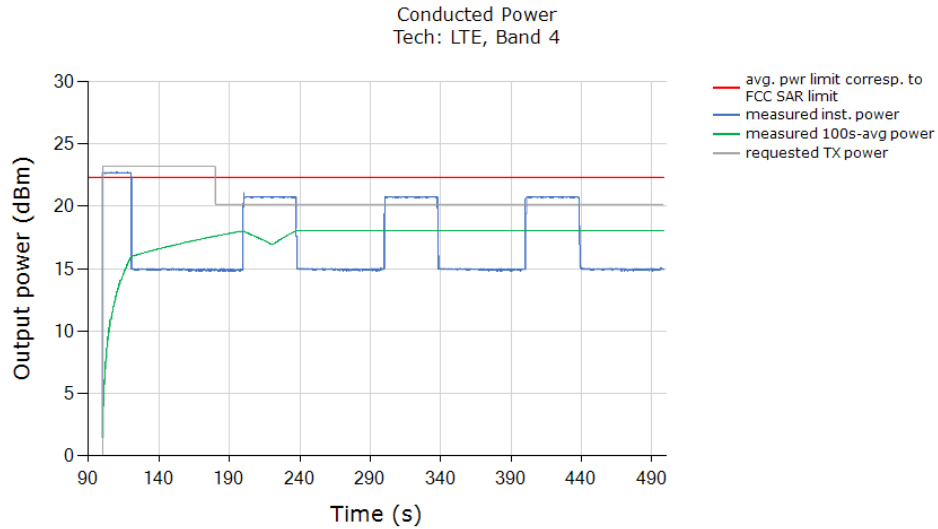
Similarly, in all the 1g or 10gSAR plots (when converted using Eq. (1a)), the green curve represents the 100s/60s-time averaged 1gSAR or 10gSAR value calculated based on instantaneous 1gSAR or 10gSAR; and the red line limit represents the FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

Time-varying Tx power measurements were conducted on test cases #1 ~ #2 in Table 6-2, by generating test sequence 1 and test sequence 2 given in APPENDIX B: using measured *P<sub>limit</sub>* and measured *P<sub>max</sub>* (last two columns of Table 6-4) for each of these test cases. Measurement results for test cases #1 ~ #2 are given in Sections 7.1.1-7.1.2.

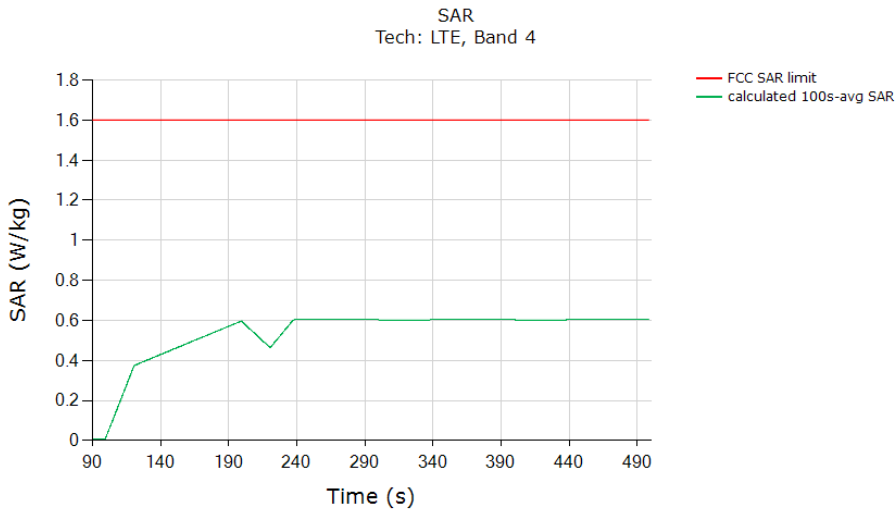
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## 7.1.1 LTE Band 4



Test result for test sequence 1:



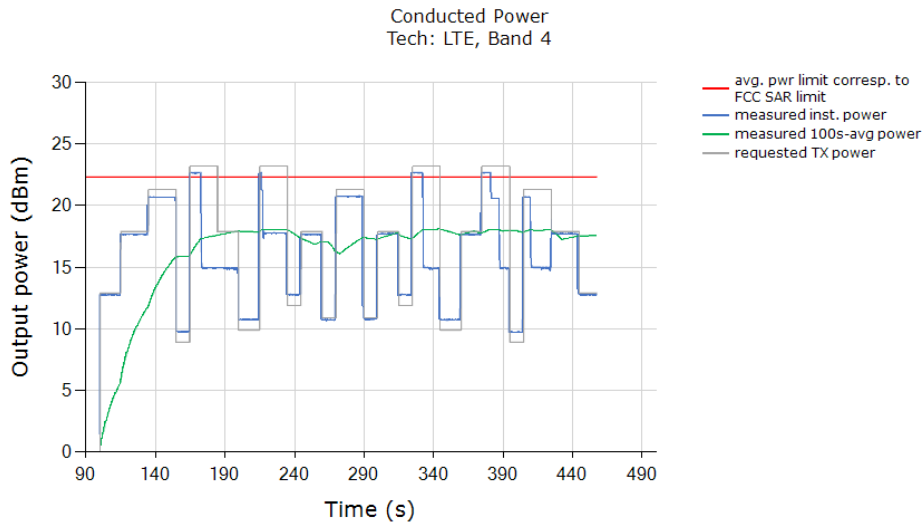
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



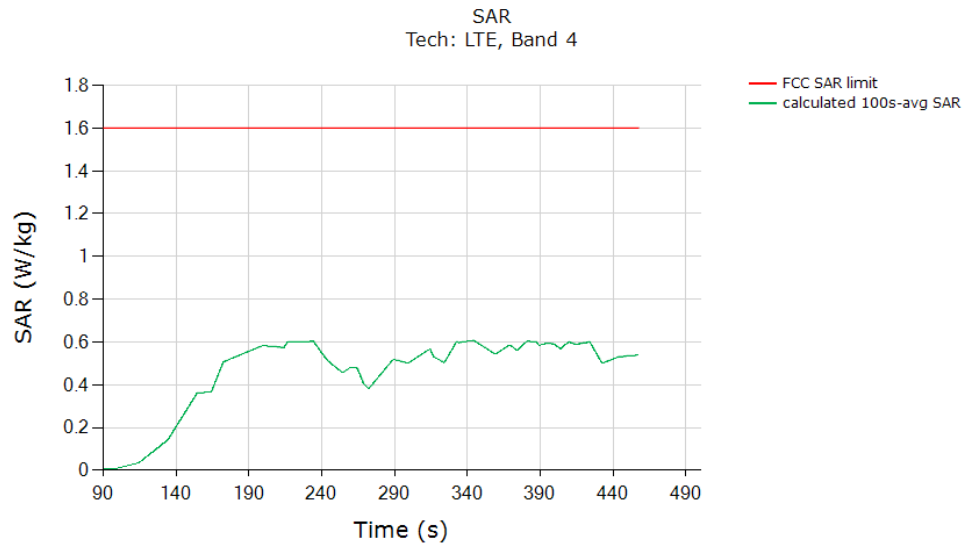
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.604
<b>Validated:</b> Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at $P_{limit}$ (last column in Table 6-2).	

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Test result for test sequence 2:



Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.607
<b>Validated:</b> Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at $P_{limit}$ (last column in Table 6-2).	

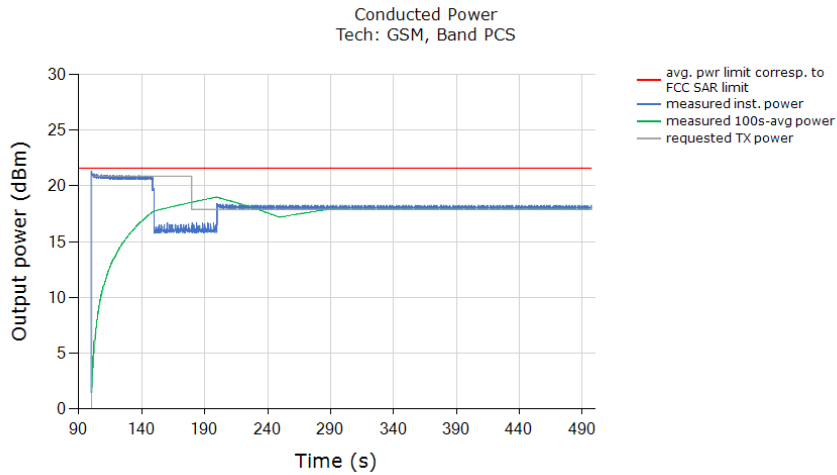
FCC ID: A3LSMN986JPN	<b>PART 2 RF EXPOSURE EVALUATION REPORT</b>		Approved by: Quality Manager
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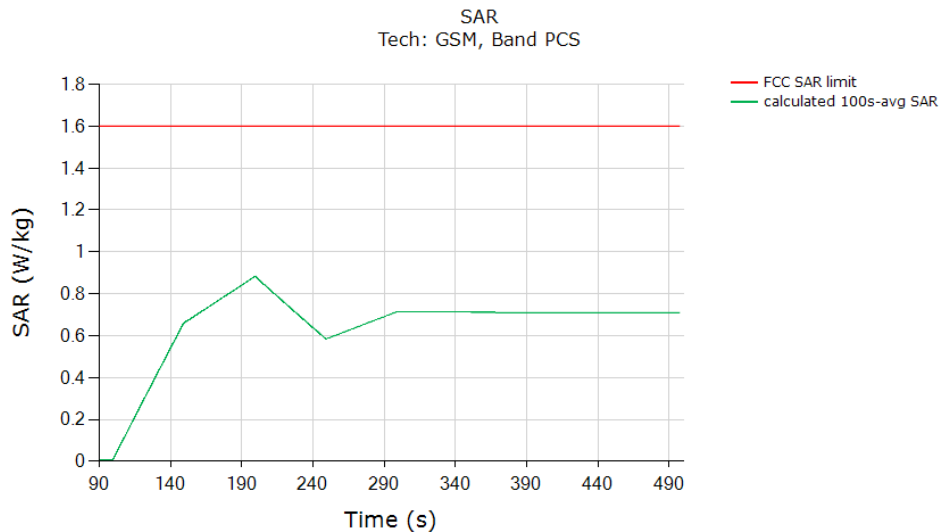
7.1.2

GSM/GPRS/EDGE 1900

Test result for test sequence 1:



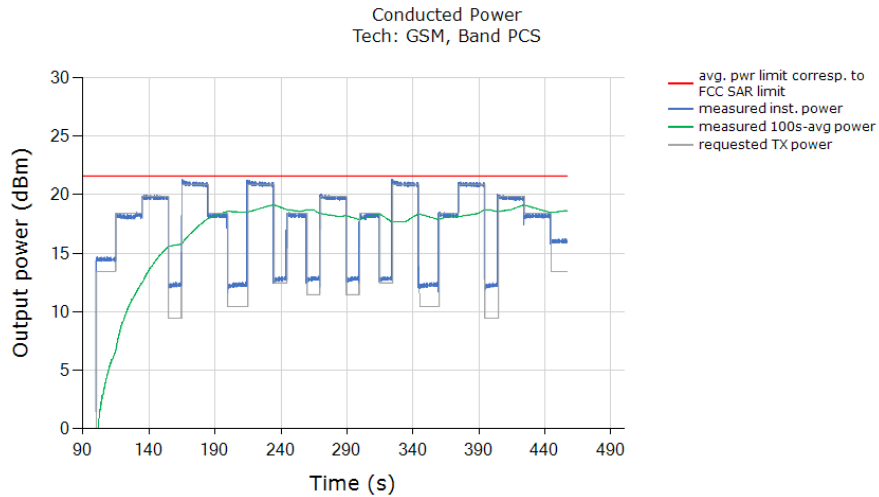
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



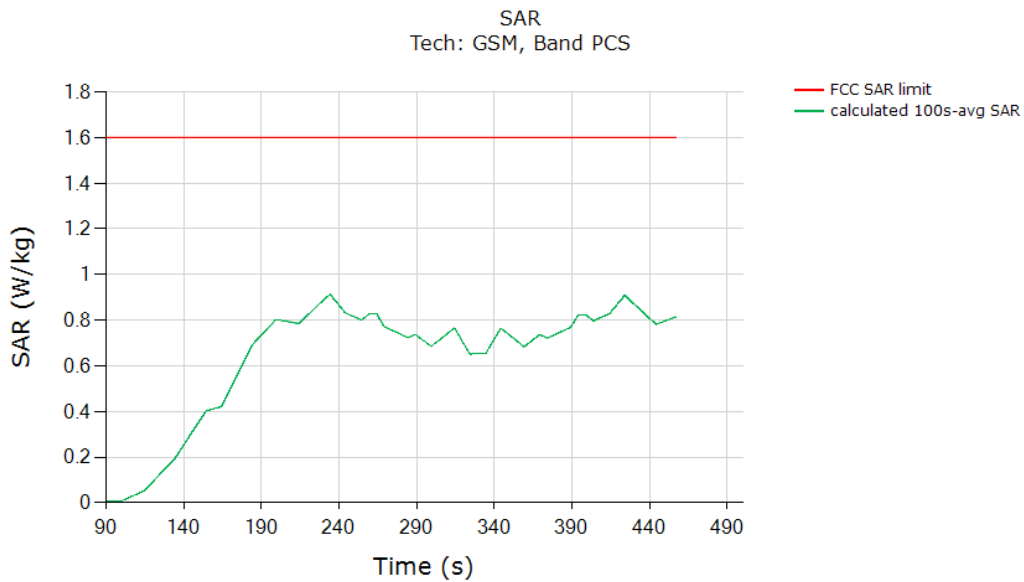
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.883
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at $P_{limit}$ (last column in Table 6-2).	

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Test result for test sequence 2:



Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.913
<b>Validated:</b> Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at $P_{limit}$ (last column in Table 6-2).	

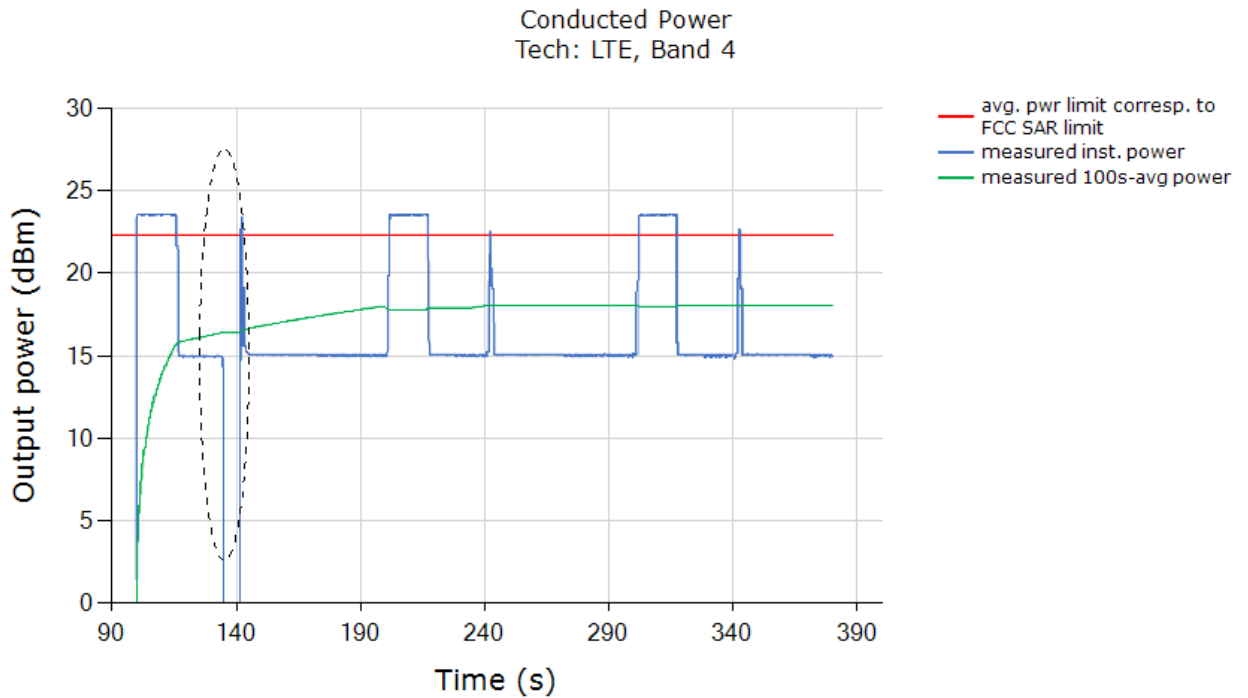
FCC ID: A3LSMN986JPN	<b>PCTEST</b> Proud to be part of <b>element</b>	<b>PART 2 RF EXPOSURE EVALUATION REPORT</b>		<b>Approved by:</b> Quality Manager
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## 7.2 Call Drop Test Case

This test was measured LTE Band 4, Antenna A, DSI=3, and with callbox requesting maximum power. The call drop was manually performed when the DUT is transmitting at  $P_{reserve}$  level as shown in the plot below (dotted black region). The measurement setup is shown in Figure 5-1. The detailed test procedure is described in Section 4.3.2.

### Call drop test result:

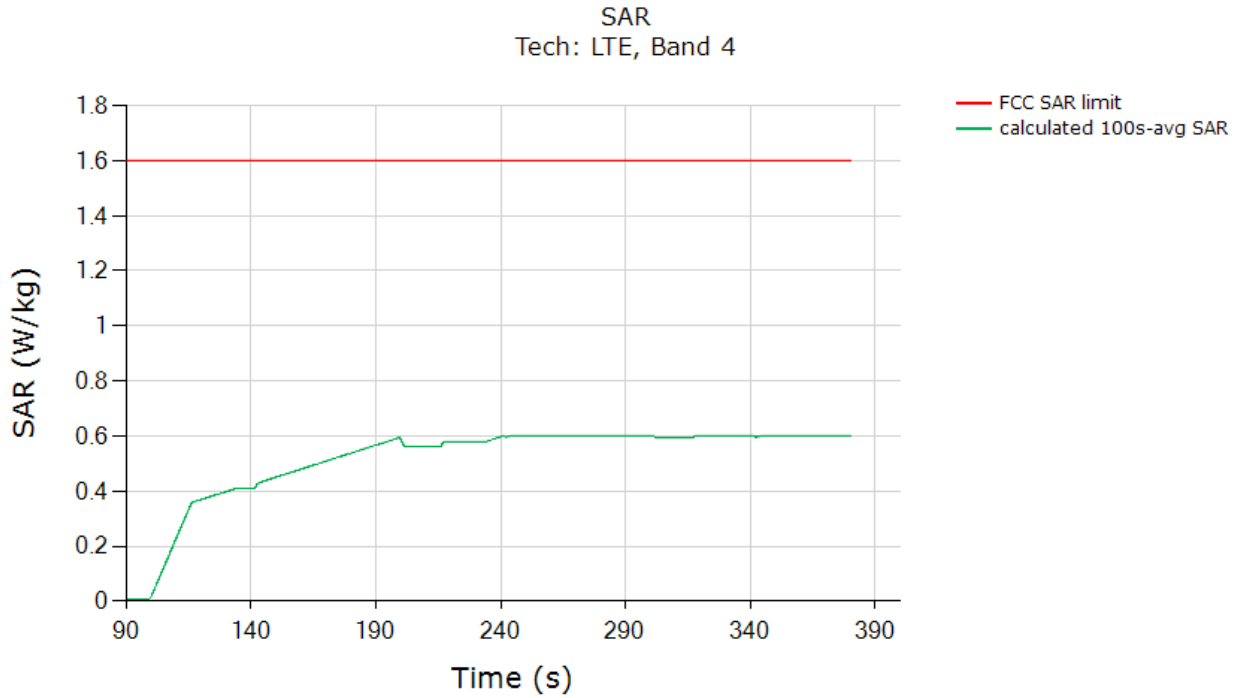
Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power kept the same  $P_{reserve}$  level of LTE Band 4 after the call was re-established:



Plot Notes: The power level after the change in call kept the same  $P_{reserve}$  level of LTE Band 4. The conducted power plot shows expected Tx transition.

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Plot 2: Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.600
Validated	

The test result validated the continuity of power limiting in call change scenario.

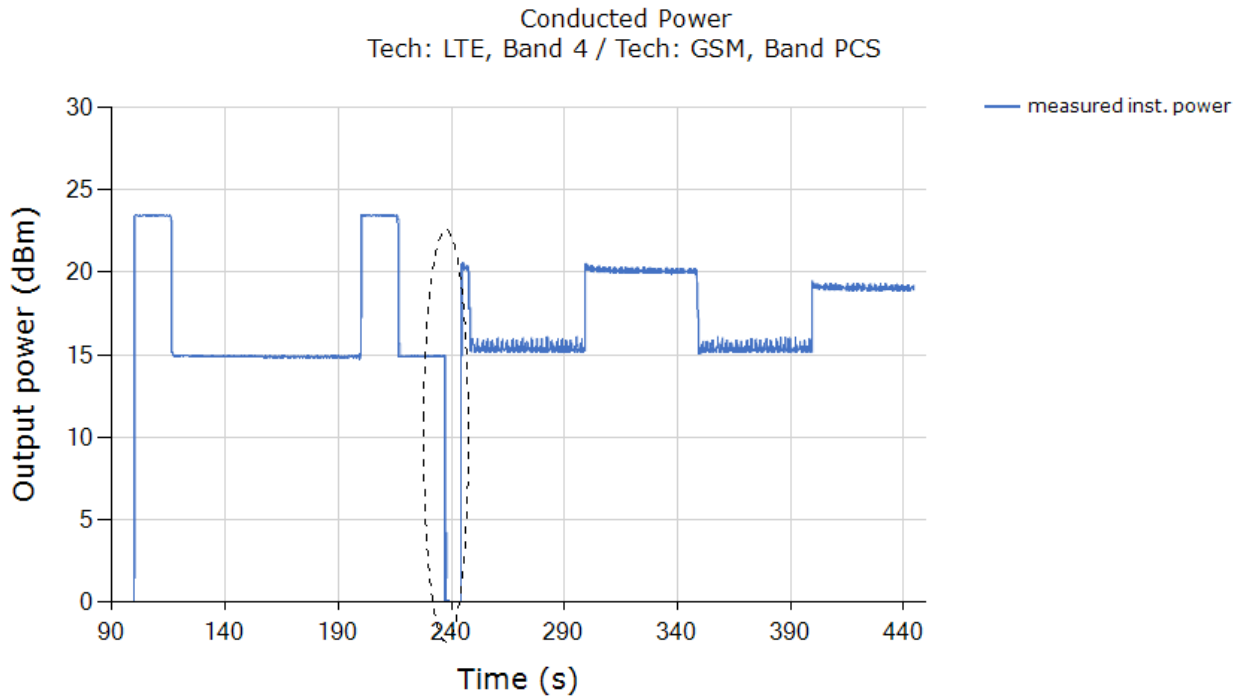
FCC ID: A3LSMN986JPN	<b>PCTEST</b> Proud to be part of <b>element</b>	<b>PART 2 RF EXPOSURE EVALUATION REPORT</b>		<b>Approved by:</b> Quality Manager
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### 7.3 Change in Technology/Band Test Case




This test was conducted with callbox requesting maximum power, and with a technology switch from LTE Band 4, Antenna A, DSI = 3 to GSM 1900, Antenna A, DSI = 3. Following procedure detailed in Section 4.3.3, and using the measurement setup shown in Figure 5-1, the technology/band switch was performed when the DUT is transmitting at  $P_{reserve}$  level as shown in the plot below (dotted black region).

Test result for change in technology/band:

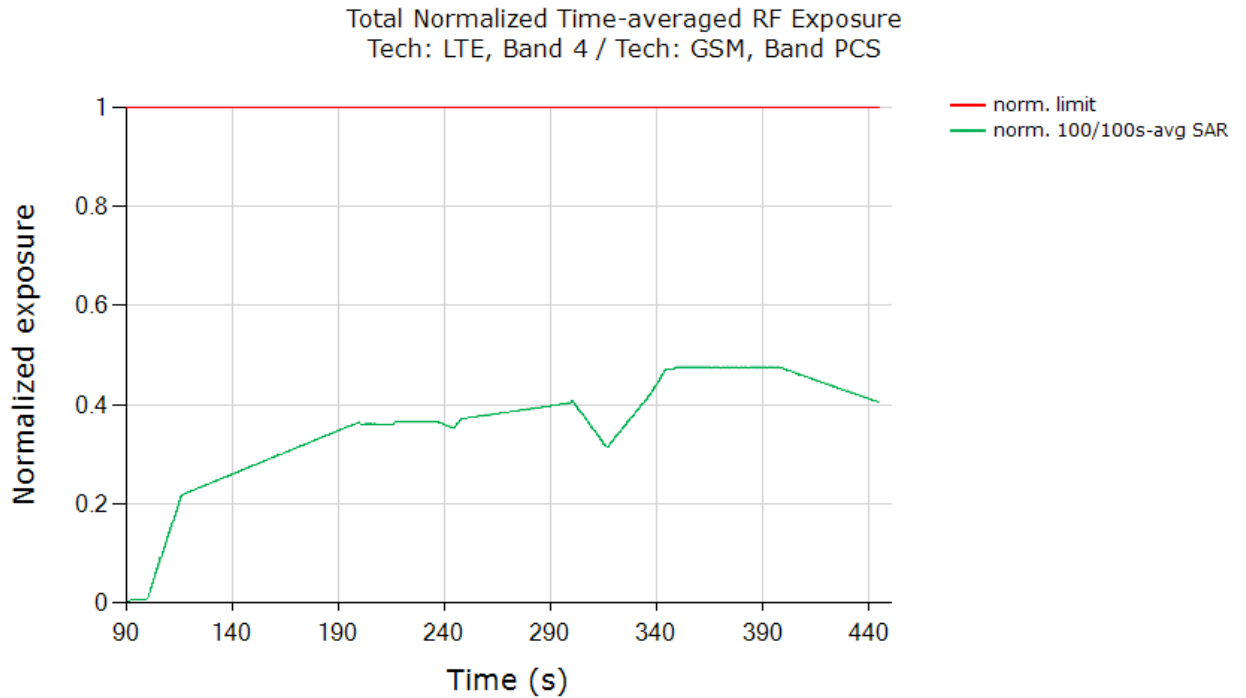
Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed from LTE Band 4, Antenna A, DSI = 3  $P_{reserve}$  level to GSM 1900, Antenna 1, DSI = 3  $P_{reserve}$  level (within 1 dB device uncertainty):



Note: As per the manufacturer,  $Reserve\_power\_margin = 3\text{ dB}$ . Based on Table 6-4,  $EFS\ Plimit = 18.5\text{dBm}$  for LTE B4 (DSI=3), and  $EFS\ Plimit = 18.90\text{dBm}$  for GSM 1900 (DSI=3), it can be seen from above plot that the difference in  $Preserve (= Plimit - 3\text{dB } Reserve\_power\_margin)$  power level corresponds to the expected difference in  $Plimit$  levels of 0.4dB (within 1dB of sub6 radio design related uncertainty). Therefore, the conducted power plot shows expected transition in Tx power.

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Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (6a), (6b) and (6c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the normalized FCC limit of 1.0:



	(W/kg)
FCC normalized SAR limit	1.0
Max 100s-time averaged normalized SAR (green curve)	0.475
Validated	

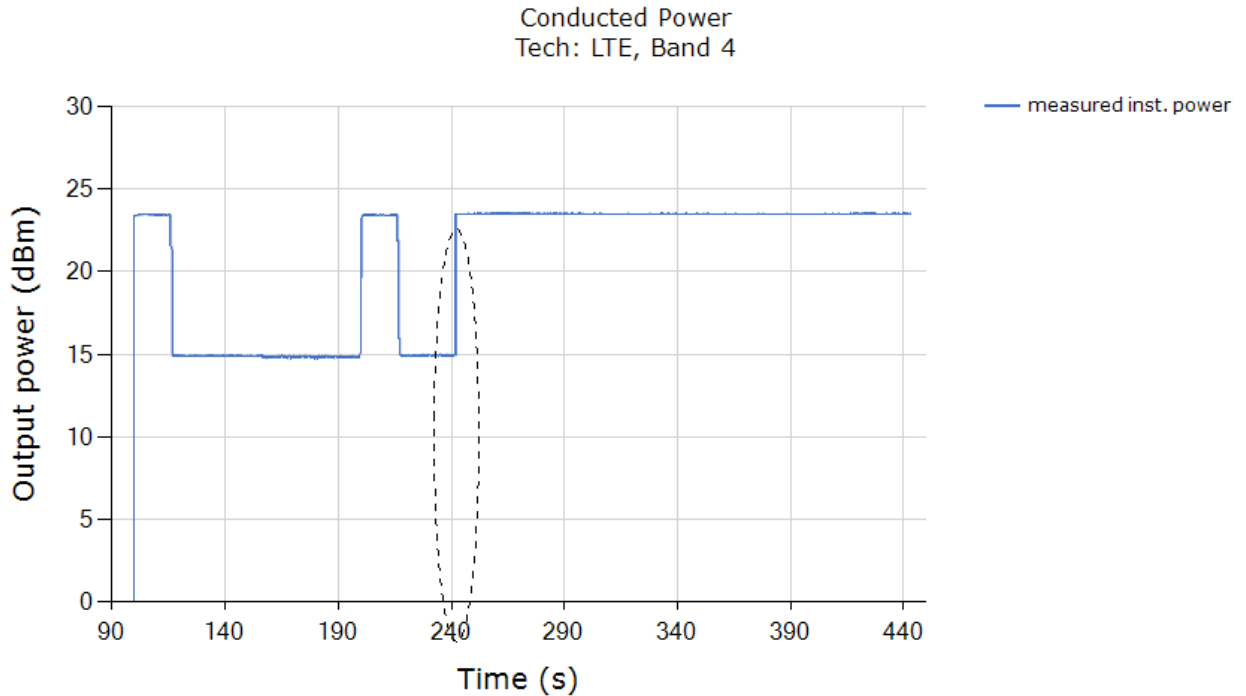
The test result validated the continuity of power limiting in technology/band switch scenario.

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## 7.4 DSI Switch Test Case

This test was conducted with callbox requesting maximum power, and with DSI switch from LTE Band 4 DSI = 3 (hotspot) to DSI = 2 (Head). Following procedure detailed in Section 4.3.5 using the measurement setup shown in Figure 6-1, the DSI switch was performed when the DUT is transmitting at  $P_{reserve}$  level as shown in the plot below (dotted black circle).

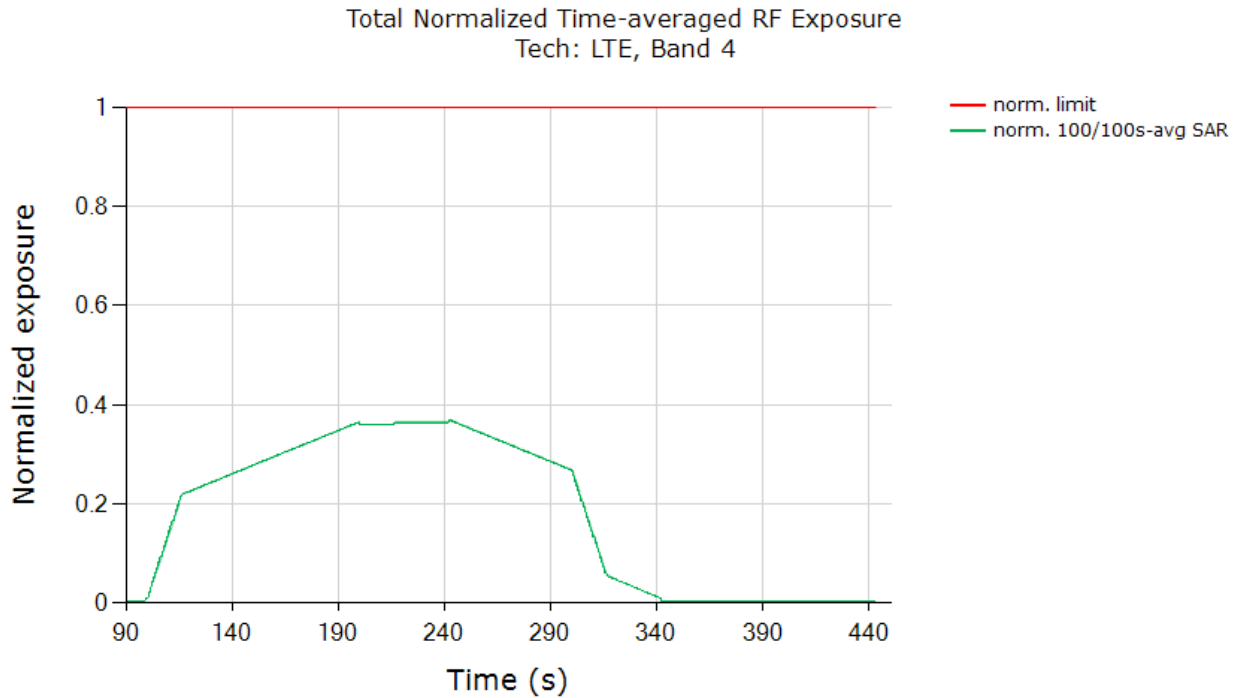
Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when DSI = 3 switches to DSI = 2:



Note: As per the manufacturer, Reserve\_power\_margin = 3dB. Based on Table 6-1, EFS Plimit = 18.5dBm for LTE Band 4 hotspot DSI = 3, and EFS Plimit = 33.9dBm (Pmax = 22.5) for Head state DSI = 2. The difference in Preserve (= Plimit – 3dB Reserve\_power\_margin) level corresponds to the expected different in Plimit levels (within 1dB of sub6 radio design related uncertainty). Therefore, the conducted power plot shows expected transition in Tx power.

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Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (6a), (6b) and (6c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit.



	(W/kg)
FCC normalized total exposure limit	1.0
Max 100s-time averaged normalized SAR (green curve)	0.369
Validated	

The test result validated the continuity of power limiting in DSI switch scenario.

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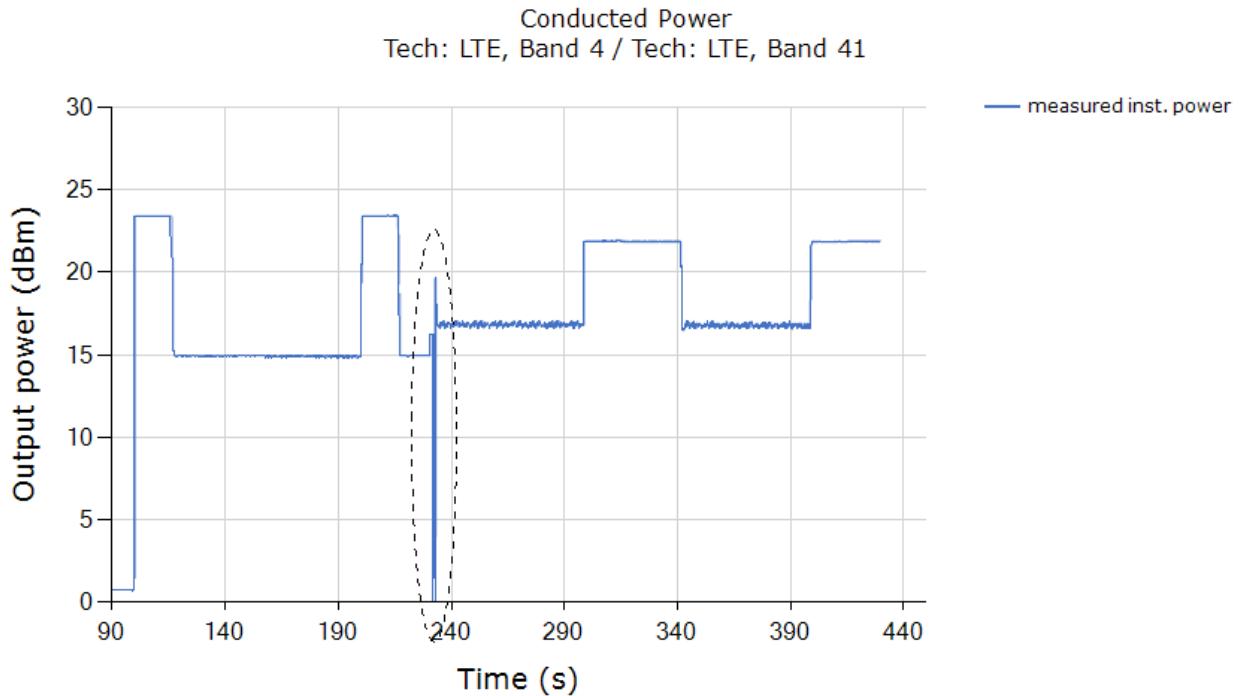


## 7.5 Change in Time window / antenna switch test results

This test was conducted with callbox requesting maximum power, and with antenna switch between LTE Band 4, Antenna A, DSI = 3 (antenna A) and LTE B41, Antenna B, DSI = 3 (antenna B). Following procedure detailed in Section 4.3.4, and using the measurement setup shown in Figure 5-1, the technology/band switch was performed when the EUT is transmitting at  $P_{reserve}$  level as shown in the plot below (dotted black region).

Test result for antenna switch (from LTE Band 4 to LTE Band 41):

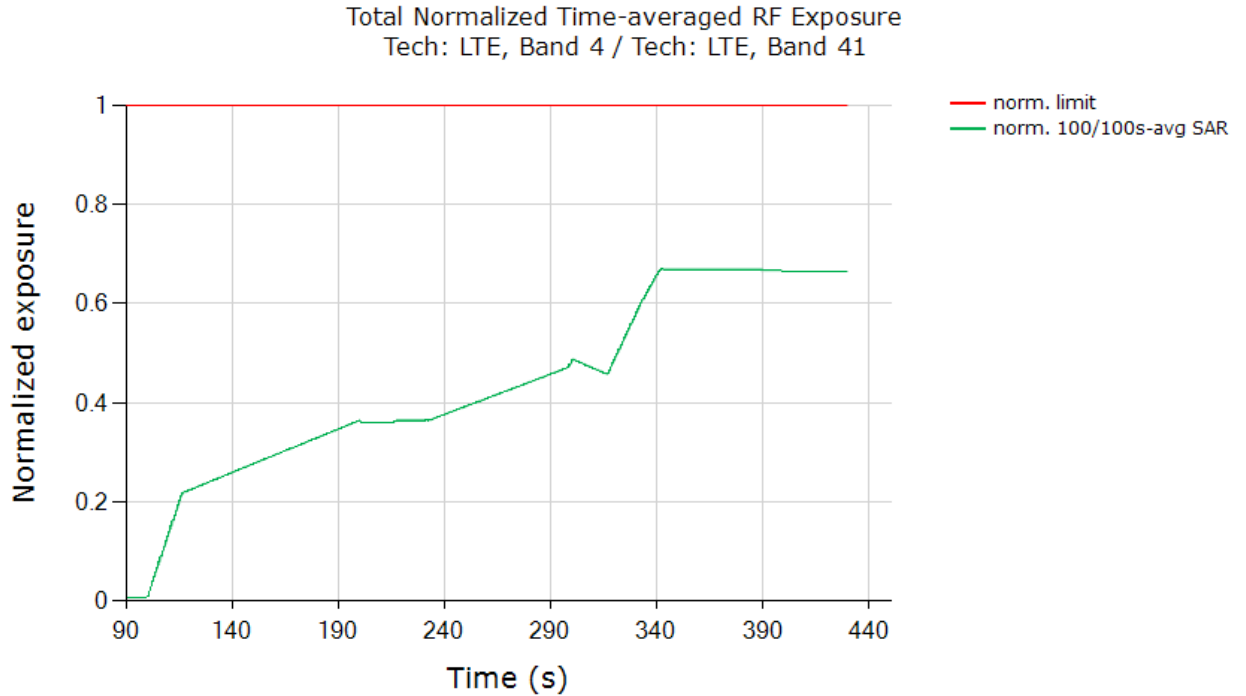
Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when LTE Band 4, Antenna A, DSI=3  $P_{reserve}$  level switches to LTE Band 41, Antenna B, DSI=3  $P_{reserve}$  level (within 1 dB device uncertainty):



Plot Note: As per Part 1 report, Reserve\_power\_margin = 3dB. Based on Table 6-1, EFS Plimit = 18.5 dBm for LTE B4 (DSI=3), and 19.8 dBm for LTE B41 (DSI=3), it can be seen from above plot that the difference in Preserve (= Plimit – 3dB Reserve\_power\_margin) power level corresponds to the expected difference in Plimit levels of 1.3 dB (within 1dB of sub6 radio design related uncertainty). Therefore, the conducted power plot shows expected transition in Tx power.

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Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (6a), (6b) and (6c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the normalized FCC limit of 1.0:



	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.670
Validated	

Plot Notes: Maximum power is requested by callbox for the entire duration of the test, with tech/band switches from antenna switch at ~230s time stamp. Smart Transmit controls the Tx power during this antenna switch to ensure total time-averaged RF exposure given by equation (7c), is always compliant. In antenna switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized SAR<sub>design target</sub> + 1dB device uncertainty. In this test, with a maximum normalized SAR of 0.67 being  $\leq 0.79 (= 1.0/1.6 + 1\text{dB device uncertainty})$ , the above test result validated the continuity of power limiting in antenna switch scenario.

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## 8

## EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Mini Circuits	ZA2PD2-63-S+	Power Splitter	CBT	N/A	CBT	SUU64901930
MlniCircuits	NLP-1200+	Low Pass Filter	N/A	N/A	N/A	VUU78201318
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	5/16/2019	Annual	11/16/2020	01492
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	5/16/2019	Annual	11/16/2020	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
Rohde & Schwarz	CMW500	Radio Communication Tester	3/27/2020	Annual	3/27/2021	128633
Rohde & Schwarz	NRP85	3-Path Dipole Power Sensor	6/1/2019	Annual	12/1/2020	108168
Rohde & Schwarz	NRP85	3-Path Dipole Power Sensor	6/1/2019	Annual	12/1/2020	108523
Rohde & Schwarz	NRP85	3-Path Dipole Power Sensor	6/10/2020	Annual	6/10/2021	109322
Rohde & Schwarz	NRP50S	3-Path Dipole Power Sensor	6/1/2019	Annual	12/1/2020	101164

## 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.

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### 9.1 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]



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## 10 REFERENCES

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