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PART 2 RF EXPOSURE EVALUATION REPORT

Applicant Name:
Apple, Inc.
One Apple Park Way
Cupertino, CA 95014

Date of Testing:
07/08/21 - 07/26/21
Test Site/Location:
PCTEST Lab, Morgan Hill, CA, USA
Document Serial No.:
1C2106080049-29.BCG (Rev 1)

FCC ID:	**BCGA2568**
APPLICANT:	**APPLE, INC.**

DUT Type:	Tablet Device
Application Type:	Certification
FCC Rule Part(s):	CFR §2.1093
Model:	A2568, A2569
Device Serial Numbers:	07PNQ, V9W3N, X0DNF, C30D1

Note: This revised Test Report 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

ACCREDITED
CERT #2041.02

T A B L E   O F   C O N T E N T S

1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
UMTS 850	Data	826.40 - 846.60 MHz
UMTS 1750	Data	1712.4 - 1752.6 MHz
UMTS 1900	Data	1852.4 - 1907.6 MHz
LTE Band 71	Data	665.5 - 695.5 MHz
LTE Band 12	Data	699.7 - 715.3 MHz
LTE Band 17	Data	706.5 - 713.5 MHz
LTE Band 13	Data	779.5 - 784.5 MHz
LTE Band 14	Data	790.5 - 795.5 MHz
LTE Band 26 (Cell)	Data	814.7 - 848.3 MHz
LTE Band 5 (Cell)	Data	824.7 - 848.3 MHz
LTE Band 4 (AWS)	Data	1710.7 - 1754.3 MHz
LTE Band 66 (AWS)	Data	1710.7 - 1779.3 MHz
LTE Band 2 (PCS)	Data	1850.7 - 1909.3 MHz
LTE Band 25 (PCS)	Data	1850.7 - 1914.3 MHz
LTE Band 30	Data	2307.5 - 2312.5 MHz
LTE Band 7	Data	2502.5 - 2567.5 MHz
LTE Band 41	Data	2498.5 - 2687.5 MHz
LTE Band 48	Data	3552.5 - 3697.5 MHz
NR Band n71	Data	665.5 - 695.5 MHz
NR Band n12	Data	701.5 - 713.5 MHz
NR Band n5 (Cell)	Data	826.5 - 846.5 MHz
NR Band n66 (AWS)	Data	1712.5 - 1777.5 MHz
NR Band n2 (PCS)	Data	1852.5 - 1907.5 MHz
NR Band n25 (PCS)	Data	1852.5 - 1912.5 MHz
NR Band n30	Data	2307.5 - 2312.5 MHz
NR Band n7	Data	2502.5 - 2567.5 MHz
NR Band n41	Data	2506.02 - 2679.99 MHz
NR Band n77 DoD	Data	3460.02 - 3540 MHz
NR Band n77 C	Data	3710.01 - 3969.99 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

1.2 Time-Averaging Algorithm for RF Exposure Compliance

This device 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. DUT contains embedded file system (EFS) version 16 configured for second generation (GEN2).

The Smart Transmit algorithm maintains the time-averaged transmit power, in turn, time-averaged RF exposure of SAR_design_target, below the predefined time-averaged power limit (i.e., Plimit for sub-6 radio), 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.

1.3 Bibliography

Report Type	Report Serial Number
Part 0 SAR Test Report	1C2106080049-27.BCG
Part 1 SAR Test Report	1C2106080049-28.BCG
RF Exposure Compliance Summary	1C2106080049-31.BCG

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 *General Population* (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT *Occupational* (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.

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

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 (or beam) 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 < 6GHz) 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 7.

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 and PD limits, through <u>time-averaged power</u> measurements
    - Measure conducted Tx power (for *f* < 6GHz) versus time, and radiated Tx power (EIRP for f > 10GHz) 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, and 7) at all times.

Mathematical expression:

For < 6 GHz transmission only:

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

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

where, $conducted\_Tx\_power(t)$, $conducted\_Tx\_power\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at P_{limit}, and measured *1gSAR or 10gSAR* values at P_{limit} corresponding to sub-6 transmission. P_{limit} is the parameters pre-defined in Part 0 and loaded via Embedded File System (EFS) onto the EUT. T_{SAR} is the FCC defined time window for sub-6 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.
  - For sub-6 transmission only, measure instantaneous SAR versus time; for LTE+sub6 NR transmission, request low power (or all-down bits) on LTE so that measured SAR predominantly corresponds to sub6 NR.
  - For LTE + mmW transmission, measure instantaneous E-field versus time for mmW radio and instantaneous conducted power versus time for LTE radio.
  - 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.

Mathematical expression:

- For sub-6 transmission only:

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR(t)\_P_{limit} \qquad (2a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR(t)dt}{FCC\ SAR\ limit} \leq 1 \qquad (2b)$$

where, $pointSAR(t)$, $pointSAR\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous point SAR, measured point SAR at P_{limit}, and measured *1gSAR* or 10gSAR values at P_{limit} corresponding to sub-6 transmission.

Note: cDASY6 measurement system by Schmid & Partner Engineering AG (SPEAG) of Zurich, Switzerland measures relative E-field, and provides ratio of $\frac{[pointE(t)]^2}{[pointE\_input.power.limit]^2}$ versus time.

4 FCC MEASUREMENT PROCEDURES (FREQ < 6 GHZ)

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 < 3GHz 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 ≥ 3GHz.

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 GHz) validation:

- Test sequence 1: request DUT's Tx power to be at maximum power, measured P_{max}†, 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 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 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 2nd 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.

4.2.6 Test configuration selection for SAR exposure switching

If supported, the test configuration for SAR exposure switching should cover

1. SAR exposure switch when two active radios are in the same time window
2. SAR exposure switch when two active radios are in different time windows. One test with two active radios in any two different time windows is sufficient as Smart Transmit operation is the same for RF exposure switch in any combination of two different time windows. For device supporting LTE + mmW NR, this test is covered in SAR vs PD exposure switch validation.

The Smart Transmit time averaging operation is independent of the source of SAR exposure (for example, LTE vs. Sub6 NR) and ensures total time-averaged RF exposure compliance. Hence, validation of Smart Transmit in any one simultaneous SAR transmission scenario (i.e., one combination for LTE + Sub6 NR transmission) is sufficient, where the SAR exposure varies among SAR_{radio1} only, SAR_{radio1} + SAR_{radio2}, and SAR_{radio2} only scenarios.

The criteria to select a test configuration for validating Smart Transmit feature during SAR exposure switching scenarios is

- Select any two < 6GHz technologies/bands that the EUT supports simultaneous transmission (for example, LTE+Sub6 NR).
- Among all supported simultaneous transmission configurations, the selection order is
    1. select one configuration where both P_{limit} of radio1 and radio2 is less than their corresponding P_{max}, preferably, with different P_{limits}. If this configuration is not available, then,
    2. select one configuration that has P_{limit} less than its P_{max} for at least one radio. If this can not be found, then,
    3. select one configuration that has P_{limit} of radio1 and radio2 greater than P_{max} but with least (P_{limit} – P_{max}) delta.

Test for one simultaneous transmission scenario 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.

    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.

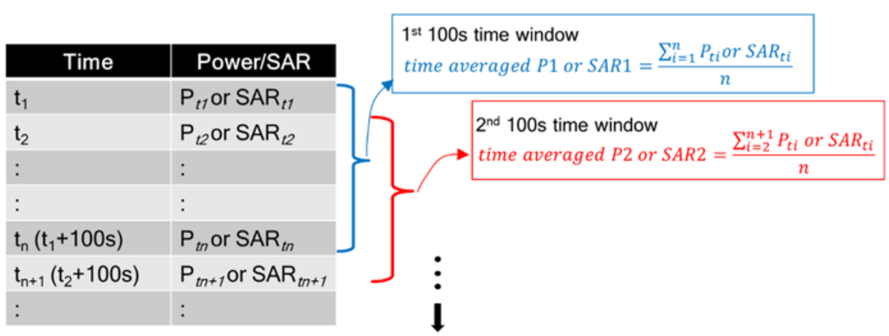


Figure 4-1
Running Average Illustration

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

$$Time\ avearged\ power\ limit = meas.P_{limit} + 10 \times \log(\frac{FCC\ SAR\ limit}{meas.SAR\_Plimit}) \qquad (3a)$$

where $meas.P_{limit}$ and $meas.SAR\_Plimit$ correspond to measured power at P_{limit} and measured SAR at P_{limit}.

4. Make another plot containing:
    a. Computed time-averaged 1gSAR or 10gSAR versus time determined in Step 2
    b. FCC $1gSAR_{limit}$ of 1.6W/kg or FCC $10gSAR_{limit}$ 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. (3a)), 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.

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.(3a).
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.(3a)), 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:

$$1g\_or\_10gSAR_1(t) = \frac{conducted\_Tx\_power\_1(t)}{conducted\_Tx\_power\_P_{limit\_1}} * 1g\_or\_10gSAR\_P_{limit\_1} \quad (4a)$$

$$1g\_or\_10gSAR_2(t) = \frac{conducted\_Tx\_power\_2(t)}{conducted\_Tx\_power\_P_{limit\_2}} * 1g\_or\_10gSAR\_P_{limit\_2} \quad (4b)$$

$$\frac{1}{T_{SAR}}\left[\int_{t-T_{SAR}}^{t_1} \frac{1g\_or\_10gSAR_1(t)}{FCC\ SAR\ limit} dt + \int_{t-T_{SAR}}^{t} \frac{1g\_or\_10gSAR_2(t)}{FCC\ SAR\ limit} dt\right] \le 1 \quad (4c)$$

where, *conducted_Tx_power_1(t)*, *conducted_Tx_power_*P_{limit_1}, and *1g_or_10gSAR_*P_{limit_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_*$P_{limit\_2}(t)$, and *1g_or_10gSAR_*P_{limit_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. (4a) and (4b) 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.(4a) & (4b), 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.(3a).
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. (4c)).

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.

4.3.5 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 (2a) and (2b) in Section 2 can be written as follows for transmission scenario having change in time window,

$$1gSAR_1(t) = \frac{conducted\_Tx\_power\_1(t)}{conducted\_Tx\_power\_P_{limit\_1}} * 1g\_or\ 10g\_SAR\_P_{limit\_1} \quad (5a)$$

$$1gSAR_2(t) = \frac{conducted\_Tx\_power\_2(t)}{conducted\_Tx\_power\_P_{limit\_2}} * 1g\_or\ 10g\_SAR\_P_{limit\_2} \quad (5b)$$

$$\frac{1}{T1_{SAR}}\left[\int_{t-T1_{SAR}}^{t_1} \frac{1g\_or\ 10g\_SAR_1(t)}{FCC\ SAR\ limit} dt\right] + \frac{1}{T2_{SAR}}\left[\int_{t-T2_{SAR}}^{t} \frac{1g_{or}10g\_SAR_2(t)}{FCC\ SAR\ limit} dt\right] \leq 1 \quad (5c)$$

where, *conducted_Tx_power_1(t)*, *conducted_Tx_power_P_{limit_1}(t)*, and *1g_ or 10g_SAR_P_{limit_1}* correspond to the instantaneous Tx power, conducted Tx power at P_{limit}, and compliance *1g_ or 10g_SAR* values at P_{limit_1} of band1 with time-averaging window '$T1_{SAR}$'; *conducted_Tx_power_2(t)*, *conducted_Tx_power_P_{limit_2}(t)*, and *1g_ or 10g_SAR_P_{limit_2}* correspond to the instantaneous Tx power, conducted Tx power at P_{limit}, and compliance *1g_ or 10g_SAR* values at P_{limit_2} of band2 with time-averaging window '$T2_{SAR}$'. One of the two bands is less than 3GHz, another is greater than 3GHz. Transition from first band with time-averaging window '$T1_{SAR}$' to the second band with time-averaging window '$T2_{SAR}$' happens at time-instant 't_1'.

Test procedure

1. Measure P_{limit} for both the technologies and bands selected in Section 4.2.6. 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 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. (5a) and (5b)) 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.(5a) & (5b), instantaneous Tx power is converted into 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.

4.3.6 SAR exposure switching

This test is to demonstrate that Smart Transmit feature is accurately accounts for switching in exposures among SAR from radio1 only, SAR from both radio1 and radio2, and SAR from radio2 only scenarios, and ensures total time-averaged RF exposure complies with the FCC limit. Here, radio1 represents primary radio (for example, LTE anchor in a NR non-standalone mode call) and radio2 represents secondary radio (for example, sub6 NR or mmW NR). The detailed test procedure for SAR exposure switching in the case of LTE+Sub6 NR non-standalone mode transmission scenario is provided in APPENDIX F:.

Test procedure:

1. Measure conducted Tx power corresponding to P_{limit} for radio1 and radio2 in selected band. Test condition to measure conducted P_{limit} is:
   - Establish device in call with the callbox for radio1 technology/band. Measure conducted Tx power corresponding to radio1 P_{limit} with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.
   - Repeat above step to measure conducted Tx power corresponding to radio2 P_{limit}. If radio2 is dependent on radio1 (for example, non-standalone mode of Sub6 NR requiring radio1 LTE as anchor), then establish radio1 + radio2 call with callbox, and request all down bits for radio1 LTE. In this scenario, with callbox requesting maximum power from radio2 Sub6 NR, measured conducted Tx power corresponds to radio2 P_{limit} (as radio1 LTE is at all-down bits)
2. Set *Reserve_power_margin* to actual (intended) value, with EUT setup for radio1 + radio2 call. In this description, it is assumed that radio2 has lower priority than radio1. Establish device in radio1+radio2 call, and request all-down bits or low power on radio1, with callbox requesting EUT's Tx power to be at maximum power in radio2 for at least one time window. After one time window, set callbox to request EUT's Tx power to be at maximum power on radio1, i.e., all-up bits. Continue radio1+radio2 call with both radios at maximum power for at least one time window, and drop (or request all-down bits on) radio2. Continue radio1 at maximum power for at least one time window. Record the conducted Tx power for both radio1 and radio2 for the entire duration of this test.
3. Once the measurement is done, extract instantaneous Tx power versus time for both radio1 and radio2 links. Convert the conducted Tx power for both these radios into 1gSAR or 10gSAR value (see Eq. (4a) and (4b)) using corresponding technology/band P_{limit} measured in Step 1, and then perform the running time average to determine time-averaged 1gSAR or 10gSAR versus time.
4. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 2.

5. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 3, (b) computed time-averaged 1gSAR versus time determined in Step 3, and (c) corresponding regulatory $1gSAR_{limit}$ of 1.6W/kg or $10gSAR_{limit}$ of 4.0W/kg.

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.

4.4 Test procedure for time-varying SAR measurements

This section provides general time-varying SAR 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.

To perform the validation through SAR measurement for transmission scenario 1 described in Section 3, the "path loss" between callbox antenna and DUT needs to be calibrated to ensure that the DUT Tx power reacts to the requested power from callbox in a radiated call. It should be noted that when signaling in closed loop mode, protocol-level power control is in play, resulting in DUT not solely following callbox TPC (Tx power control) commands. In other words, DUT response has many dependencies (RSSI, quality of signal, path loss variation, fading, etc.,) other than just TPC commands. These dependencies have less impact in conducted setup (as it is a controlled environment and the path loss can be very well calibrated) but have significant impact on radiated testing in an uncontrolled environment, such as SAR test setup. Therefore, the deviation in DUT Tx power from callbox requested power is expected, however the time-averaged SAR should not exceed FCC SAR requirement at all times as Smart Transmit controls Tx power at DUT.

The following steps are for time averaging feature validation through SAR measurement:

1. "Path Loss" calibration: Place the DUT against the phantom in the worst-case position determined based on Section 4.2.1. For each band selected, prior to SAR measurement, perform "path loss" calibration between callbox antenna and DUT. Since the SAR test environment is not controlled and well calibrated for OTA (Over the Air) test, extreme care needs to be taken to avoid the influence from reflections. The test setup is described in Section 6.2.

2. Time averaging feature validation:

   i For a given radio configuration (technology/band) selected in Section 4.2.1, enable Smart Transmit and set *Reserve_power_margin* to 0 dB, with callbox to request maximum power, perform area scan, conduct pointSAR measurement at peak location of the area scan. This point SAR value, $pointSAR\_P_{limit}$, corresponds to point SAR at the measured P_{limit} (i.e., measured P_{limit} from the DUT in Step 1 of Section 4.3.1).

   ii Set *Reserve_power_margin* to actual (intended) value and reset power on DUT to enable Smart Transmit. Note, if *Reserve_power_margin* cannot be set wirelessly, care must be taken to re-position the DUT in the exact same position relative to the SAM phantom as in above Step 2.i. Establish radio link in desired radio configuration, with callbox requesting the DUT's Tx power at power levels described by test sequence 1 generated in Step 1 of Section 4.3.1, conduct point SAR measurement versus time at peak location of the area scan determined in Step 2.i of this section. Once the measurement is done, extract instantaneous point SAR vs time data, *pointSAR(t)*, and convert it into instantaneous 1gSAR or 10gSAR vs. time using Eq. (2a), re-written below:

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit}$$

where, *pointSAR_P*$_{limit}$ is the value determined in Step 2.i, and *pointSAR(t)* is the instantaneous point SAR measured in Step 2.ii, $1g\_or\_10gSAR\_P_{limit}$ is the measured 1gSAR or 10gSAR value listed in Part 1 report.

iii Perform 100s running average to determine time-averaged 1gSAR or 10gSAR versus time.

iv Make one plot containing: (a) time-averaged 1gSAR or 10gSAR versus time determined in Step 2.iii of this section, (b) FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

v Repeat 2.ii ~ 2.iv for test sequence 2 generated in Step 1 of Section 4.3.1.

vi Repeat 2.i ~ 2.v for all the technologies and bands selected in Section 4.2.1.

The time-averaging validation criteria for SAR measurement is that, 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 (i.e., Eq. (2b)).

5 MEASUREMENT TEST SETUP (FREQ < 6 GHZ)

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 D – Test Setup Photo 1) for measurements with a single antenna of DUT, in Figure 5-1b (Appendix D – Test Setup Photo 2) for measurements involving antenna switch, and in in Figure 5-1c (Appendix D – Test Setup Photo 3) for measurements involving interband ULCA. For single antenna measurement and technology/band switch measurement, one port (RF1 COM) of the callbox is connected to the RF port of the DUT using a directional coupler. For Antenna switch measurement, two port (RF1 COM and RF3 COM) are connected to the RF port of the DUT using directional couplers. The other end of the directional coupler is connected to a splitter to connect to the power meter. In the setups, power meter is used to tap the directional coupler for measuring the conducted output power of the DUT. For interband ULCA conducted tests, RF1 COM port and RF 3 COM port are used to communicate with the DUT, each port connected to the DUT via directional coupler.

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.

Sub6 NR test setup:

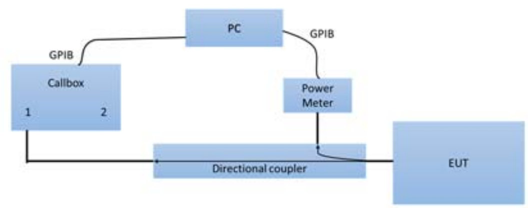
The KeySight UXM 5G callbox was used in this test. The test setup schematic is the same as the Legacy Test Setup shown in Figure 5-1d (Appendix D – Test Setup Photo 4). One port of the callbox is connected to the RF port of the DUT using a directional coupler. In the setup, the power meter is used to tap the directional coupler for measuring the conducted output power of 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.

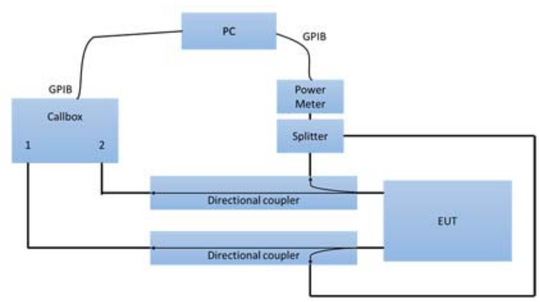
LTE+Sub6 NR test setup:

LTE conducted port and Sub6 NR conducted port are different on this EUT, therefore, the LTE and Sub6 NR signals for power meter measurement are performed on separate paths as shown below in Figure 5-1e (Appendix D – Test Setup Photo 5).

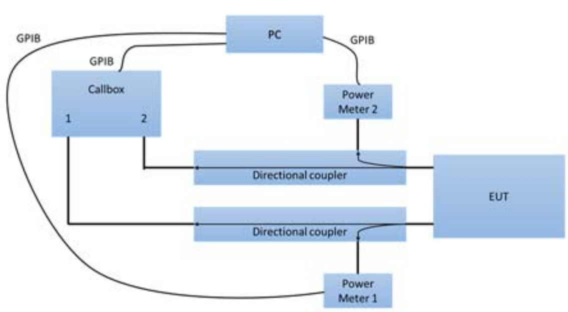
All the path losses from RF port of DUT to the callbox RF COM port and to the power meter are calibrated and automatically entered as offsets in the callbox and the power meter via test scripts on the PC used to control callbox and power meter.



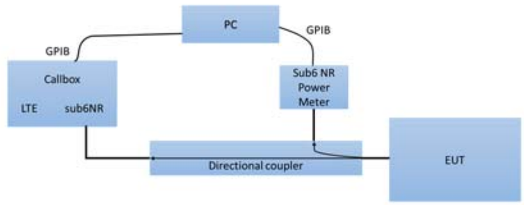
(a) Appendix D – Test Setup Photo 1



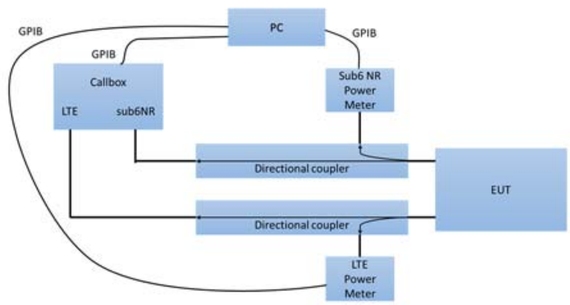
(b) Appendix D – Test Setup Photo 2



(c) Appendix D – Test Setup Photo 3



(d) Appendix D – Test Setup Photo 4



(e) Appendix D – Test Setup Photo 5

Figure 5-1
Conducted power measurement setup

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 1st 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 2nd 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.

5.2 SAR Measurement setup

The measurement setup is similar to normal SAR measurements as described in the Part 1 Test Report. The difference in SAR measurement setup for time averaging feature validation is that the callbox is signaling in close loop power control mode (instead of requesting maximum power in open loop control mode) and callbox is connected to the PC using GPIB so that the test script executed on PC can send GPIB commands to control the callbox's requested power over time (test sequence). The same test script used in conducted setup for time-varying Tx power measurements is also used in this section for running the test sequences during SAR measurements, and the recorded values from the disconnected power meter by the test script were discarded.

As mentioned in Section 4.4, for DUT to follow TPC command sent from the callbox wirelessly, the "path loss" between callbox antenna and the DUT needs to be very well calibrated. Since the SAR chamber is in uncontrolled environment, precautions must be taken to minimize the environmental influences on "path loss". Similarly, in the case of time-varying SAR measurements in Sub6 NR (with LTE as anchor), "path loss" between callbox antenna and the EUT needs to be carefully calibrated for both LTE link as well as for Sub6 NR link.

The DUT is placed in worst-case position according to Table 6-2.

6 TEST CONFIGURATIONS (FREQ < 6 GHZ)

6.1 WWAN (sub-6) transmission

The P_{limit} values, corresponding to 0.8 W/kg (1gSAR) 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:	Ant 1a/1b Body	Ant 1a/1b Maximum Tune-up Output Power*	Ant 2 Body	Ant 2 Maximum Tune-up Output Power*	Ant 3a/3b Body	Ant 3a/3b Maximum Tune-up Output Power*	Ant 4 Body	Ant 4 Maximum Tune-up Output Power*
Averaging Volume:	1g		1g		1g		1g	
Spacing:	0 mm		0 mm		0 mm		0 mm	
DSI:	1		1		1		1	
Technology/Band	**Plimit corresponding to 0.8 W/kg**	Pmax	**Plimit corresponding to 0.8 W/kg**	Pmax	**Plimit corresponding to 0.8 W/kg**	Pmax	**Plimit corresponding to 0.8 W/kg**	Pmax
UMTS 850	N/A	N/A	16.70	24.20	N/A	N/A	17.80	24.70
UMTS 1750	11.20	21.70	13.10	22.70	12.20	23.70	13.30	24.70
UMTS 1900	10.20	21.70	12.80	22.70	11.50	23.70	13.00	24.70
LTE Band 71	N/A	N/A	17.50	24.20	N/A	N/A	19.50	24.70
LTE Band 12	N/A	N/A	17.50	24.20	N/A	N/A	17.90	24.70
LTE Band 17	N/A	N/A	17.50	24.20	N/A	N/A	17.90	24.70
LTE Band 13	N/A	N/A	17.25	24.20	N/A	N/A	18.50	24.70
LTE Band 14	N/A	N/A	17.25	24.20	N/A	N/A	18.50	24.70
LTE Band 26 (Cell)	N/A	N/A	16.70	24.20	N/A	N/A	17.80	24.70
LTE Band 5 (Cell)	N/A	N/A	16.70	24.20	N/A	N/A	17.80	24.70
LTE Band 5 ULCA (Cell)	N/A	N/A	16.70	24.20	N/A	N/A	17.80	24.70
LTE Band 66 (AWS)	11.20	21.70	13.10	22.70	12.20	23.70	13.30	24.70
LTE Band 66 ULCA (AWS)	11.20	22.00	13.10	23.00	12.20	24.00	13.30	24.70
LTE Band 4 (AWS)	11.20	21.70	13.10	22.70	12.20	23.70	13.30	24.70
LTE Band 25 (PCS)	10.20	21.70	12.80	22.70	11.50	23.70	13.00	24.70
LTE Band 2 (PCS)	10.20	21.70	12.80	22.70	11.50	23.70	13.00	24.70
LTE Band 30	11.30	21.70	12.20	21.70	13.40	23.20	13.20	21.00
LTE Band 7	12.00	21.70	10.80	22.20	13.70	23.20	11.00	24.70
LTE Band 7 ULCA	12.00	22.00	10.80	22.50	13.70	23.50	11.00	24.70
LTE Band 41 PC3	11.21	21.71	11.11	22.21	12.81	22.71	11.71	22.71
LTE Band 41 ULCA PC3	11.21	22.01	11.11	22.51	12.81	22.71	11.71	22.71
LTE Band 41 PC2	11.21	20.06	11.11	20.56	12.81	21.56	11.71	23.06
LTE Band 41 ULCA PC2	11.21	20.36	11.11	20.86	12.81	21.86	11.71	23.36
LTE Band 48	9.31	16.61	10.01	17.31	9.01	16.41	8.91	16.91
LTE Band 48 ULCA	9.31	16.61	10.01	17.31	9.01	16.41	8.91	16.91
NR Band n71	N/A	N/A	17.50	24.20	N/A	N/A	19.50	24.70
NR Band n12	N/A	N/A	17.50	24.20	N/A	N/A	17.90	24.70
NR Band n5 (Cell)	N/A	N/A	16.70	24.20	N/A	N/A	17.80	24.70
NR Band n66 (AWS)	11.20	21.70	13.10	22.70	12.20	23.70	13.30	24.70
NR Band n25 (PCS)	10.20	21.70	12.80	22.70	11.50	23.70	13.00	24.70
NR Band n2 (PCS)	10.20	21.70	12.80	22.70	11.50	23.70	13.00	24.70
NR Band n30	11.30	17.20	12.20	17.70	13.40	18.70	13.20	20.20
NR Band n7	12.00	21.70	10.80	22.20	13.70	23.20	11.00	24.70
NR Band n41 PC3	11.70	24.70	11.50	24.70	13.90	22.70	11.10	24.70
NR Band n41 PC2	11.70	26.70	11.50	26.70	13.90	22.70	11.10	24.70
NR Band n77 PC3	9.40	23.20	10.40	22.20	10.00	24.70	10.50	24.70
NR Band n77 PC2	9.40	23.20	10.40	22.20	10.00	25.20	10.50	25.70

* 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 values for selected technology/band/DSI are extracted from Part 1 report and are listed in the last column of Table 6-2. The highest bandwidth and mid channel was selected for testing configuration.

Based on equations (1a) and (2a), 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) and (2a), 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.

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 Plimit (W/kg)
1	Test Sequence 1	LTE	71	4	1	133297	680.5	1/0/20 MHz BW	QPSK	Body, Back Side 0mm	0.741
	Test Sequence 2					133297	680.5	1/0/20 MHz BW	QPSK		
2	Test Sequence 1		48	4	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body, Back Side 0mm	0.627
	Test Sequence 2					56207	3646.7	1/50/20 MHz BW	QPSK		
3	Test Sequence 1	WCDMA	5	2	1	4132	836.5	-	RMC	Body, Back Side 0mm	0.814
	Test Sequence 2					4132	836.5	-	RMC		
4	Test Sequence 1		4	1b	1	1412	1732.4	-	RMC	Body, Back Side 0mm	0.736
	Test Sequence 2					1412	1732.4	-	RMC		
5	Test Sequence 1	Sub6 NR	n66/SA	1b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body, Back Side 0mm	0.719
	Test Sequence 2					349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK		
6	Test Sequence 1		n71/SA	4	1	136100	680.5	1/1/20 MHz BW	DFT-s-OFDM QPSK	Body, Back Side 0mm	0.758
	Test Sequence 2					136100	680.5	1/1/20 MHz BW	DFT-s-OFDM QPSK		
7	Call Drop	LTE	48	4	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body, Back Side 0mm	0.627
8	Tech Switch	LTE	71	4	1	133297	680.5	1/0/20 MHz BW	QPSK	Body, Back Side 0mm	0.741
		WCDMA	4	1b	1	1412	1732.4	-	RMC	Body, Back Side 0mm	0.736
9	Antenna Switch	WCDMA	5	4	1	4132	836.5	-	RMC	Body, Back Side 0mm	0.786
				2	1	4132				Body, Back Side 0mm	0.814
10	Time Window Switch	LTE	71	2	1	133297	680.5	1/0/20 MHz BW	QPSK	Body, Back Side 0mm	0.678
			48	2	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body, Back Side 0mm	0.732
11	SAR1 vs SAR2	LTE	5	4	1	20525	836.5	1/25/10 MHz BW	QPSK	Body, Back Side 0mm	0.712
		Sub6 NR	n66	3b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body, Back Side 0mm	0.646
12	SAR1 vs SAR2	LTE	48	2	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body, Back Side 0mm	0.732
		Sub6 NR	n66	1b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body, Back Side 0mm	0.719
13	Interband ULCA	LTE	2	1b	1	18900	1880	1/50/20 MHz BW	QPSK	Body, Back Side 0mm	0.809
		LTE	5	2		20525	836.5	1/25/10 MHz BW	QPSK	Body, Back Side 0mm	0.733

Note1: As Part 1 and Part 2 testing took place in parallel the selected technologies/bands were chosen based upon anticipated values encountered during pretesting before Tx powers were finalized. The above values represent the SAR levels at the final P_{limits}.

Note2: The DUT has detect mode to manage exposure in portable use conditions, which is represented with DSI = 1 is used in Smart Transmit feature for time averaging operation. 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:

1. Technologies and bands for time-varying Tx power transmission: The test case 1~6 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.
2. Technology and band for change in call test: LTE B48, having the lowest P_{limit} among all technologies and bands based upon anticipated values encountered during pretesting before Tx powers were finalized (test case 7 in Table 6-2), is selected for performing the call drop test in conducted power setup.
3. Technologies and bands for change in technology/band test: Following the guidelines in Section 4.2.3, test case 8 in Table 6-2 is selected for handover test from a technology/band within one technology group (LTE Band 71, DSI=1, antenna 4), to a technology/band in the same DSI within another technology group (WCDMA B4, DSI=1, antenna 1b) in conducted power setup.
4. Technologies and bands for change in antenna: Based on selection criteria in Section 4.2.4, for a given DSI=1, test case 9 in Table 6-2 is selected for antenna switch between one antenna (WCDMA B5, DSI=1, antenna 4) and another antenna (WCDMA B5, DSI=1, antenna 2) in conducted power setup.

5. Technologies and bands for change in time-window: Based on selection criteria in Section 4.2.5, for a given DSI=1, test case 10 in Table 6-2 is selected for time window switch between 100s window (LTE Band 71, Antenna 2) and 60s window (LTE Band 48, Antenna 2) in conducted power setup.
6. Technologies and bands for switch in SAR exposure (ENDC): Based on selection criteria in Section 4.2.6 Scenario 1 and Scenario 2, test case 11 and test case 12 in Table 6-2 is selected for SAR exposure switching test in one of the supported simultaneous WWAN transmission scenario, i.e., LTE + Sub6 NR active in the same 100s time window, in conducted power setup, and LTE + Sub6 NR active in the different time windows.
7. Technologies and bands for switch in SAR exposure (Interband ULCA): Based on selection criteria in Section 4.2.6 Scenario 1, test case 13 in Table 6-2 is selected for SAR exposure switching test in one of the supported simultaneous LTE transmission scenario, i.e., LTE interband ULCA, in conducted power setup.

Note: This device does not support multiple DSI states corresponding to portable use conditions, therefore, no change in DSI testing was performed.

Note: All sub6 transmitting antennas are within one sub6 antenna group, thus no new test are needed for GEN2 sub6 operation, per Qualcomm's 80-w2112-5 document Appendix N.

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 6-3. 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.

Per Qualcomm's 80-w2112-5 document Appendix I, the Part 1 and the Part 2 tests were done in parallel. The below table includes the P_{limit} and P_{max} values used in the test sample for Part 2 testing and the final P_{limit} and P_{max} values.

Table 6-3
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 Plimit for Part 2 Test [dBm]	Tune-up Pmax for Part 2 Test [dBm]	EFS Plimit [dBm]	Tune-up Pmax [dBm]	Measured Plimit [dBm]	Measured Pmax [dBm]
1	Test Sequence 1	LTE	71	4	1	133297	680.5	1/0/20 MHz BW	QPSK	Body	19.50	25.00	19.50	24.70	18.98	24.67
	Test Sequence 2					133297	680.5	1/0/20 MHz BW	QPSK		19.50	25.00	19.50	24.70	18.98	24.67
2	Test Sequence 1		48	4	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body	8.50	22.50	8.91	16.91	8.59	22.18
	Test Sequence 2					56207	3646.7	1/50/20 MHz BW	QPSK		8.50	22.50	8.91	16.91	8.59	22.18
3	Test Sequence 1	WCDMA	5	2	1	4132	836.5	-	RMC	Body	18.30	24.50	16.70	24.20	18.34	24.03
	Test Sequence 2					4132	836.5	-	RMC		18.30	24.50	16.70	24.20	18.34	24.03
4	Test Sequence 1		4	1b	1	1412	1732.4	-	RMC	Body	8.70	22.00	11.20	21.70	8.82	22.17
	Test Sequence 2					1412	1732.4	-	RMC		8.70	22.00	11.20	21.70	8.82	22.17
5	Test Sequence 1	Sub6 NR	n66/SA	1b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body	11.20	20.50	11.20	21.70	11.78	20.60
	Test Sequence 2					349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK		11.20	20.50	11.20	21.70	11.78	20.60
6	Test Sequence 1		n71/SA	4	1	136100	680.5	1/1/20 MHz BW	DFT-s-OFDM QPSK	Body	19.30	25.00	19.50	24.70	19.65	25.20
	Test Sequence 2					136100	680.5	1/1/20 MHz BW	DFT-s-OFDM QPSK		19.30	25.00	19.50	24.70	19.65	25.20
7	Call Drop	LTE	48	4	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body	8.50	22.50	8.91	16.91	8.59	22.18
8	Tech Switch	LTE	71	4	1	133297	680.5	1/0/20 MHz BW	QPSK	Body	19.50	25.00	19.50	24.70	18.98	24.67
		WCDMA	4	1b	1	1412	1732.4	-	RMC	Body	8.70	22.00	11.20	21.70	8.82	22.17
9	Antenna Switch	WCDMA	5	4	1	4132	836.5	-	RMC	Body	17.40	25.00	17.80	24.70	17.32	24.91
				2	1	4132				Body	18.30	24.50	16.70	24.20	18.34	24.03
10	Time Window Switch	LTE	71	2	1	133297	680.5	1/0/20 MHz BW	QPSK	Body	19.10	24.50	17.50	24.20	18.80	23.65
			48	2	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body	10.70	20.30	10.01	17.31	10.90	19.95
11	SAR1 vs SAR2	LTE	5	4	1	20525	836.5	1/25/10 MHz BW	QPSK	Body	17.40	25.00	17.80	24.70	17.44	24.88
		Sub6 NR	n66	3b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body	11.80	24.00	12.20	23.70	12.55	23.81
12	SAR1 vs SAR2	LTE	48	2	1	56207	3646.7	1/50/20 MHz BW	QPSK	Body	10.70	20.30	10.01	17.31	10.16	20.51
		Sub6 NR	n66	1b	1	349000	1745	1/1/40 MHz BW	DFT-s-OFDM QPSK	Body	11.20	20.50	11.20	21.70	11.18	20.60
13	Interband ULCA	LTE	2	1b	1	18900	1880	1/50/20 MHz BW	QPSK	Body	10.80	22.00	10.20	21.70	10.04	21.72
		LTE	5	2		20525	836.5	1/25/10 MHz BW	QPSK	Body	18.30	24.50	16.70	24.20	18.20	23.93

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

6.3 EFS v16 verification

Per Qualcomm's 80-w2112-5 document, embedded file system (EFS) version 16 products are required to be verified for Smart Tx generation for relevant MCC settings. It was confirmed that this DUT contains embedded file system (EFS) version 16 configured for Smart Tx second generation (GEN2) with MCC settings of 310 for the US market.

EFS V16 Generation	MCC
GEN2	310

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, $conducted\_Tx\_power(t)$, $conducted\_Tx\_power\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at P_{limit}, and measured *1gSAR* and *10gSAR* values at P_{limit} reported in Part 1 test (listed in Table 6-2 of this report as well).

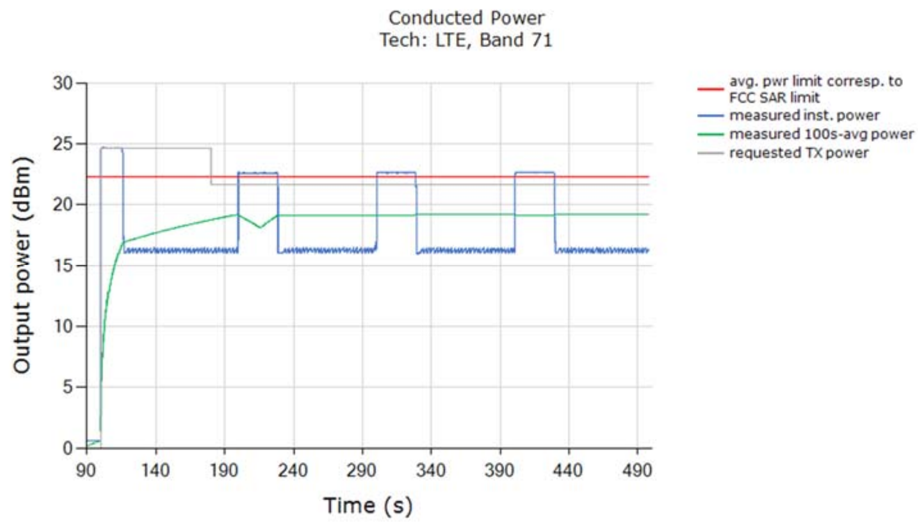
Following the test procedure in Section 4.3, the conducted Tx power measurement for all selected configurations are reported in this section. In all the conducted Tx power plots, the dotted line represents the requested power by callbox (test sequence 1 or test sequence 2), the blue curve represents 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.

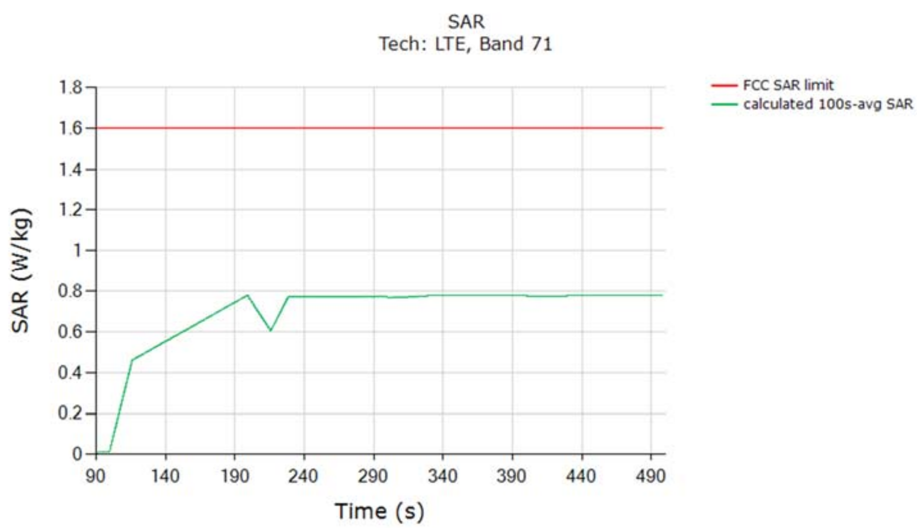
Time-varying Tx power measurements were conducted on test cases #1 ~ #6 in Table 6-2, by generating test sequence 1 and test sequence 2 given in APPENDIX E: using measured P_{limit} and measured P_{max} (last two columns of Table 6-3) for each of these test cases. Measurement results for test cases #1 ~ #6 are given in Sections 7.1.1 – 7.1.6.

7.1.1 LTE Band 71 Ant 4

<u>Test result for test sequence 1:</u>

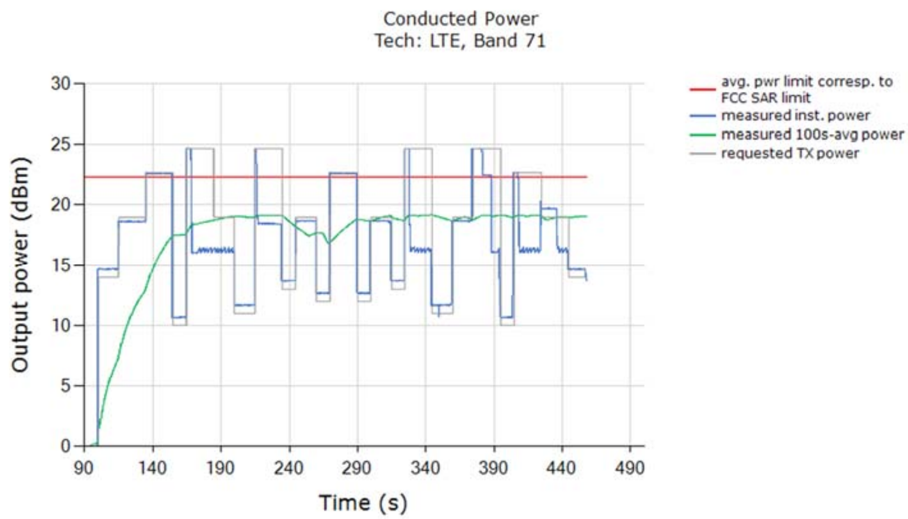


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

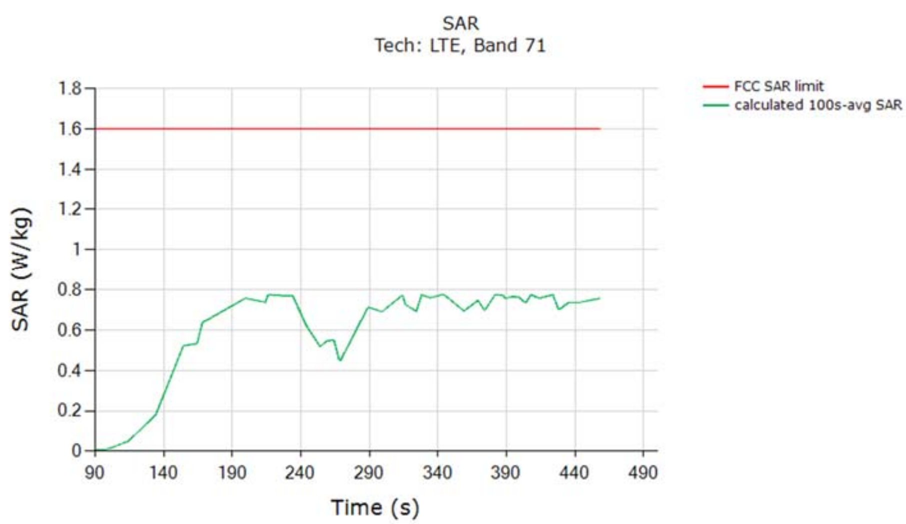


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.780
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

Test result for test sequence 2:



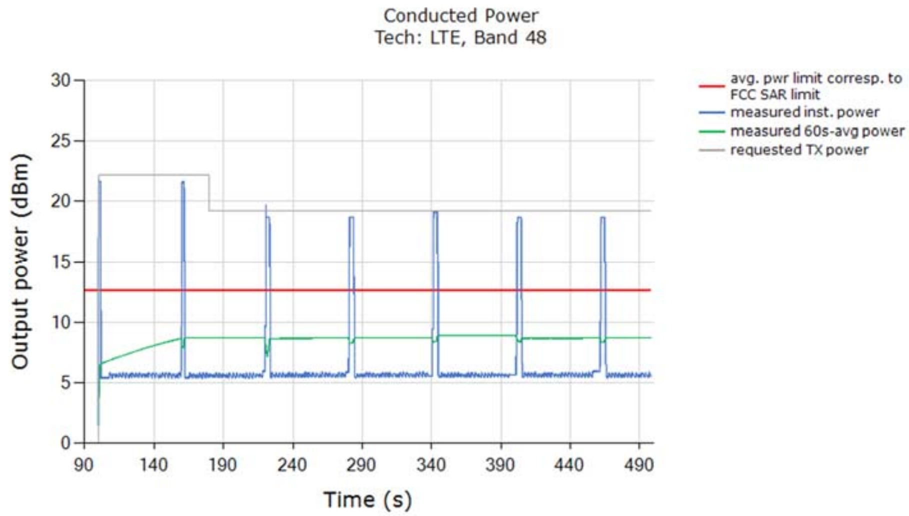
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



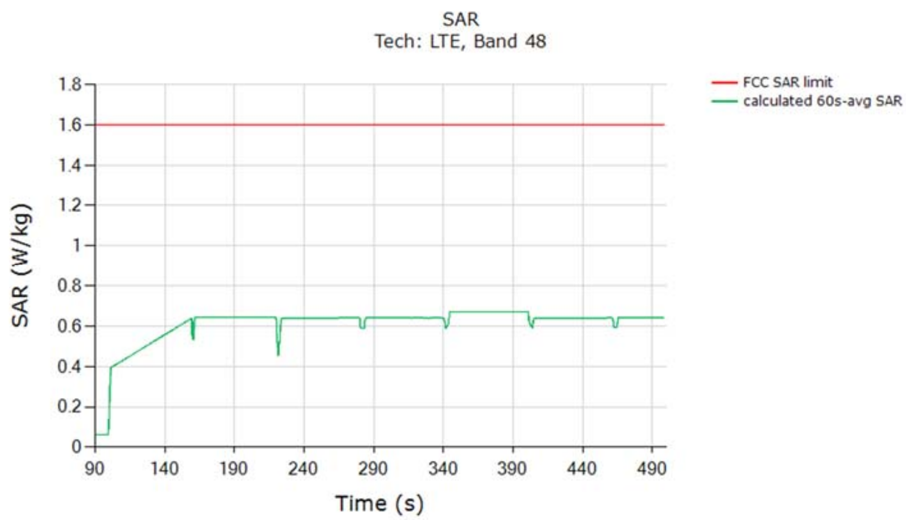
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.776
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

7.1.2 LTE Band 48 Ant 4

Test result for test sequence 1:

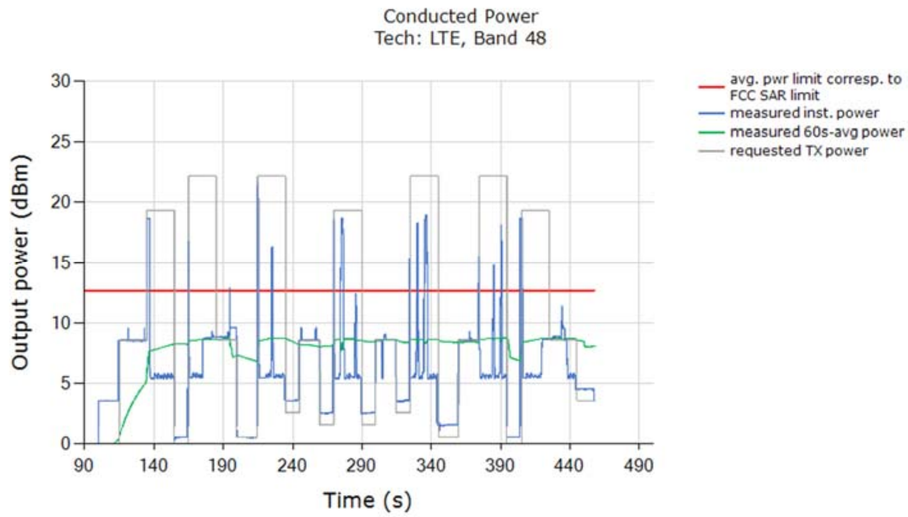


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

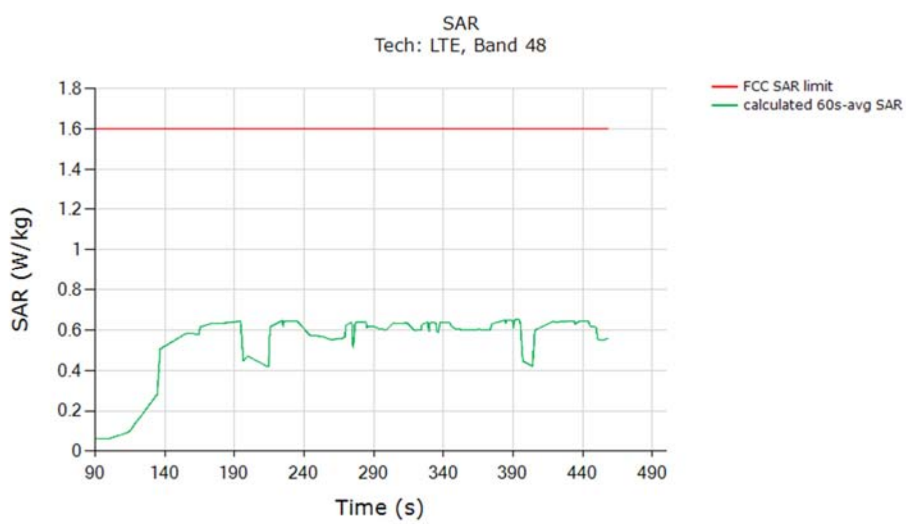


	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (green curve)	0.672
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

Test result for test sequence 2:



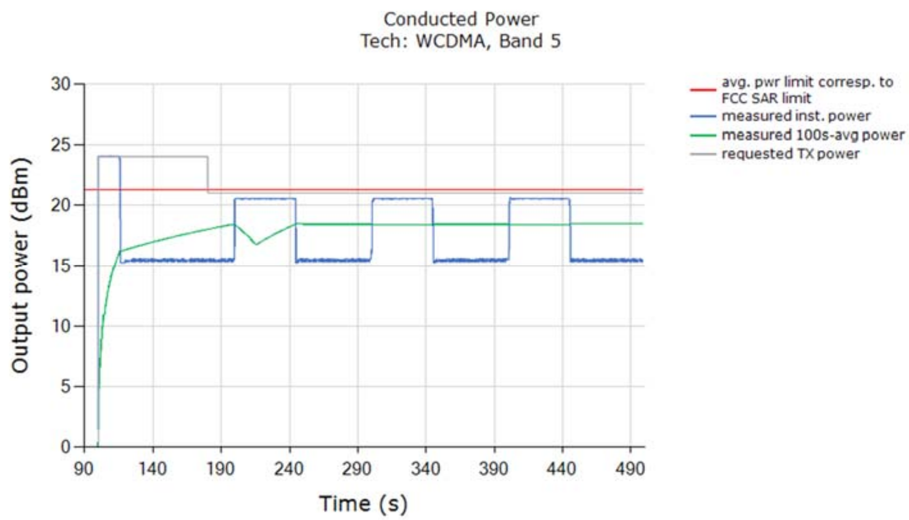
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



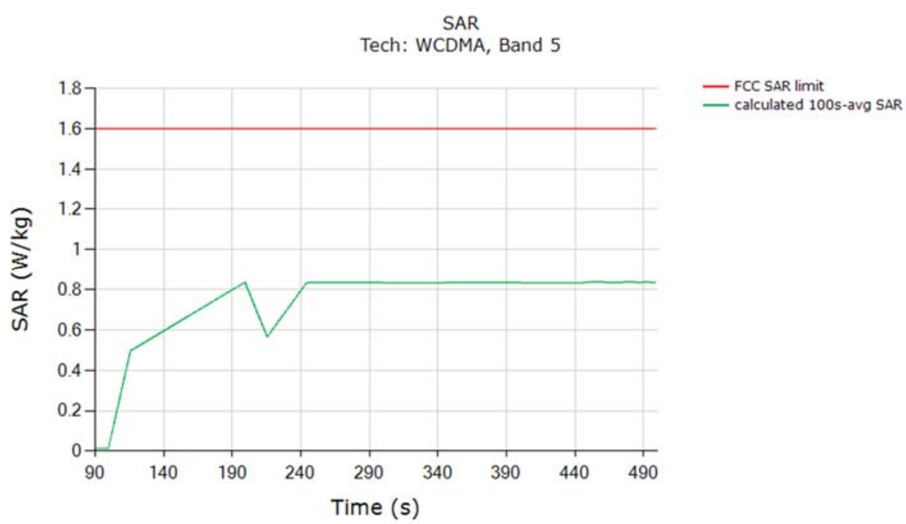
	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (green curve)	0.651
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

7.1.3 WCDMA Band 5 Ant 2

Test result for test sequence 1:

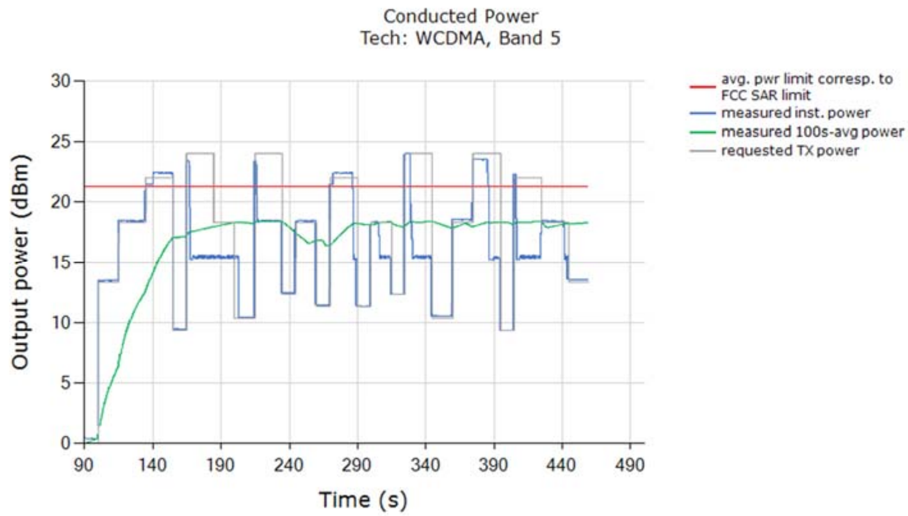


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

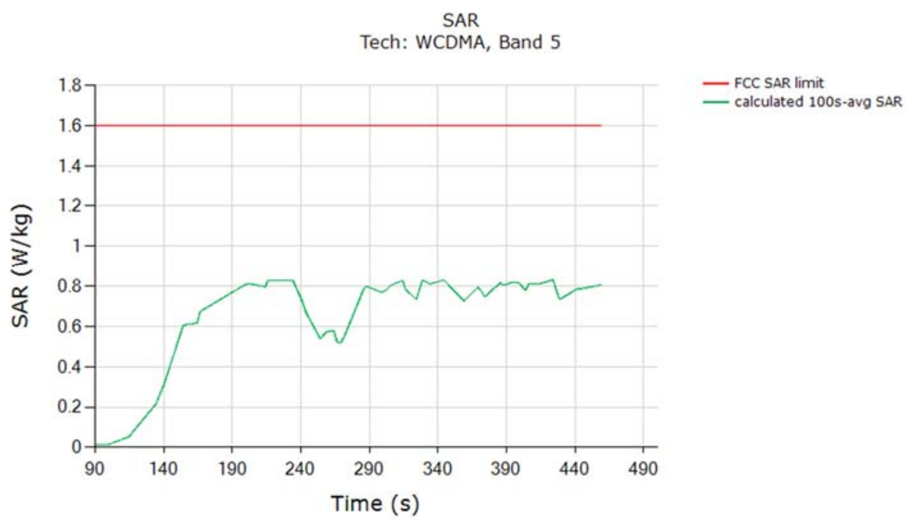


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.836
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

Test result for test sequence 2:



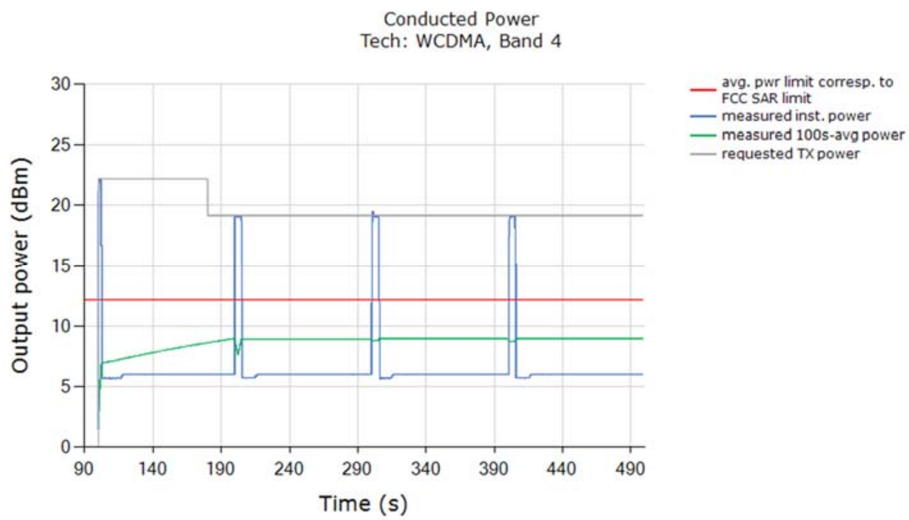
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



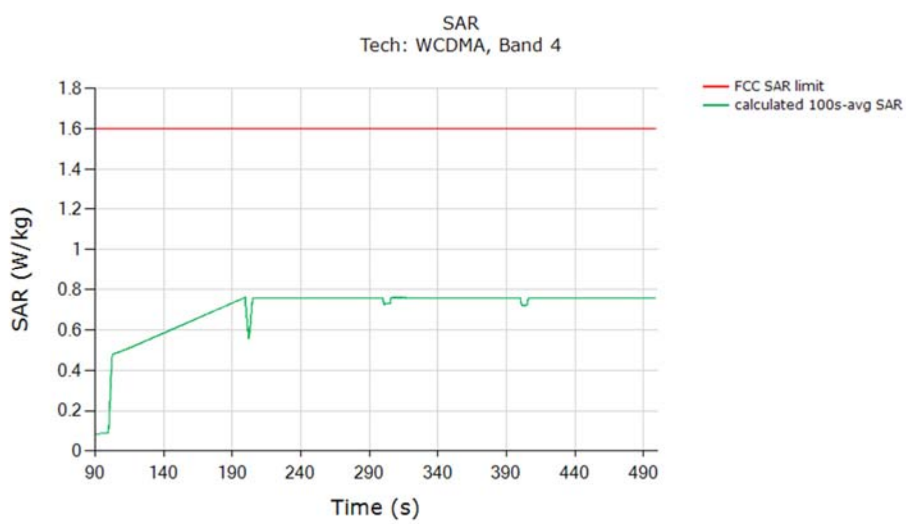
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.831
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

7.1.4 WCDMA Band 4 Ant 1b

<u>Test result for test sequence 1:</u>

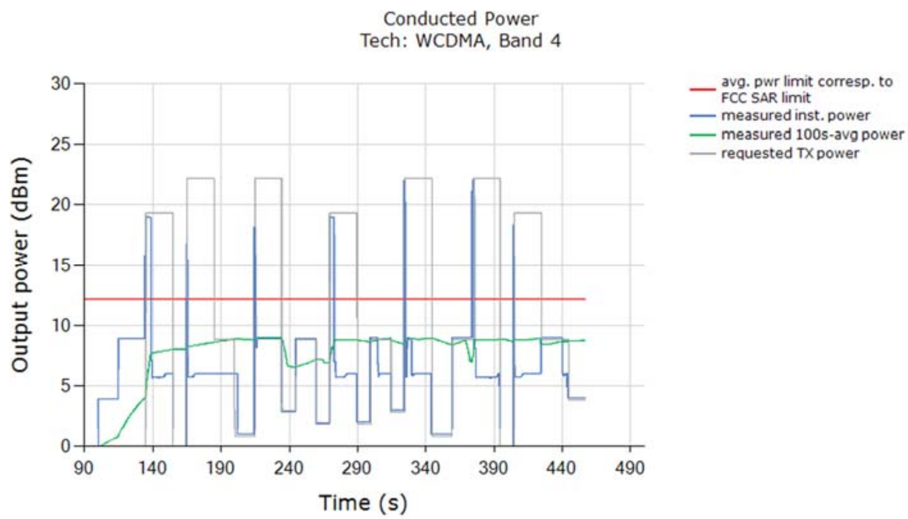


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

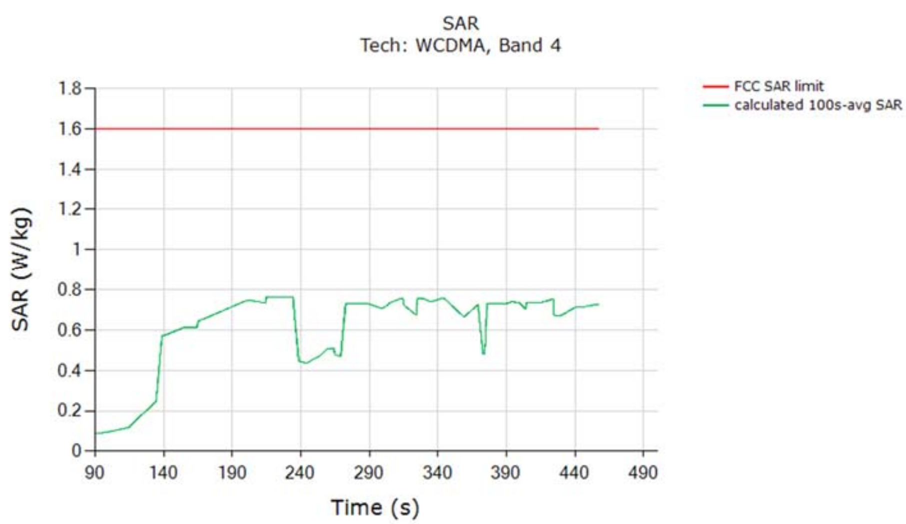


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.761
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

Test result for test sequence 2:



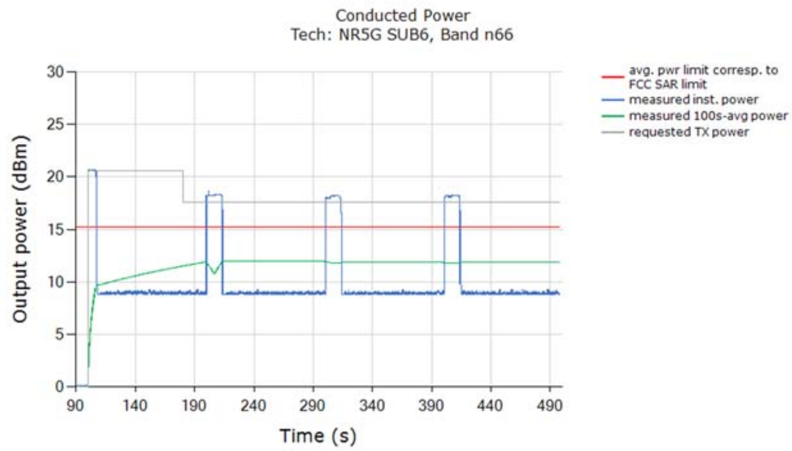
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



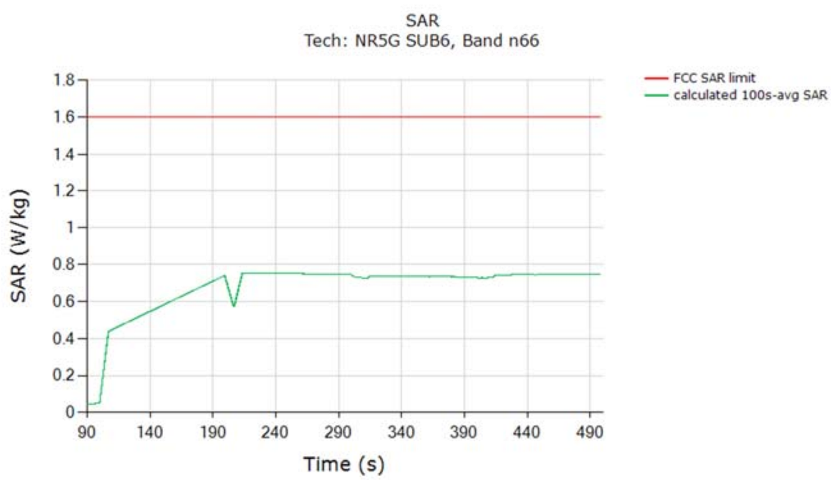
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.763
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

7.1.5 NR n66 SA Ant 1b

Test result for test sequence 1:

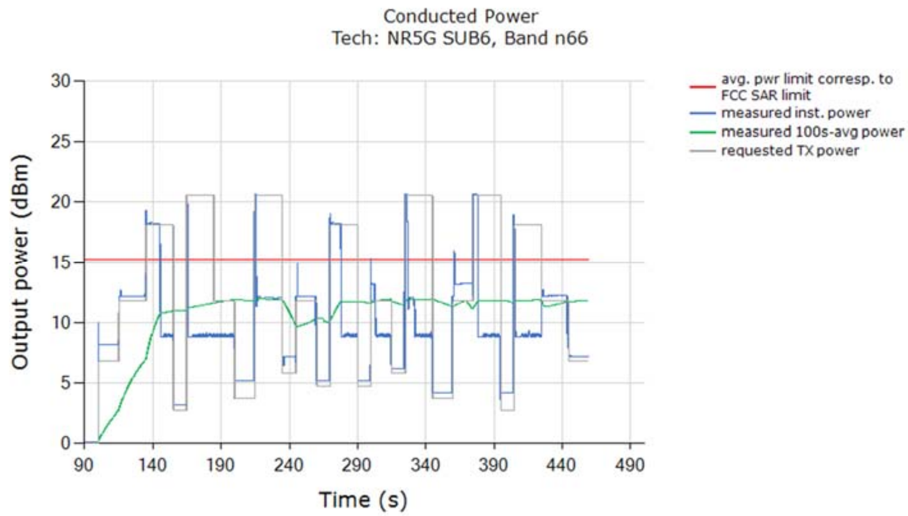


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

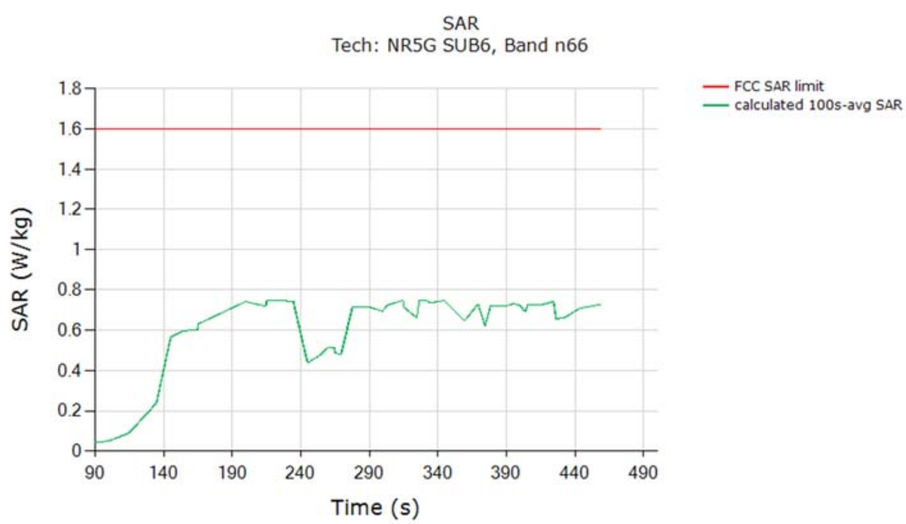


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.751
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

Test result for test sequence 2:



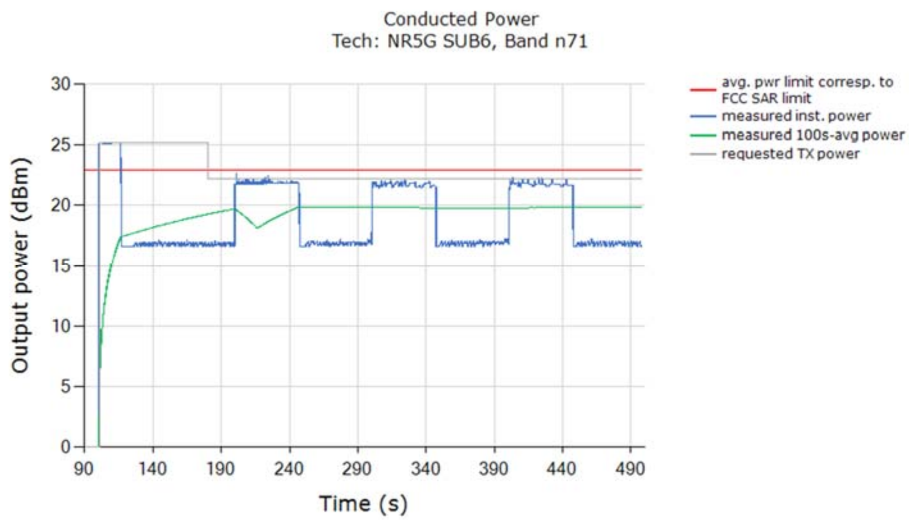
Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



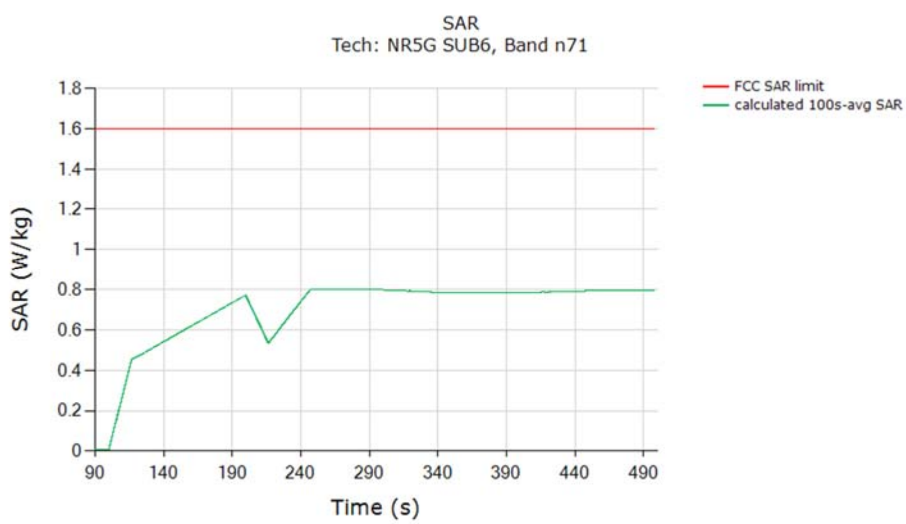
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.748
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (last column in Table 6-2).	

7.1.6 NR n71 SA Ant 4

Test result for test sequence 1:

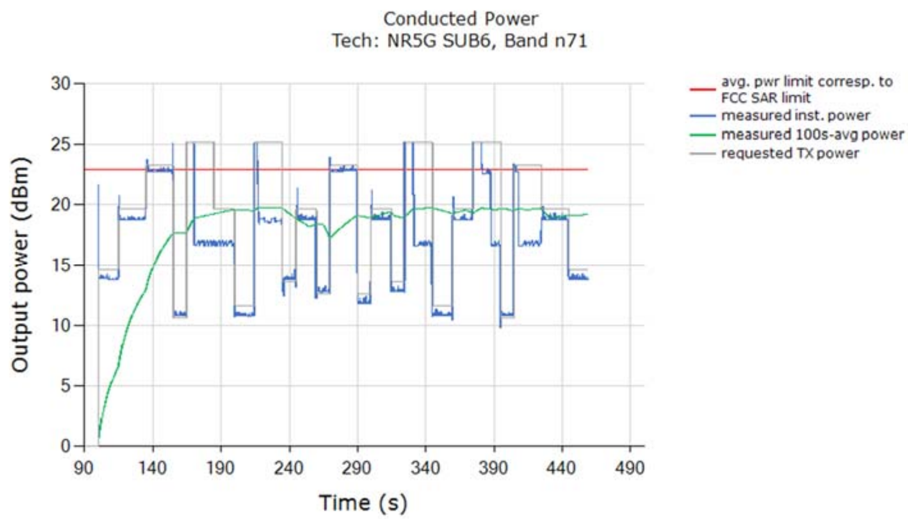


Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (1a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

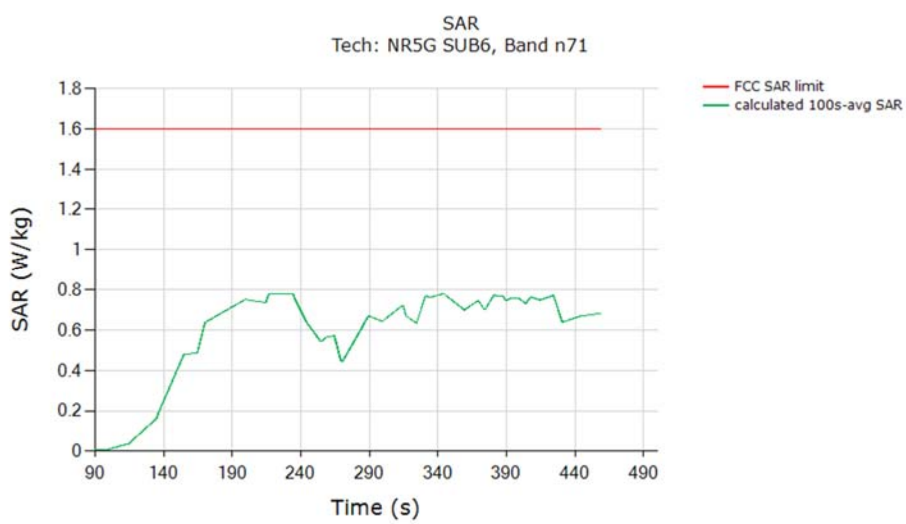


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.800
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of the measured SAR at *Plimit* (last column in Table 6-2).	

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:



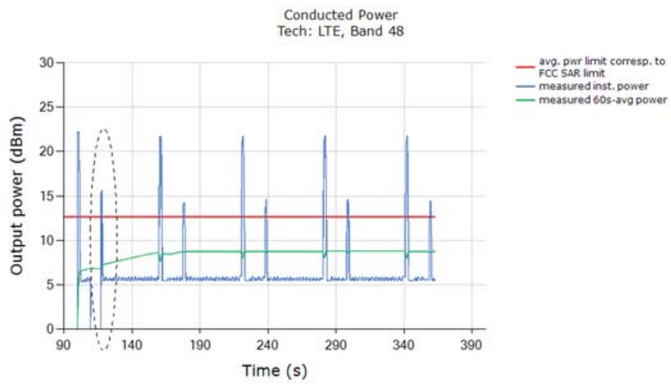
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.780
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of the measured SAR at *Plimit* (last column in Table 6-2).	

7.2 Call Drop Test Case

This test was measured LTE Band 48, Antenna 4, DSI=1, 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.

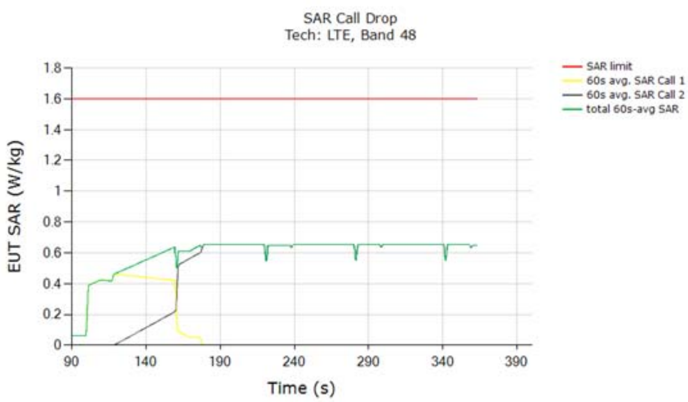
Call drop test result:

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power kept the same $P_{reserve}$ level of LTE Band 48 after the call was re-established:



Plot Notes: The power level after the change in call kept the same *Preserve* level of LTE Band 48. The conducted power plot shows expected Tx transition.

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 60s-time averaged 1gSAR (green curve)	0.655
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of the measured SAR at *Plimit* (last column in Table 6-2).	

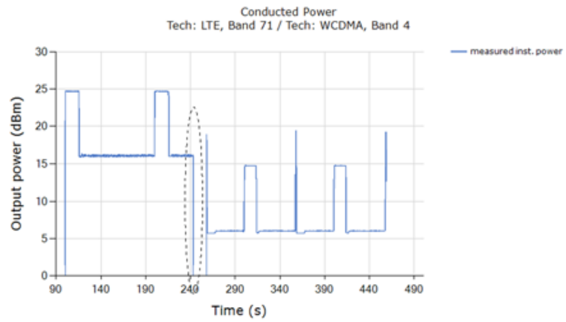
The test result validated the continuity of power limiting in call change scenario.

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 71, Antenna 4, DSI = 1 to WCDMA Band 4, Antenna 1b, DSI = 1. 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).

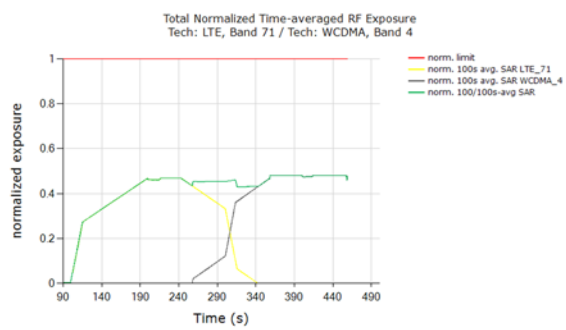
Test result for change in technology/band:

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed from LTE Band 71, Antenna 4, DSI = 1 $P_{reserve}$ level to WCDMA Band 4, Antenna 1b, DSI = 1 $P_{reserve}$ level (within 1 dB device uncertainty):



Note: As per the manufacturer, *Reserve_power_margin* = 3 dB. Based on Table 6-1, EFS *Plimit* = 19.50dBm for LTE Band 71 (Ant 4, DSI=1), and EFS *Plimit* = 8.70 dBm for WCDMA Band 4 (Ant 1b, DSI=1), 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 10.8 dB (within 1 dB of sub6 radio design related uncertainty). Therefore, the conducted power plot shows expected transition in Tx power.

Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (4a), (4b) and (4c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the normalized FCC limit of 1:



	(W/kg)
FCC normalized SAR limit	1.0
Max 100s-time averaged normalized SAR (green curve)	0.482
Validated	

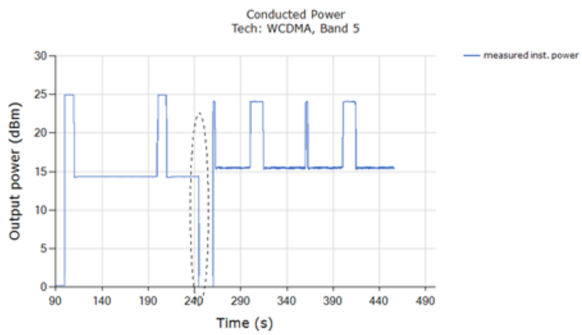
The test result validated the continuity of power limiting in technology/band switch scenario.

7.4 Change in Antenna

This test was conducted with callbox requesting maximum power, and with a antenna switch from WCDMA Band 5, Antenna 4, DSI = 1 to WCDMA Band 5, Antenna 2, DSI = 1. 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).

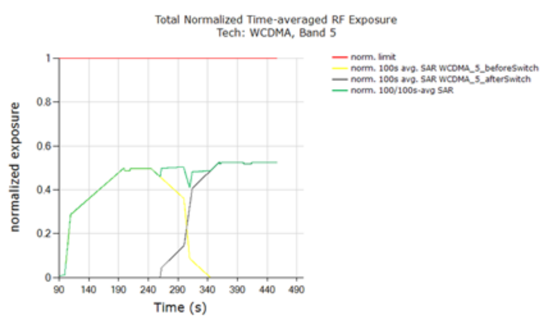
<u>Test result for change in antenna:</u>

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed from WCDMA Band 5, Antenna 4, DSI = 1 $P_{reserve}$ level to WCDMA Band 5, Antenna 2, DSI = 1 $P_{reserve}$ level (within 1 dB device uncertainty):



Note: As per the manufacturer, *Reserve_power_margin* = 3 dB. Based on Table 6-1, EFS *Plimit* = 17.4dBm for WCDMA Band 5, Antenna 4 (DSI=1), and EFS *Plimit* = 18.3 dBm for WCDMA Band 5, Antenna 2 (DSI=1), 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 0.9 dB (within 1 dB of sub6 radio design related uncertainty). Therefore, the conducted power plot shows expected transition in Tx power.

Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (4a), (4b) and (4c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the normalized FCC limit of 1:



	(W/kg)
FCC normalized SAR limit	1.0
Max 100s-time averaged normalized SAR (green curve)	0.526
Validated	

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

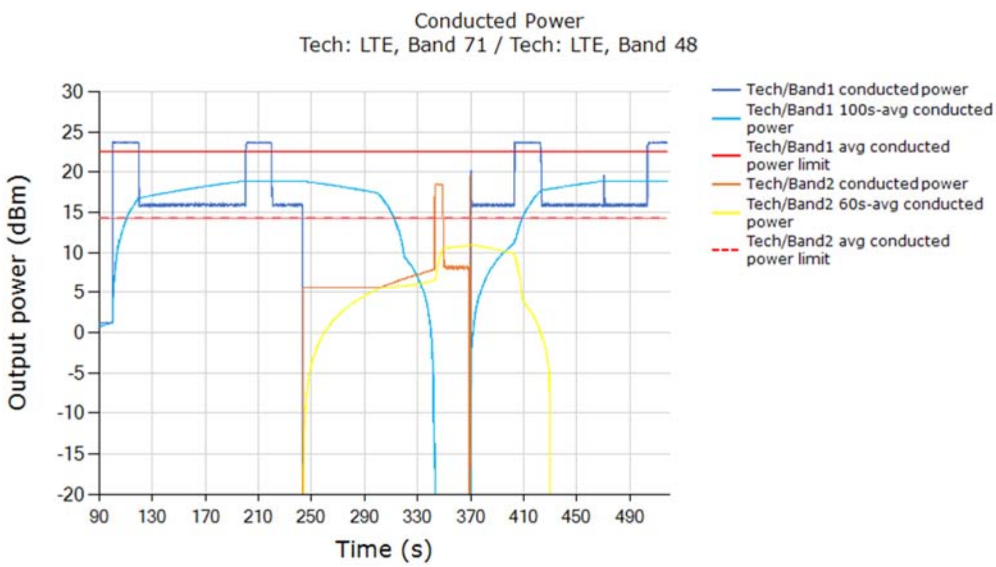
7.5 Change in Time window switch test results

This test was conducted with callbox requesting maximum power, and with time-window switch between LTE Band 71, Antenna 2, DSI = 1 (100s window) and LTE Band 48, Antenna 2, DSI = 1 (60s window). Following procedure detailed in Section 4.3.6, and using the measurement setup shown in Figure 5-1(b), the time-window switch via tech/band/antenna switch was performed when the EUT is transmitting at $P_{reserve}$ level.

7.5.1 Test case 1: transition from LTE Band 71 to LTE Band 48 (i.e., 100s to 60s), then back to LTE Band 71

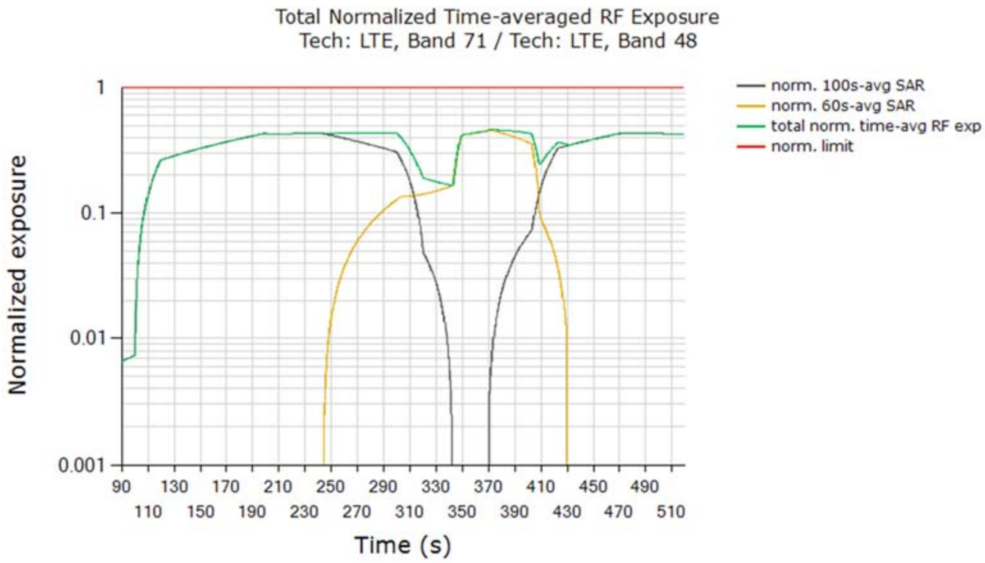
Test result for change in time-window (from 100s to 60s to 100s):

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when LTE Band 71 switches to LTE Band 48 (~250 seconds timestamp) and switches back to LTE Band 71 (~370s seconds timestamp):



Plot Notes: As per the manufacturer, *Reserve_power_margin* = 3dB. Based on Table 6-1, EFS *Plimit* = 19.10 dBm for LTE Band 71, Antenna 2, DSI = 1 (100s window), and EFS *Plimit* = 10.70 dBm for LTE Band 48, Antenna 2, DSI = 1 (60s window). The conducted power plot shows expected transitions in Tx power at ~250 seconds (100s-to-60s transition) and at ~370 seconds (60s-to-100s transition) in order to maintain total time-averaged RF exposure compliance across time windows, as show in next plot.

Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (5a), (5b) and (5c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (5a) is used to convert the Tx power of device to obtain 100s-averaged normalized SAR in LTE Band 71 as shown in black curve. Similarly, equation (5b) is used to obtain 60s-averaged normalized SAR in LTE B48 as shown in orange curve. Equation (5c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



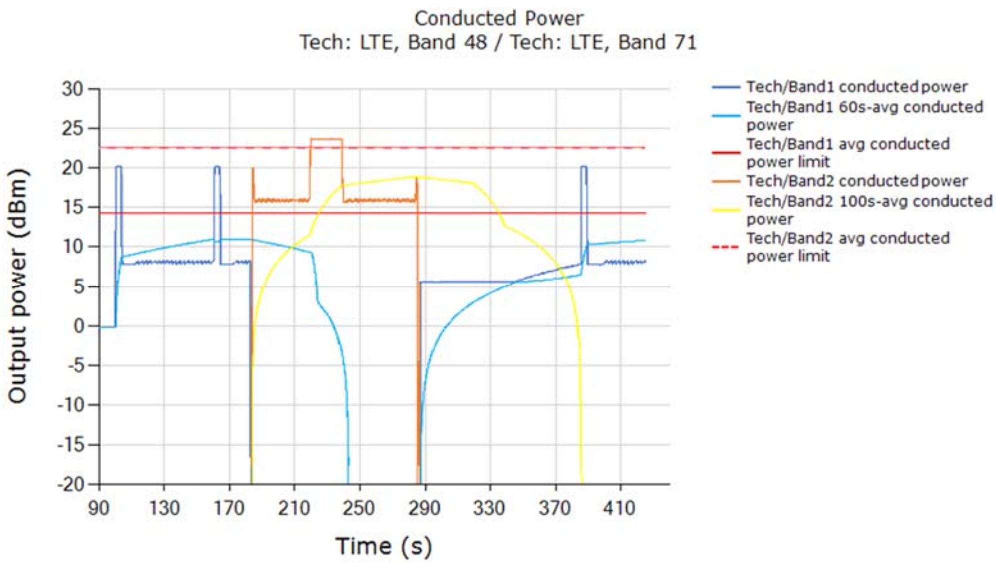
	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.462
Validated	

Plot Notes: Maximum power is requested by callbox for the entire duration of the test, with tech/band switches from 100s-to-60s window at ~250s time stamp, and from 60s-to-100s window at ~370s time stamp. Smart Transmit controls the Tx power during these time-window switches to ensure total time-averaged RF exposure, i.e., sum of black and orange curves given by equation (5c), is always compliant. In time-window switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1 dB device uncertainty. In this test, with a maximum normalized SAR of 0.462 being ≤ 0.63 (= 0.8/1.6 + 1 dB device uncertainty), the above test result validated the continuity of power limiting in time-window switch scenario.

7.5.2 Test case 2: transition from LTE Band 48 to LTE Band 71 (i.e., 60s to 100s), then back to LTE Band 48

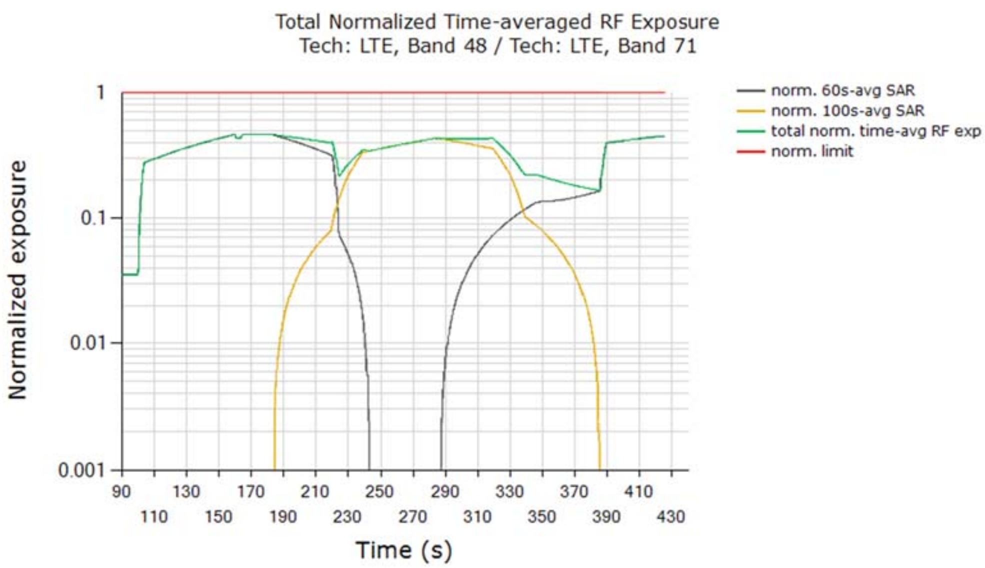
Test result for change in time-window (from 60s to 100s to 60s):

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when LTE Band 48 switches to LTE Band 71 (~190 seconds timestamp) and switches back to LTE Band 48 (~290 seconds timestamp):



Note: As per the manufacturer, *Reserve_power_margin* = 3dB. Based on Table 6-1, EFS *Plimit* = 10.70 dBm for LTE Band 48, Ant 2, DSI = 1 (60s window), and EFS *Plimit* = 19.10 dBm for LTE B71, Ant2, DSI = 1 (100s window).The conducted power plot shows expected transitions in Tx power at ~190s (60s-to-100s transition) and at ~290s (100s-to-60s transition) in order to maintain total time-averaged RF exposure compliance across time windows, as show in next plot.

Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (5a), (5b) and (5c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (5a) is used to convert the Tx power of device to obtain 60s-averaged normalized SAR in LTE Band 48 as shown in black curve. Similarly, equation (5b) is used to obtain 100s-averaged normalized SAR in LTE Band 71 as shown in orange curve. Equation (5c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



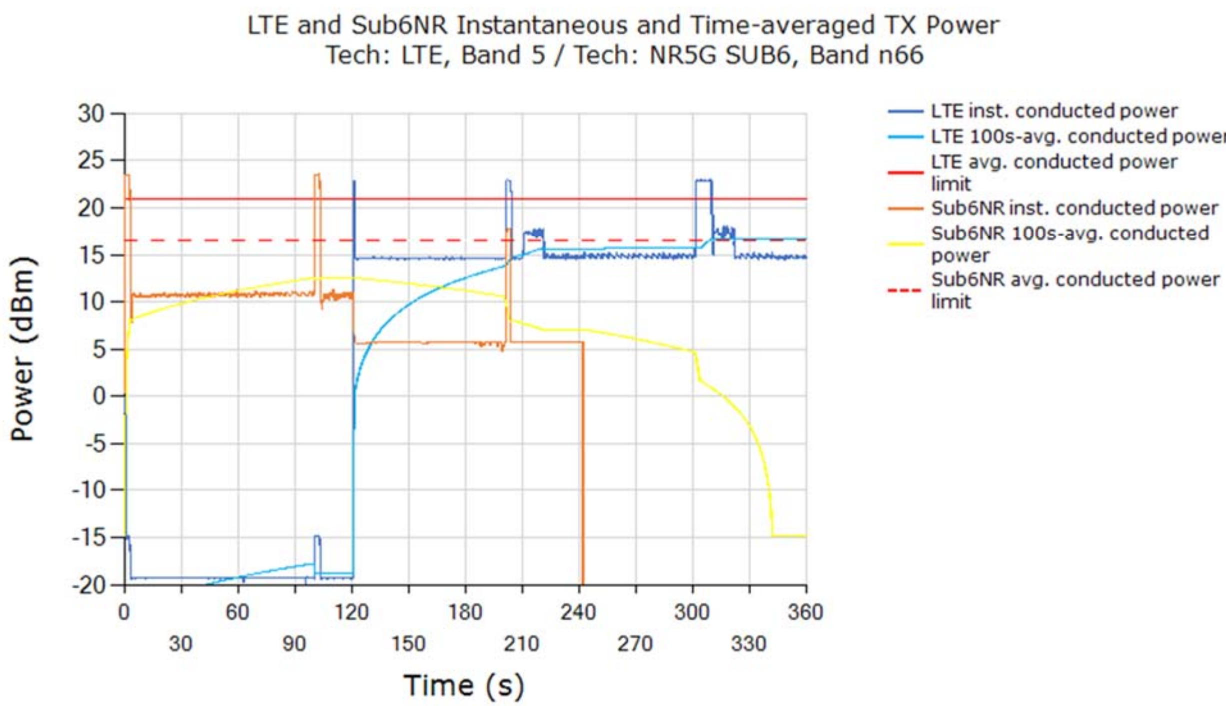
	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.464
Validated	

Plot Notes: Maximum power is requested by callbox for the entire duration of the test, with tech/band switches from 60s-to-100s window at ~190 time stamp, and from 100s-to-60s window at ~290s time stamp. Smart Transmit controls the Tx power during these time-window switches to ensure total time-averaged RF exposure, i.e., sum of black and orange curves given by equation (5c), is always compliant. In time-window switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1 dB device uncertainty. In this test, with a maximum normalized SAR of 0.464 being ≤ 0.63 (= 0.8/1.6 + 1 dB device uncertainty), the above test result validated the continuity of power limiting in time-window switch scenario.

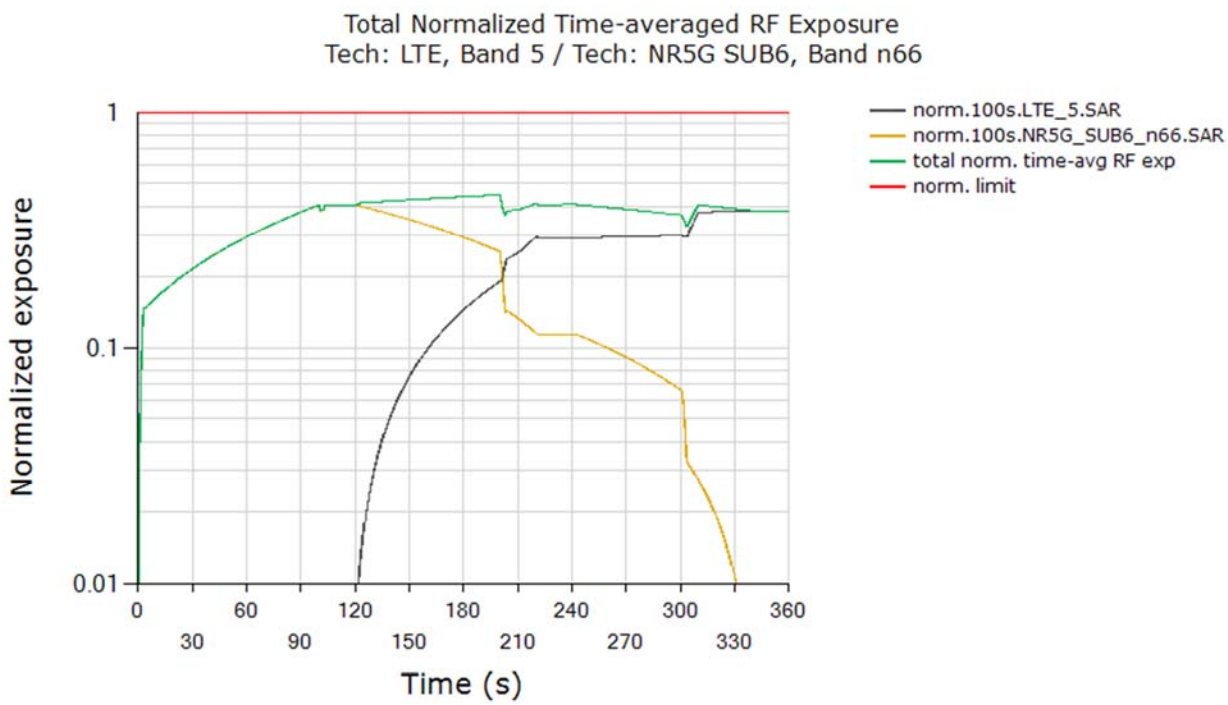
7.6 Switch in SAR exposure test results (ENDC; Same Time Window)

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 5, Antenna 4 + Sub6 NR Band n66, Antenna 3b call. Following procedure detailed in Section 4.3.7 and Appendix F.2, and using the measurement setup shown in Figure 5-1(e) since LTE and Sub6 NR do not share the same antenna port, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios, i.e., in SAR_{sub6NR} only scenario (t =0s ~120s), SAR_{su6NR} + SAR_{LTE} scenario (t =120s ~ 240s) and SAR_{LTE} only scenario (t > 240s).

The Smart Transmit algorithm reserve power from anchor band (LTE B5) for NR (n66). The reservation amount varies based on the anchor band and the NR band. Due to this reservation, anchor band do not reach to the P_{max} power.



Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (5a), (5b) and (5c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (5a) is used to convert the LTE Tx power of device to obtain 100s-averaged normalized SAR in LTE B5 as shown in black curve. Similarly, equation (5b) is used to obtain 100s-averaged normalized SAR in Sub6 NR n66 as shown in orange curve. Equation (5c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



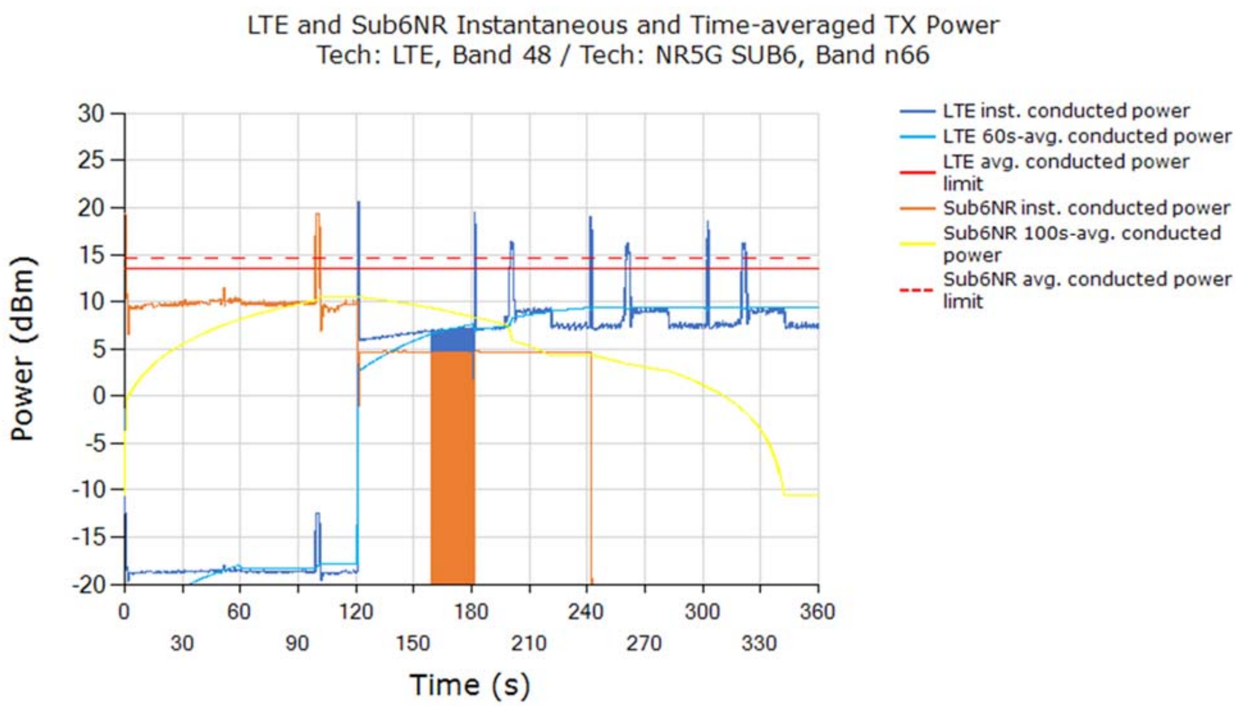
	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.448
Validated	

Plot Notes: Device starts predominantly in Sub6 NR SAR exposure scenario between 0s and 120s, and in LTE SAR + Sub6 NR SAR exposure scenario between 120s and 240s, and in predominantly in LTE SAR exposure scenario after t=240s. For predominantly NR SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.646 W/kg measured SAR at LTE *Plimit* / 1.6W/kg limit = 0.404 ± 1 dB device related uncertainty (see orange curve between 0s~120s). For predominantly LTE SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.712 W/kg measured SAR at LTE *Plimit* / 1.6W/kg limit = 0.445 ± 1 dB device related uncertainty (see black curve after t = 240s). Additionally, in SAR exposure switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1 dB device uncertainty. In this test, with a maximum normalized SAR of 0.448 being ≤ 0.63 (= 0.8/1.6 + 1 dB device uncertainty), the above test result validated the continuity of power limiting in SAR exposure switch scenario.

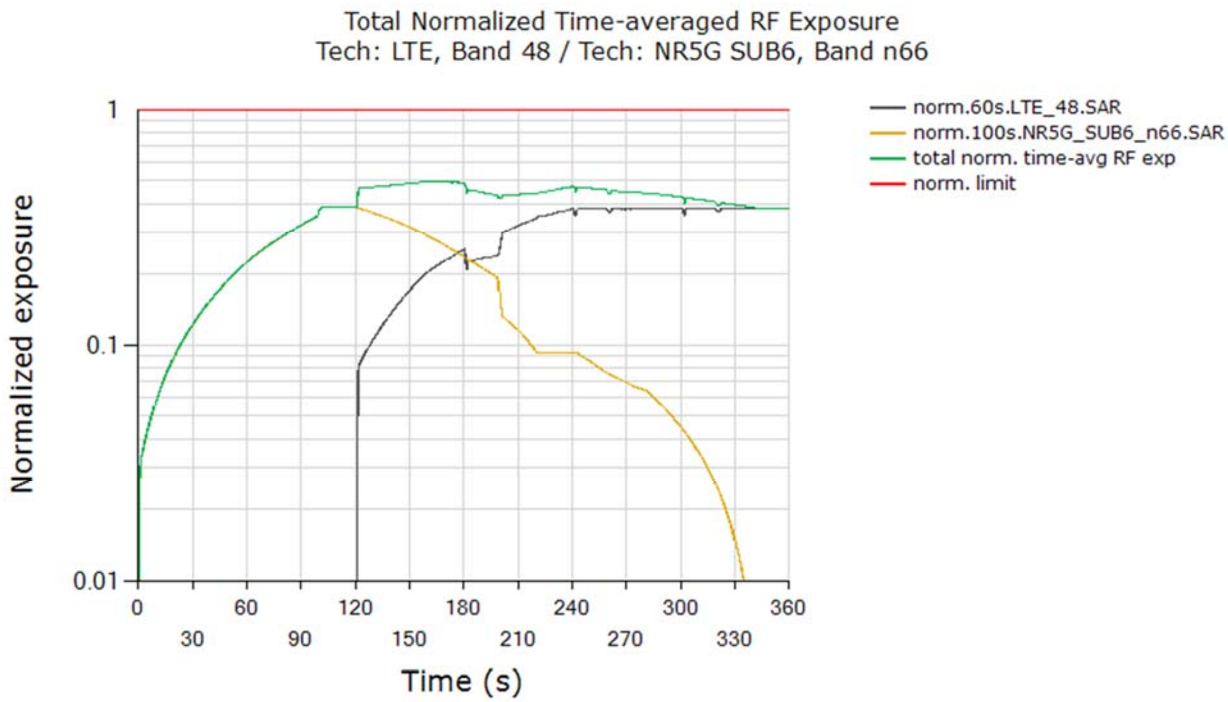
7.7 Switch in SAR exposure test results (ENDC; Different Time Window)

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 48, Antenna 2 + Sub6 NR Band n66, Antenna 1b call. Following procedure detailed in Section 4.3.7 and Appendix F.2, and using the measurement setup shown in Figure 5-1(e) since LTE and Sub6 NR do not share the same antenna port, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios, i.e., in SAR_{sub6NR} only scenario (t =0s ~120s), SAR_{su6NR} + SAR_{LTE} scenario (t =120s ~ 240s) and SAR_{LTE} only scenario (t > 240s).

The Smart Transmit algorithm reserve power from anchor band (LTE B48) for NR (n66). The reservation amount varies based on the anchor band and the NR band. Due to this reservation, anchor band do not reach to the P_{max} power.



Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (5a), (5b) and (5c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (5a) is used to convert the LTE Tx power of device to obtain 60s-averaged normalized SAR in LTE B48 as shown in black curve. Similarly, equation (5b) is used to obtain 100s-averaged normalized SAR in Sub6 NR n66 as shown in orange curve. Equation (5c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



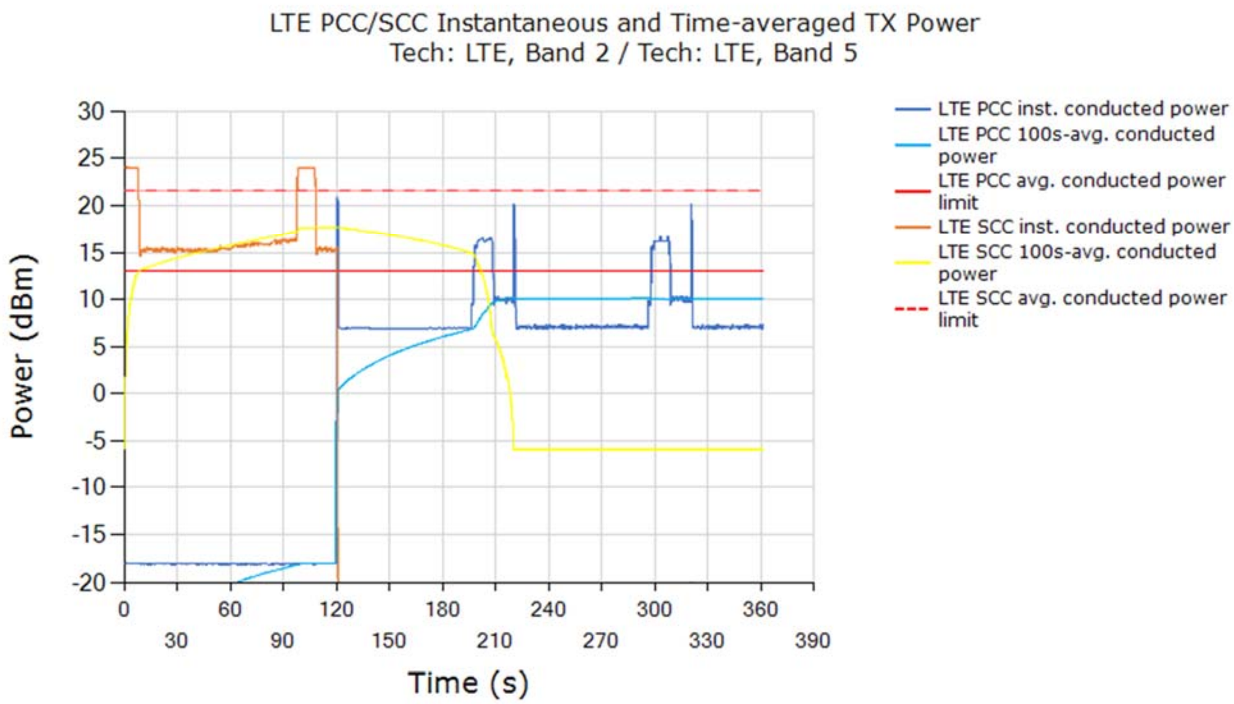
	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.497
Validated	

Plot Notes: Device starts predominantly in Sub6 NR SAR exposure scenario between 0s and 120s, and in LTE SAR + Sub6 NR SAR exposure scenario between 120s and 240s, and in predominantly in LTE SAR exposure scenario after t=240s. For predominantly NR SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.732 W/kg measured SAR at LTE *Plimit* / 1.6W/kg limit = 0.458 ± 1 dB device related uncertainty (see orange curve between 0s~120s). For predominantly LTE SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.719 W/kg measured SAR at LTE *Plimit* / 1.6W/kg limit = 0.449 ± 1 dB device related uncertainty (see black curve after t = 240s). Additionally, in SAR exposure switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1 dB device uncertainty. In this test, with a maximum normalized SAR of 0.497 being ≤ 0.63 (= 0.8/1.6 + 1 dB device uncertainty), the above test result validated the continuity of power limiting in SAR exposure switch scenario.

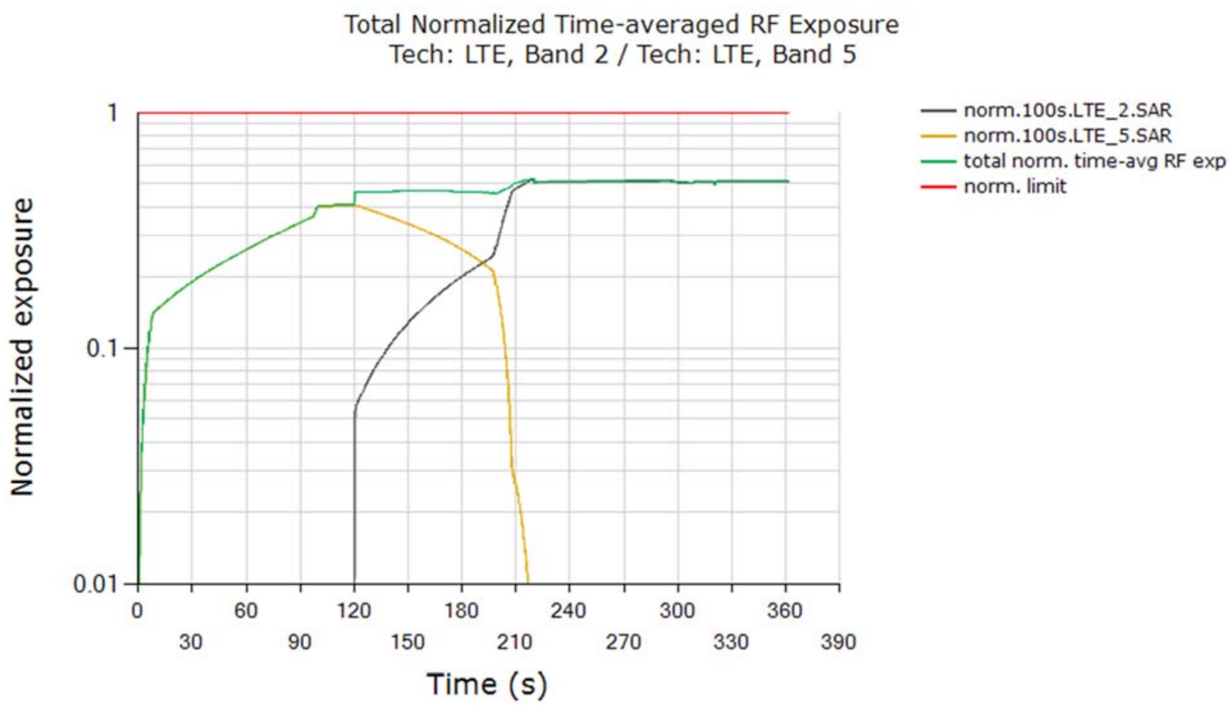
7.8 Switch in SAR exposure test results (Interband ULCA)

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 2 (PCC), Antenna 1b + LTE Band 5 (SCC), Antenna 2 call. The measurement setup shown in Figure 5-1(c) was used because each LTE do not share the same antenna port. The SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios, i.e., in SAR_{SCC} max scenario (t =0s ~120s), SAR_{PCC} + SAR_{SCC} max scenario (t =120s ~ 240s) and SAR_{PCC} max scenario (t > 240s).

The Smart Transmit algorithm reserve power from PCC band (LTE B2) for SCC band (LTE B5). The reservation amount varies based on the PCC band and the SCC band. Due to this reservation, PCC band do not reach to the P_{max} power.



Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (5a), (5b) and (5c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (5a) is used to convert the LTE Tx power of device to obtain 100s-averaged normalized SAR in LTE B2 (PCC) as shown in black curve. Similarly, equation (5b) is used to obtain 100s-averaged normalized SAR in LTE B5 (SCC) as shown in orange curve. Equation (5c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).



	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.528
Validated	

Plot Notes: Device starts predominantly in LTE B2 (SCC) SAR exposure scenario between 0s and 120s, and in LTE B5 (PCC) SAR + LTE B2 (SCC) SAR exposure scenario between 120s and 240s, and in predominantly in LTE B2 (SCC) SAR exposure scenario after t=240s. In SAR exposure switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1 dB device uncertainty. In this test, with a maximum normalized SAR of 0.528 being ≤ 0.63 (= 0.8/1.6 + 1 dB device uncertainty), the above test result validated the continuity of power limiting in SAR exposure switch scenario.

8 SYSTEM VERIFICATION (FREQ < 6 GHZ)

8.1 Tissue Verification

Table 8-1
Measured Tissue Properties

Calibrated for Tests Performed on:	Tissue Type	Tissue Temp During Calibration (°C)	Measured Frequency (MHz)	Measured Conductivity, σ (S/m)	Measured Dielectric Constant, ε	TARGET Conductivity, σ (S/m)	TARGET Dielectric Constant, ε	% dev σ	% dev ε
07/21/2021	750 Body	21.5	680	0.95	55.292	0.958	55.804	-0.84%	-0.92%
			695	0.955	55.256	0.959	55.745	-0.42%	-0.88%
			700	0.957	55.245	0.959	55.726	-0.21%	-0.86%
			710	0.96	55.225	0.96	55.687	0.00%	-0.83%
			725	0.966	55.19	0.961	55.629	0.52%	-0.79%
			750	0.976	55.119	0.964	55.531	1.24%	-0.74%
			770	0.984	55.059	0.965	55.453	1.97%	-0.71%
			785	0.989	55.022	0.966	55.395	2.38%	-0.67%
			800	0.993	54.985	0.967	55.336	2.69%	-0.63%
07/26/2021	750 Body	20.7	680	0.955	54.402	0.958	55.804	-0.31%	-2.51%
			695	0.96	54.37	0.959	55.745	0.10%	-2.47%
			700	0.962	54.357	0.959	55.726	0.31%	-2.46%
			710	0.966	54.338	0.96	55.687	0.63%	-2.42%
			725	0.971	54.299	0.961	55.629	1.04%	-2.39%
			750	0.981	54.219	0.964	55.531	1.76%	-2.36%
			770	0.988	54.175	0.965	55.453	2.38%	-2.30%
			785	0.993	54.151	0.966	55.395	2.80%	-2.25%
			800	0.998	54.124	0.967	55.336	3.21%	-2.19%
07/08/2021	835 Body	21.6	820	0.986	54.052	0.969	55.258	1.75%	-2.18%
			835	0.993	54.016	0.97	55.2	2.37%	-2.14%
			850	0.999	53.985	0.988	55.154	1.11%	-2.12%
07/16/2021	1750 Body	21.5	1710	1.457	53.327	1.463	53.537	-0.41%	-0.39%
			1720	1.466	53.303	1.469	53.511	-0.20%	-0.39%
			1745	1.492	53.258	1.485	53.445	0.47%	-0.35%
			1750	1.497	53.249	1.488	53.432	0.60%	-0.34%
			1770	1.518	53.197	1.501	53.379	1.13%	-0.34%
			1790	1.538	53.134	1.514	53.326	1.59%	-0.36%
07/21/2021	1750 Body	21.5	1710	1.472	53.402	1.463	53.537	0.62%	-0.25%
			1720	1.479	53.385	1.469	53.511	0.68%	-0.24%
			1745	1.496	53.347	1.485	53.445	0.74%	-0.18%
			1750	1.5	53.34	1.488	53.432	0.81%	-0.17%
			1770	1.512	53.304	1.501	53.379	0.73%	-0.14%
			1790	1.526	53.268	1.514	53.326	0.79%	-0.11%
07/26/2021	3600 Body	23.5	3300	3.112	50.001	3.08	51.593	1.04%	-3.09%
			3350	3.163	49.958	3.139	51.525	0.76%	-3.04%
			3450	3.255	49.858	3.256	51.389	-0.03%	-2.98%
			3500	3.3	49.764	3.314	51.321	-0.42%	-3.03%
			3550	3.345	49.72	3.372	51.254	-0.80%	-2.99%
			3560	3.353	49.694	3.384	51.24	-0.92%	-3.02%
			3600	3.395	49.613	3.431	51.186	-1.05%	-3.07%
			3650	3.447	49.539	3.489	51.118	-1.20%	-3.09%
			3690	3.478	49.467	3.536	51.063	-1.64%	-3.13%
			3700	3.49	49.457	3.548	51.05	-1.63%	-3.12%
			3750	3.555	49.387	3.606	50.982	-1.41%	-3.13%
			3900	3.719	49.205	3.781	50.779	-1.64%	-3.10%
			3930	3.756	49.196	3.816	50.738	-1.57%	-3.04%
			4100	3.94	48.977	4.015	50.507	-1.87%	-3.03%
			4150	3.996	48.92	4.073	50.439	-1.89%	-3.01%

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB Publication 865664 D01v01r04 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

8.2 Test System Verification

Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in Appendix C.

Table 8-2
System Verification Results – 1g

System Verification TARGET & MEASURED												
SAR System #	**Tissue Frequency (MHz)**	**Tissue Type**	**Date**	**Amb. Temp (°C)**	**Liquid Temp (°C)**	**Input Power (W)**	**Source SN**	**Probe SN**	**Measured SAR_{1g} (W/kg)**	**1 W Target SAR_{1g} (W/kg)**	**1 W Normalized SAR_{1g} (W/kg)**	**$Deviation_{1g}$ (%)**
AM3	750	BODY	7/21/2021	21.0	21.2	0.200	1097	7490	1.710	8.410	8.550	1.66%
AM3	750	BODY	7/26/2021	22.2	20.7	0.200	1057	7490	1.740	8.640	8.700	0.69%
AM10	850	BODY	7/8/2021	21.6	21.6	0.200	1010	7639	1.970	9.970	9.850	-1.20%
AM3	1750	BODY	7/16/2021	22.5	21.9	0.100	1083	3949	3.670	37.100	36.700	-1.08%
AM3	1750	BODY	7/21/2021	21.0	21.2	0.100	1083	7490	3.840	37.100	38.400	3.50%
AM1	3700	BODY	7/26/2021	22.0	21.9	0.100	1002	3837	6.420	64.700	64.200	-0.77%

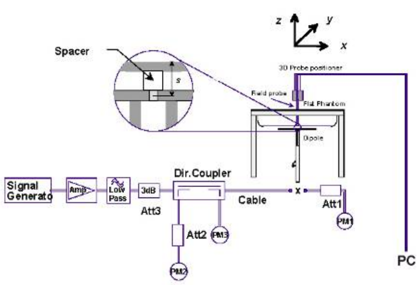


Figure 8-1
System Verification Setup Diagram

Figure 8-2
System Verification Setup Photo

9 SAR TEST RESULTS (FREQ < 6 GHZ)

9.1 Time-varying Tx Power Case

Following Section 4.4 procedure, time-averaged SAR measurements are conducted using a SAR probe at peak location of area scan over 500 seconds. cDASY6 system verification for SAR measurement is provided in Section 10, and the associated SPEAG certificates are attached in Appendix G.

SAR probe integration times depend on the communication signal being tested as defined in the probe calibration parameters.

Since the sampling rate used by cDASY6 for pointSAR measurements is not in user control, the number of points in 100s interval is determined from the scan duration setting in cDASY6 time-average pointSAR measurement by (100s cDASY6_scan_duration * total number of pointSAR values recorded). Running average is performed over these number of points in excel spreadsheet to obtain 100s averaged point SAR.

Following Section 4.4, for each of selected technology/band (listed in Table 6-2):

8. With *Reserve_power_margin* set to 0 dB, area scan is performed at P_{limit}, and time-averaged pointSAR measurements are conducted to determine the pointSAR at P_{limit} at peak location, denoted as *point*SAR$_{Plimit}$.
9. With *Reserve_power_margin* set to actual (intended) value, two more time-averaged pointSAR measurements are performed at the same peak location for test sequences 1 and 2.

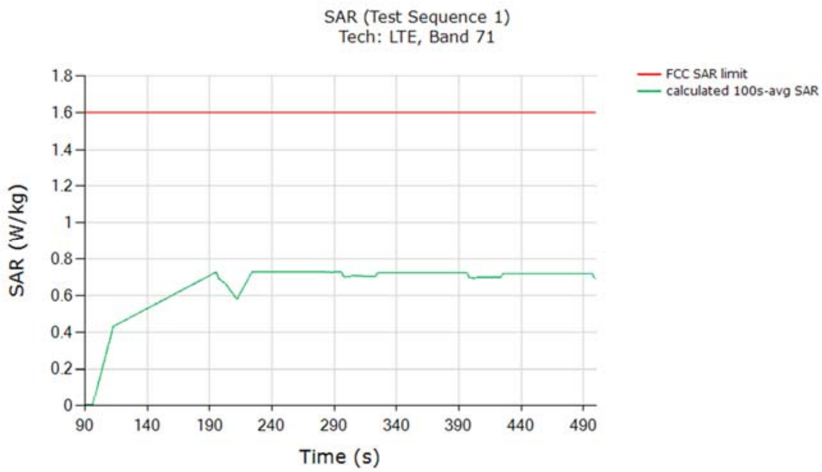
To demonstrate compliance, all the pointSAR measurement results were converted into 1gSAR or 10gSAR values by using Equation (2a), rewritten below:

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \qquad (2a)$$

where, $pointSAR(t)$, $pointSAR\_P_{limit}$, and $1g\_or\_10gSAR\_P_{limit}$ correspond to the measured instantaneous point SAR, measured point SAR at P_{limit} from above step 1 and 2, and measured *1gSAR* or 10gSAR values at P_{limit} obtained from Part 1 report and listed in Table 6-2 of this report.

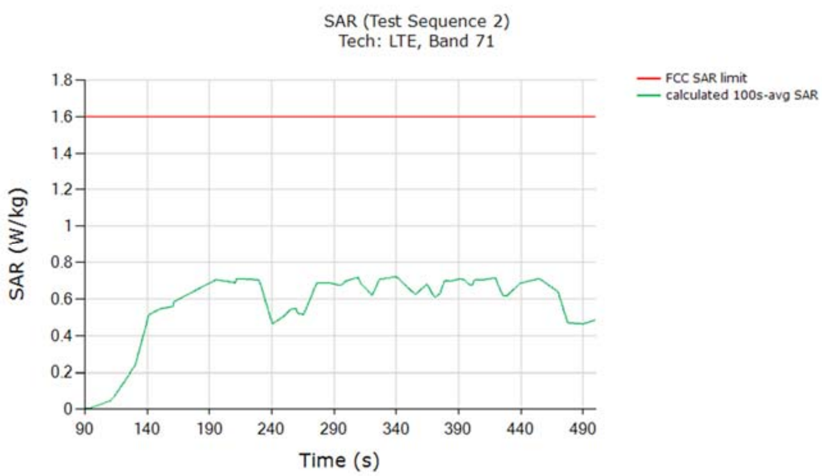
9.1.1 LTE Band 71 Ant 4

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.728
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).	

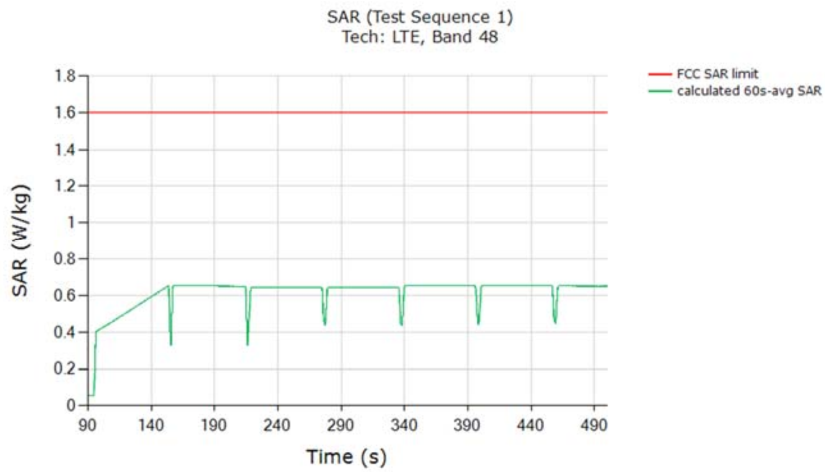
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.721
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).	

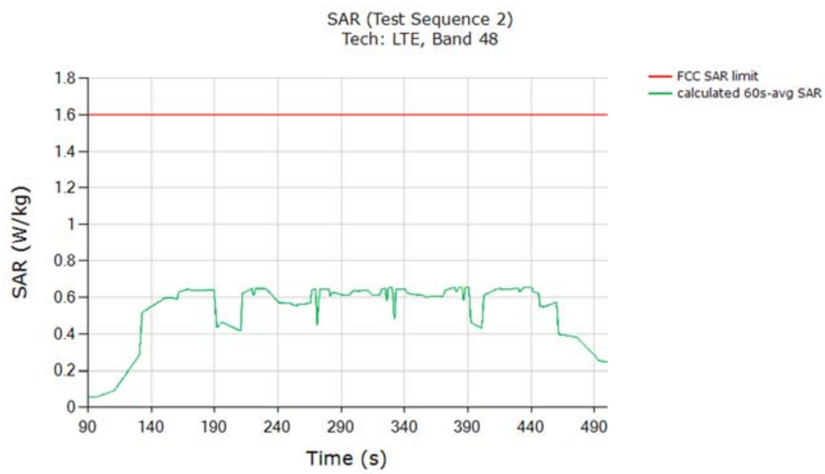
9.1.2 LTE Band 48 Ant 4

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged point 1gSAR (green curve)	0.656
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).	

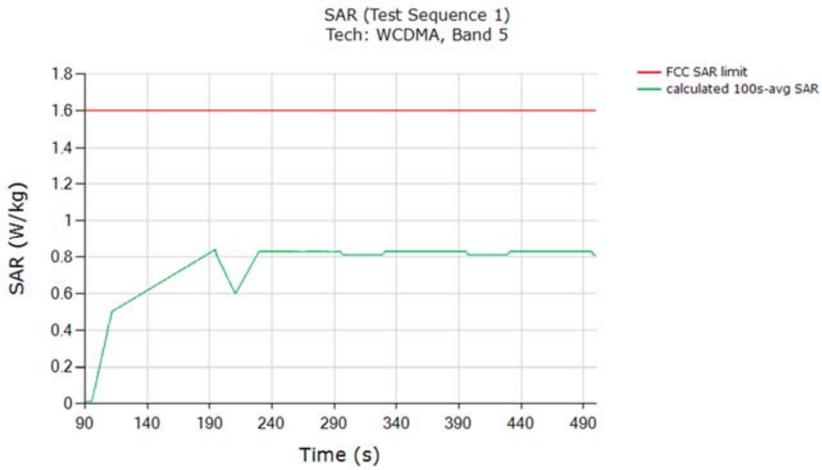
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (green curve)	0.653
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).	

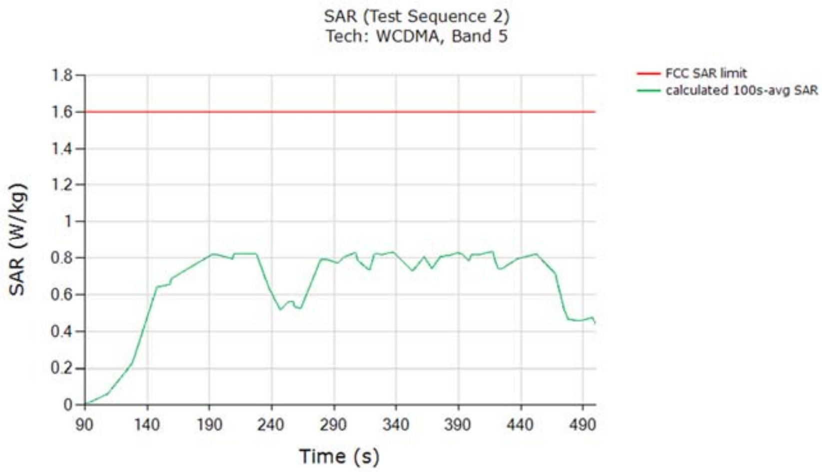
9.1.3 WCDMA Band 5 Ant 2

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.839
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).	

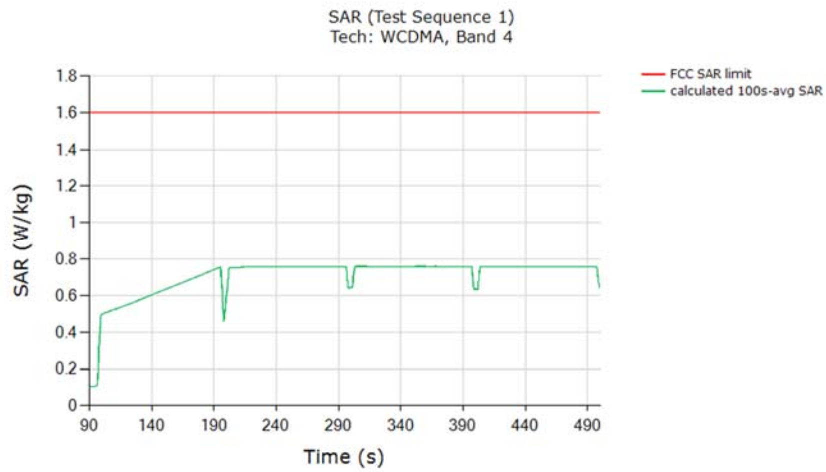
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.834
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).	

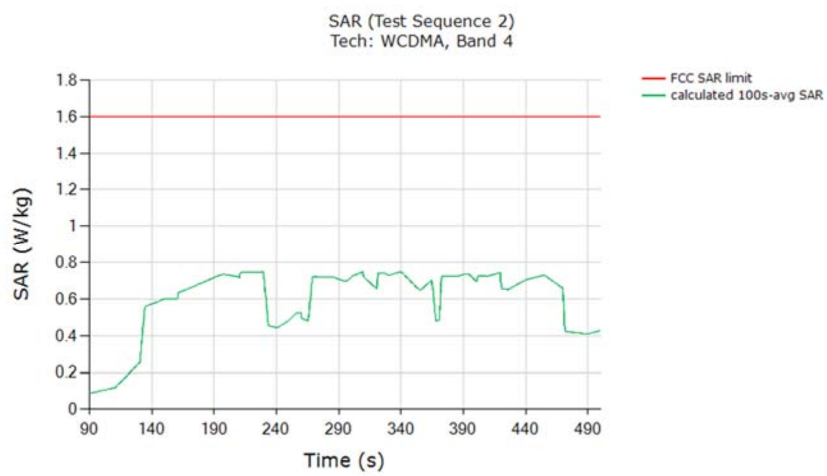
9.1.4 WCDMA Band 4 Ant 1b

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.759
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).	

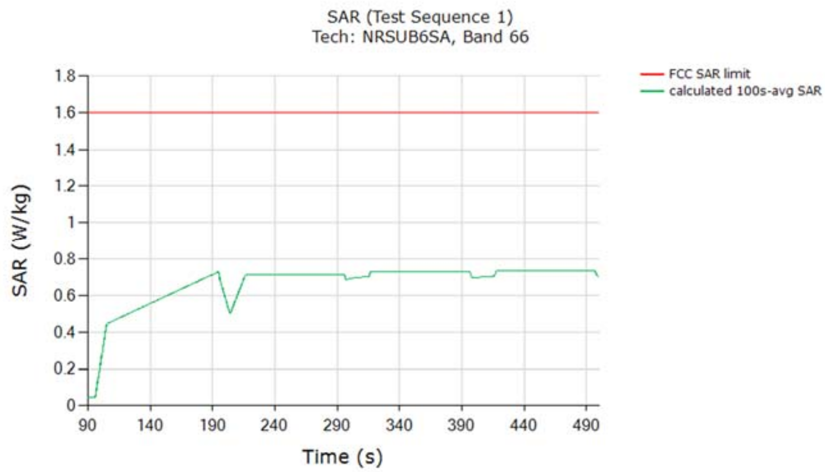
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.748
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).	

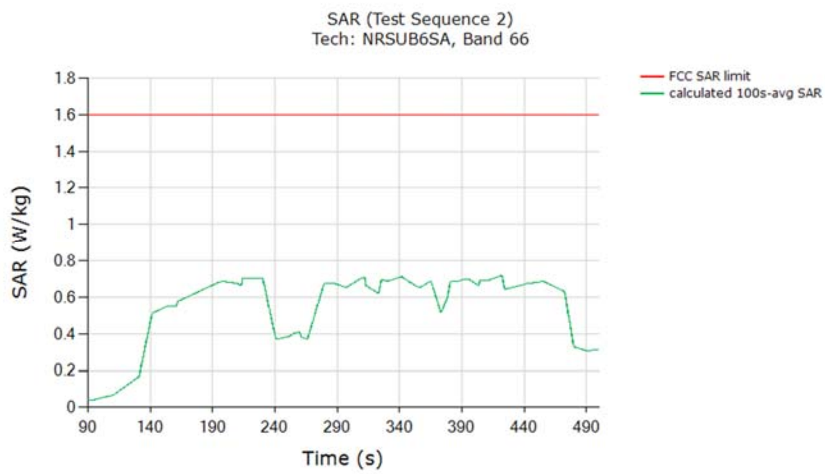
9.1.5 NR n66 SA Ant 1b

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.736
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).	

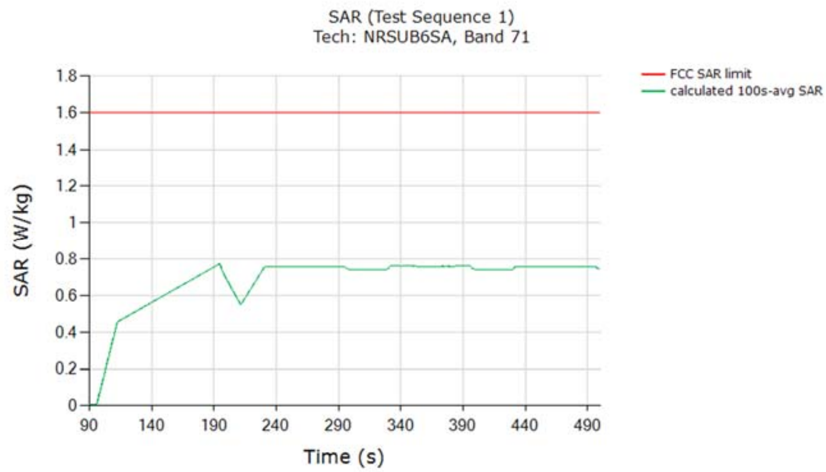
SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.718
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).	

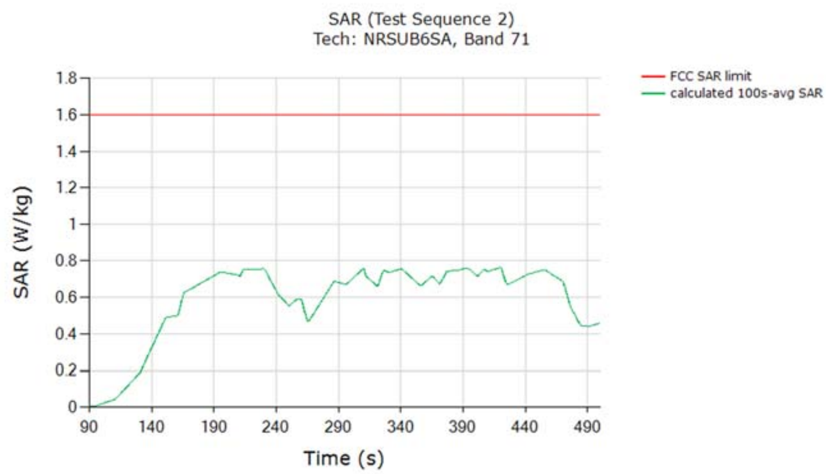
9.1.6 NR n71 SA Ant 4

SAR test results for test sequence 1:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged point 1gSAR (green curve)	0.789
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of the measured SAR at *Plimit* (last column in Table 6-2).	

SAR test results for test sequence 2:



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (green curve)	0.762
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of the measured SAR at *Plimit* (last column in Table 6-2).	

10 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/16/2020	Annual	9/16/2021	MY40000670
Agilent	E4438C	ESG Vector Signal Generator	12/2/2020	Annual	12/2/2021	MY42081752
Agilent	E5515C	Wireless Communications Test Set	12/15/2020	Annual	12/15/2021	GB42361078
Agilent	E4440A	PSA Series Spectrum Analyzer	1/29/2021	Annual	1/29/2022	MY46186272
Agilent	E4438C	ESG Vector Signal Generator	9/29/2020	Annual	9/29/2021	MY45093852
Agilent	N5182A	MXG Vector Signal Generator	9/25/2020	Annual	9/25/2021	US46240505
Agilent	N5182A	MXG Vector Signal Generator	12/1/2020	Annual	12/1/2021	MY47420837
Agilent	N9020A	MXA Signal Analyzer	12/21/2020	Annual	12/21/2021	MY50200571
Amplifier Research	150A100C	Amplifier	CBT	N/A	CBT	350132
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	ML2495A	Power Meter	11/3/2020	Annual	11/3/2021	1039008
Anritsu	MA24106A	USB Power Sensor	9/15/2020	Annual	9/15/2021	1244515
Anritsu	MT8820C	Radio Communication Analyzer	9/30/2020	Annual	9/30/2021	6201240328
Anritsu	MA24106A	USB Power Sensor	10/14/2020	Annual	10/14/2021	1827530
Anritsu	MA24106A	USB Power Sensor	12/18/2020	Annual	12/18/2021	1827532
Anritsu	MA24106A	USB Power Sensor	9/15/2020	Annual	9/15/2021	1827526
Anritsu	MA24106A	USB Power Sensor	9/15/2020	Annual	9/15/2021	1827527
Anritsu	MA2411B	Pulse Power Sensor	12/18/2020	Annual	12/18/2021	1126066
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670646
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
Control Company	4040	Therm./Clock/Humidity Monitor	3/12/2020	Biennial	3/12/2023	210202100
Control Company	4040	Therm./Clock/Humidity Monitor	3/12/2020	Biennial	3/12/2023	210202151
Rohde & Schwarz	SMBV100A	VECTOR SIGNAL GENERATOR	12/1/2020	Annual	12/1/2021	263201
Keysight	E7515B	UXM 5G WIRELESS TEST PLATFORM	11/14/2020	Annual	11/14/2021	MY60192562
Keysight Technologies	AT/N6705B	DC Power Supply	CBT	N/A	CBT	MY53001315
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Rosenberger	32W1006-016	Torque Wrench	12/1/2020	Annual	12/1/2021	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	10/16/2020	Annual	10/16/2021	101699
Rohde & Schwarz	CMW500	Radio Communication Tester	10/16/2020	Annual	10/16/2021	106578
Rohde & Schwarz	CMW500	Radio Communication Tester	10/27/2020	Annual	10/27/2021	108843
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670646
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
Insize	1108-150	Digital Caliper	1/17/2020	Biennial	1/17/2022	409193536
MCL	BW-N10W5+	10dB Attenuator	CBT	N/A	CBT	1611
SPEAG	DAKS-3.5	Portable DAK	9/9/2020	Annual	9/9/2021	1045
MCL	BW-N3W5+	3dB Attenuator	CBT	N/A	CBT	1812
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1311
Mini-Circuits	NLP-1000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	ZHDC-16-63-S+	50-6000MHz Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	4/27/2021	Annual	4/27/2022	167285
Rohde & Schwarz	FSP-7	Spectrum Analyzer	1/9/2020	Biennial	1/9/2022	100990
Rohde& Schwarz	CMW500	Wideband Radio Communication Tester	9/17/2020	Annual	9/17/2021	145663
SPEAG	MAIA	Modulation and Audio Interference Analyzer	CBT	N/A	CBT	1237
Rosenberger	32W1006-016	Torque Wrench	12/1/2020	Annual	12/1/2021	N/A
SPEAG	DAKS-3.5	Portable DAK	9/9/2020	Annual	9/9/2021	1045
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/11/2021	Annual	5/11/2022	728
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/11/2021	Annual	1/11/2022	1646
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/13/2021	Annual	1/13/2022	793
SPEAG	EX3DV4	SAR Probe	12/15/2020	Annual	12/15/2021	7490
SPEAG	EX3DV4	SAR Probe	3/3/2021	Annual	3/3/2022	7639
SPEAG	EX3DV4	SAR Probe	8/19/2020	Annual	8/19/2021	3949
SPEAG	EX3DV4	SAR Probe	1/18/2021	Annual	1/18/2022	3837
SPEAG	D750V3	750 MHz SAR Dipole	9/8/2020	Annual	9/8/2021	1097
SPEAG	D750V3	750 MHz SAR Dipole	6/20/2019	Triennial	6/20/2022	1057
SPEAG	D850V2	850 MHz SAR Dipole	9/8/2020	Annual	9/8/2021	1010
SPEAG	D1750V2	1750 MHz SAR Dipole	6/19/2019	Triennial	6/19/2022	1083
SPEAG	D3700V2	3700 MHz SAR Dipole	10/17/2019	Biennial	10/17/2021	1002
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2021	Annual	5/12/2022	1070
SPEAG	DAK-12	Dielectric Assessment Kit (10MHz - 3GHz)	11/12/2020	Annual	11/12/2021	1121
SPEAG	DAKS-3.5	Portable DAK	9/9/2020	Annual	9/9/2021	1045
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	12/5/2020	Annual	12/5/2021	109961
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	12/5/2020	Annual	12/5/2021	109956
Rohde & Schwarz	NRP50S	3-Path Dipole Power Sensor	12/11/2020	Annual	12/11/2021	101350

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.

11 MEASUREMENT UNCERTAINTIES

For SAR Measurements

a	c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Uncertainty Component	Tol. (± %)	Prob. Dist.	Div.	c_i 1gm	c_i 10 gms	1gm u_i (± %)	10gms u_i (± %)	v_i
Measurement System								
Probe Calibration	6.55	N	1	1.0	1.0	6.6	6.6	∞
Axial Isotropy	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	2.0	R	1.73	1.0	1.0	1.2	1.2	∞
Linearity	0.3	N	1	1.0	1.0	0.3	0.3	∞
System Detection Limits	0.25	R	1.73	1.0	1.0	0.1	0.1	∞
Readout Electronics	0.3	N	1	1.0	1.0	0.3	0.3	∞
Response Time	0.8	R	1.73	1.0	1.0	0.5	0.5	∞
Integration Time	2.6	R	1.73	1.0	1.0	1.5	1.5	∞
RF Ambient Conditions - Noise	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
RF Ambient Conditions - Reflections	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	0.4	R	1.73	1.0	1.0	0.2	0.2	∞
Probe Positioning w/ respect to Phantom	6.7	R	1.73	1.0	1.0	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	4.0	R	1.73	1.0	1.0	2.3	2.3	∞
Test Sample Related								
Test Sample Positioning	2.7	N	1	1.0	1.0	2.7	2.7	35
Device Holder Uncertainty	1.67	N	1	1.0	1.0	1.7	1.7	5
Output Power Variation - SAR drift measurement	5.0	R	1.73	1.0	1.0	2.9	2.9	∞
SAR Scaling	0.0	R	1.73	1.0	1.0	0.0	0.0	∞
Phantom & Tissue Parameters								
Phantom Uncertainty (Shape & Thickness tolerances)	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	4.2	N	1	0.78	0.71	3.3	3.0	10
Liquid Permittivity - measurement uncertainty	4.1	N	1	0.23	0.26	1.0	1.1	10
Liquid Conductivity - Temperature Uncertainty	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)		RSS				11.5	11.3	60
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2				23.0	22.6	

12 CONCLUSION

12.1 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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APPENDIX A: SYSTEM VERIFICATION

PCTEST

DUT: Dipole 750.0 MHz; Type: D750V3 - SN1097

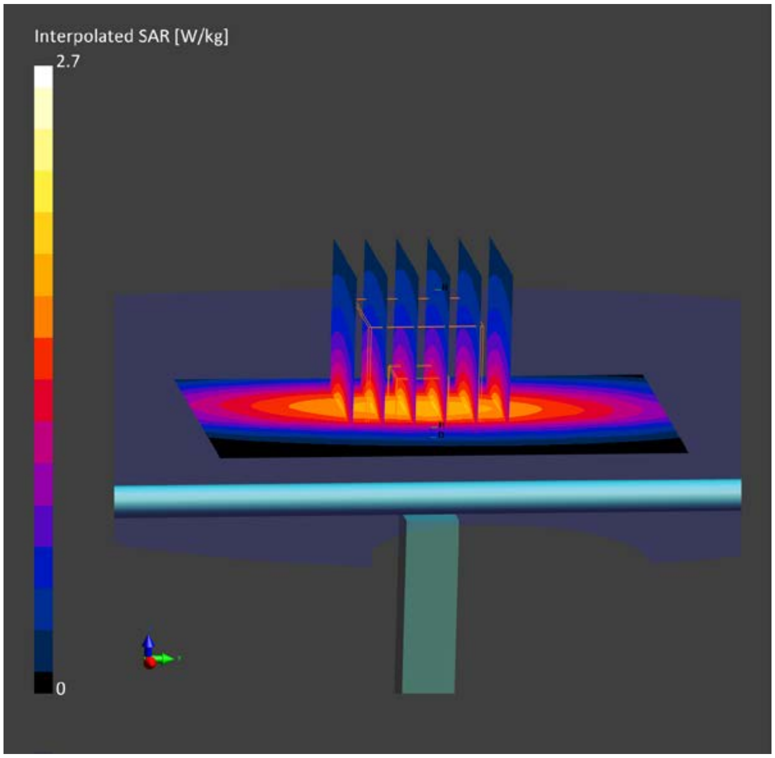
Communication System: UID: 0, CW; Frequency: 750.0 MHz
Medium: 750 Body; Medium parameters used:
f = 750.0 MHz; cond = 0.98 S/m; perm = 55.1; density = 1000 kg/m3
Phantom Section: Flat; Space: 15 mm

Test Date: 07/21/2021; Ambient Temp: 21.0°C; Tissue Temp: 21.2°C

Probe: EX3DV4 - SN7490; ConvF:(10.4,10.4,10.4); Calibrated: 2020-12-15
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn728; Calibrated: 2021-05-11
Phantom: Twin-SAM V8.0; Serial: 1944
Measurement SW: cDASY6 Module SAR V6.14.0.959

750.0 MHz System Verification at 23.0 dBm

Area Scan (60.0 x 90.0): Measurement grid: dx=15.0 mm, dy=15.0 mm
Zoom Scan (30.0 x 30.0 x 30.0): Measurement grid: dx=6.0 mm, dy=6.0 mm, dz=1.5 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 2.70 W/kg
SAR(1 g) = 1.71 W/kg
Deviation (1 g) = 1.66%



PCTEST

DUT: Dipole 750.0 MHz; Type: D750V3 - SN1057

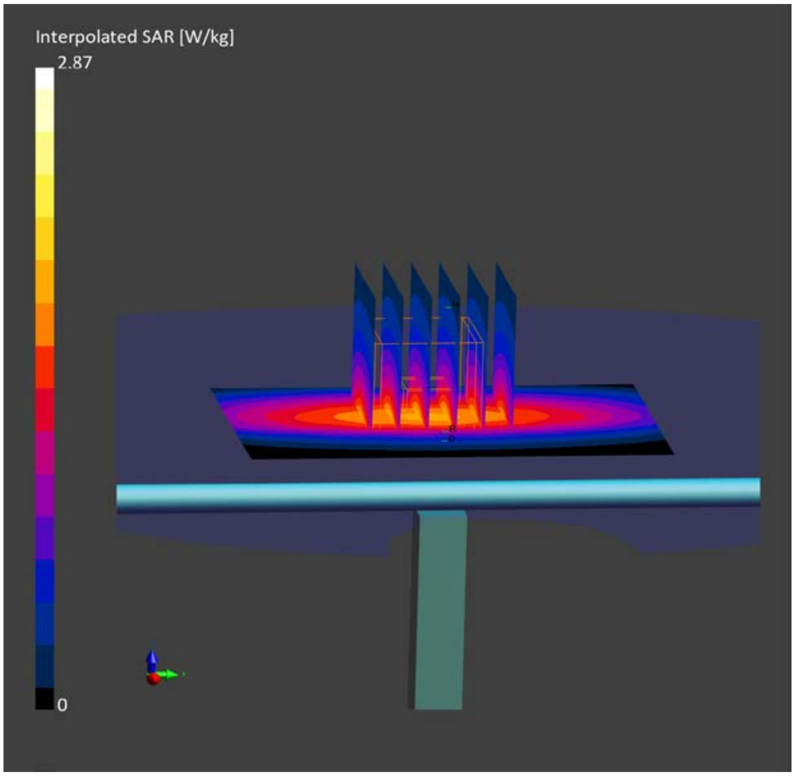
Communication System: UID: 0, CW; Frequency: 750.0 MHz
Medium: 750 Body; Medium parameters used:
f = 750.0 MHz; cond = 0.98 S/m; perm = 54.2; density = 1000 kg/m3
Phantom Section: Flat; Space: 15 mm

Test Date: 07/26/2021; Ambient Temp: 22.2°C; Tissue Temp: 20.7°C

Probe: EX3DV4 - SN7490; ConvF:(10.4,10.4,10.4); Calibrated: 2020-12-15
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn728; Calibrated: 2021-05-11
Phantom: Twin-SAM V8.0; Serial: 1944
Measurement SW: cDASY6 Module SAR V6.14.0.959

750.0 MHz System Verification at 23.0 dBm

Area Scan (60.0 x 90.0): Measurement grid: dx=15.0 mm, dy=15.0 mm
Zoom Scan (30.0 x 30.0 x 30.0): Measurement grid: dx=6.0 mm, dy=6.0 mm, dz=1.5 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 2.87 W/kg
SAR(1 g) = 1.74 W/kg
Deviation (1 g) = 0.69%



PCTEST

DUT: Dipole 850.0 MHz; Type: D850V2 - SN1010

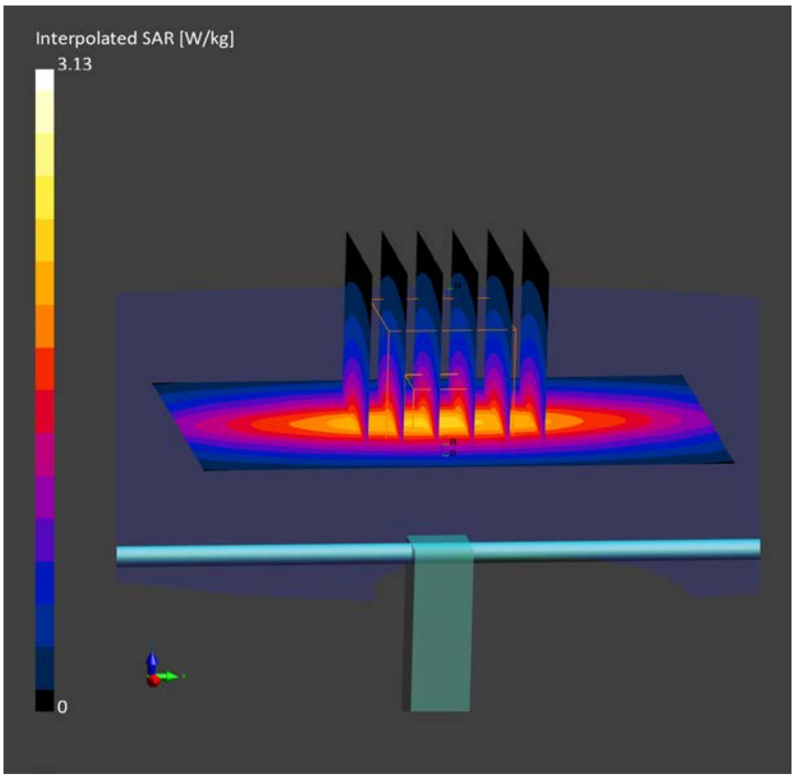
Communication System: UID: 0, CW; Frequency: 850.0 MHz
Medium: 835 Body; Medium parameters used:
f = 850.0 MHz; cond = 1.00 S/m; perm = 54.0; density = 1000 kg/m3
Phantom Section: Flat; Space: 15 mm

Test Date: 07/08/2021; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: EX3DV4 - SN7639; ConvF:(10.53,10.53,10.53); Calibrated: 2021-03-03
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn1646; Calibrated: 2021-01-11
Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 2029
Measurement SW: cDASY6 Module SAR V6.14.0.959

850.0 MHz System Verification at 23.0 dBm

Area Scan (60.0 x 90.0): Measurement grid: dx=15.0 mm, dy=15.0 mm
Zoom Scan (30.0 x 30.0 x 30.0): Measurement grid: dx=6.0 mm, dy=6.0 mm, dz=1.5 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 3.13 W/kg
SAR(1 g) = 1.97 W/kg
Deviation (1 g) = -1.20%



PCTEST

DUT: Dipole 1750.0 MHz; Type: D1750V2 - SN1083

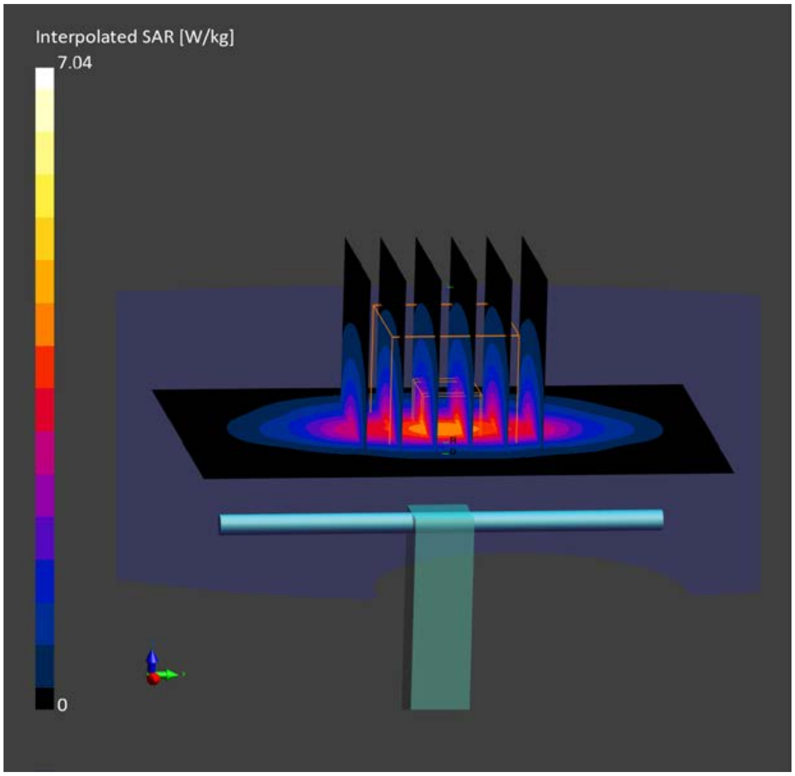
Communication System: UID: 0, CW; Frequency: 1750.0 MHz
Medium: 1750 Body; Medium parameters used:
f = 1750.0 MHz; cond = 1.50 S/m; perm = 53.2; density = 1000 kg/m3
Phantom Section: Flat; Space: 10 mm

Test Date: 07/16/2021; Ambient Temp: 22.5°C; Tissue Temp: 21.9°C

Probe: EX3DV4 - SN3949; ConvF:(8.85,8.85,8.85); Calibrated: 2020-08-19
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn728; Calibrated: 2021-05-11
Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1944
Measurement SW: cDASY6 Module SAR V6.14.0.959

1750.0 MHz System Verification at 20.0 dBm

Area Scan (60.0 x 90.0): Measurement grid: dx=15.0 mm, dy=15.0 mm
Zoom Scan (30.0 x 30.0 x 30.0): Measurement grid: dx=6.0 mm, dy=6.0 mm, dz=1.5 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 7.04 W/kg
SAR(1 g) = 3.67 W/kg
Deviation (1 g) = -1.08%



PCTEST

DUT: Dipole 1750.0 MHz; Type: D1750V2 - SN1083

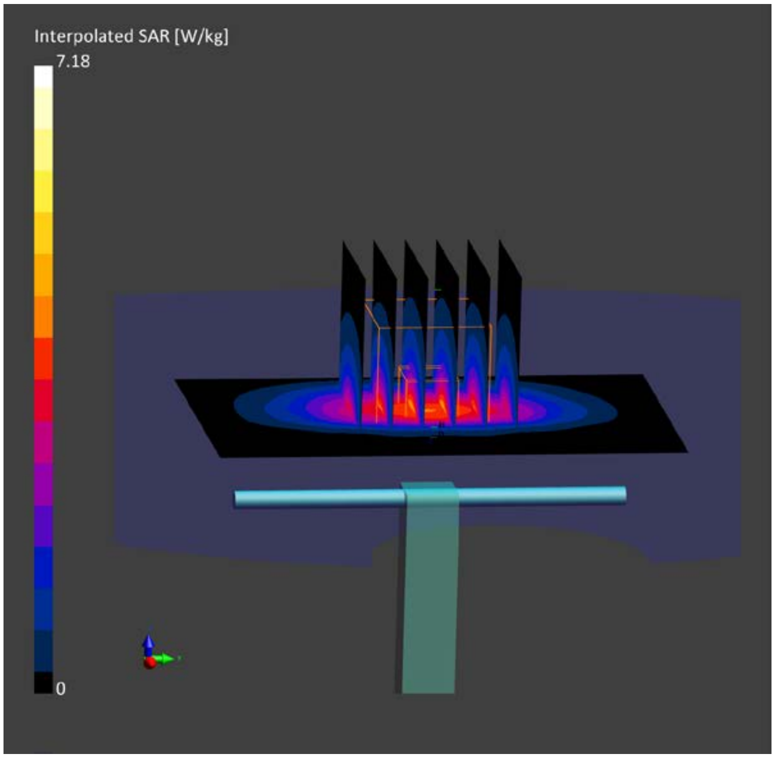
Communication System: UID: 0, CW; Frequency: 1750.0 MHz
Medium: 1750 Body; Medium parameters used:
f = 1750.0 MHz; cond = 1.50 S/m; perm = 53.3; density = 1000 kg/m3
Phantom Section: Flat; Space: 10 mm

Test Date: 07/21/2021; Ambient Temp: 21.0°C; Tissue Temp: 21.2°C

Probe: EX3DV4 - SN7490; ConvF:(8.57,8.57,8.57); Calibrated: 2020-12-15
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn728; Calibrated: 2021-05-11
Phantom: Twin-SAM V8.0; Serial: 1944
Measurement SW: cDASY6 Module SAR V6.14.0.959

1750.0 MHz System Verification at 20.0 dBm

Area Scan (60.0 x 90.0): Measurement grid: dx=15.0 mm, dy=15.0 mm
Zoom Scan (30.0 x 30.0 x 30.0): Measurement grid: dx=6.0 mm, dy=6.0 mm, dz=1.5 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 7.18W/kg
SAR(1 g) = 3.84 W/kg
Deviation (1 g) = 3.50%



PCTEST

DUT: Dipole 3700.0 MHz; Type: D3700V2 - SN1002

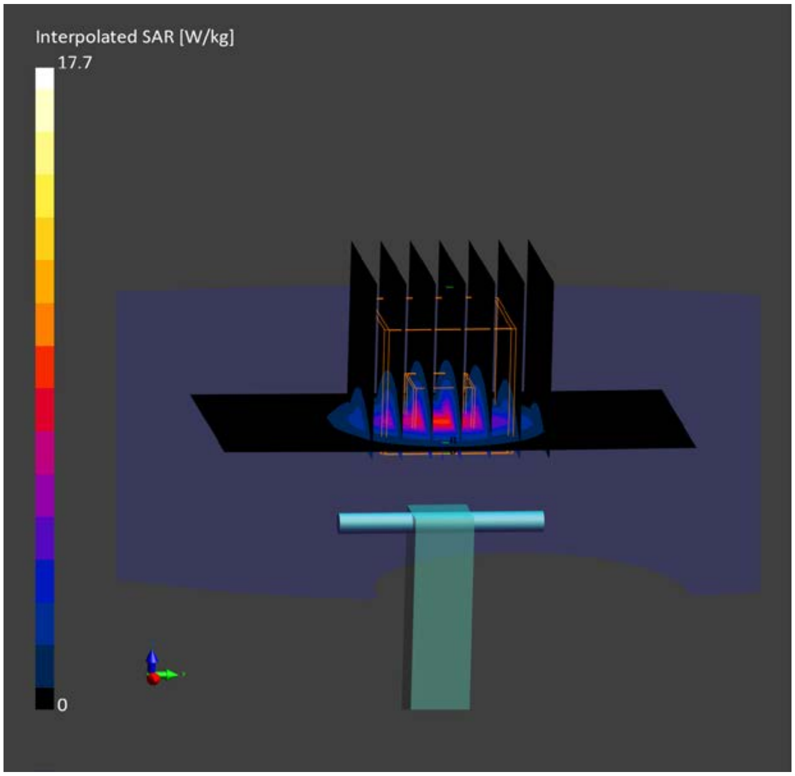
Communication System: UID: 0, CW; Frequency: 3700.0 MHz
Medium: 3600 Body; Medium parameters used:
f = 3700.0 MHz; cond = 3.49 S/m; perm = 49.5; density = 1000 kg/m3
Phantom Section: Flat; Space: 10 mm

Test Date: 07/26/2021; Ambient Temp: 22.0°C; Tissue Temp: 21.9°C

Probe: EX3DV4 - SN3837; ConvF:(6.06,6.06,6.06); Calibrated: 2021-01-18
Sensor-Surface: 1.4mm (VMS + 6p)
Electronics: DAE4 Sn793; Calibrated: 2021-01-13
Phantom: Main; Serial: 1736
Measurement SW: cDASY6 Module SAR V6.14.0.959

3700.0 MHz System Verification at 20.0 dBm

Area Scan (40.0 x 80.0): Measurement grid: dx=10.0 mm, dy=10.0 mm
Zoom Scan (28.0 x 28.0 x 28.0): Measurement grid: dx=5.0 mm, dy=5.0 mm, dz=1.4 mm; Graded Ratio: 1.5
Peak SAR (extrapolated) = 17.7 W/kg
SAR(1 g) = 6.42 W/kg
Deviation (1 g) = -0.77%



APPENDIX B: SAR TISSUE SPECIFICATIONS

Measurement Procedure for Tissue verification:

1) The network analyzer and probe system was configured and calibrated.
2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
3) The complex admittance with respect to the probe aperture was measured
4) The complex relative permittivity ε' can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\varepsilon_r\varepsilon_0}{[\ln(b/a)]^2}\int_a^b\int_a^b\int_0^\pi \cos\phi' \frac{\exp\left[-j\omega r(\mu_0\varepsilon_r^{'}\varepsilon_0)^{1/2}\right]}{r}d\phi' d\rho' d\rho$$

where *Y* is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, ω is the angular frequency, and $j = \sqrt{-1}$.

3 Composition / Information on ingredients

3.2 Mixtures
Description: Aqueous solution with surfactants and inhibitors
Declarable, or hazardous components:

CAS: 107-21-1 EINECS: 203-473-3 Reg.nr.: 01-2119456816-28-0000	**Ethanediol** STOT RE 2, H373; Acute Tox. 4, H302	>1.0-4.9%
CAS: 68608-26-4 EINECS: 271-781-5 Reg.nr.: 01-2119527859-22-0000	**Sodium petroleum sulfonate** Eye Irrit. 2, H319	< 2.9%
CAS: 107-41-5 EINECS: 203-489-0 Reg.nr.: 01-2119539582-35-0000	**Hexylene Glycol / 2-Methyl-pentane-2,4-diol** Skin Irrit. 2, H315; Eye Irrit. 2, H319	< 2.9%
CAS: 68920-66-1 NLP: 500-236-9 Reg.nr.: 01-2119489407-26-0000	**Alkoxylated alcohol, > C_{16}** Aquatic Chronic 2, H411; Skin Irrit. 2, H315; Eye Irrit. 2, H319	< 2.0%

Additional information:
For the wording of the listed risk phrases refer to section 16.
Not mentioned CAS-, EINECS- or registration numbers are to be regarded as Proprietary/Confidential.
The specific chemical identity and/or exact percentage concentration of proprietary components is withheld as a trade secret.

Figure B -1

Note: Liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

Schmid & Partner Engineering AG **s p e a g**

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Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Measurement Certificate / Material Test

Item Name	**Body Tissue Simulating Liquid (MBBL600-6000V6)**
Product No.	SL AAM U16 BC (Batch: 181029-1)
Manufacturer	SPEAG

Measurement Method

TSL dielectric parameters measured using calibrated DAK probe.

Target Parameters

Target parameters as defined in the KDB 865664 compliance standard.

Test Condition

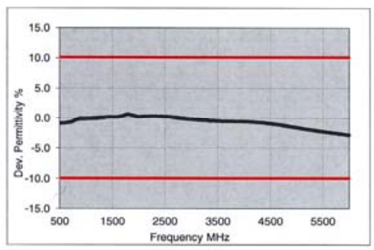
Ambient Condition	22°C ; 30% humidity
TSL Temperature	22°C
Test Date	30-Oct-18
Operator	CL

Additional Information

TSL Density
TSL Heat-capacity

Results

	Measured			Target		Diff.to Target [%]	
f [MHz]	e'	e''	sigma	eps	sigma	Δ-eps	Δ-sigma
800	55.1	21.3	0.95	55.3	0.97	-0.4	-2.1
825	55.1	20.8	0.96	55.2	0.98	-0.3	-2.0
835	55.1	20.6	0.96	55.1	0.99	0.0	-2.5
850	55.1	20.4	0.96	55.2	0.99	-0.1	-3.0
900	55.0	19.7	0.98	55.0	1.05	0.0	-6.7
1400	54.2	15.6	1.22	54.1	1.28	0.2	-4.7
1450	54.1	15.4	1.24	54.0	1.30	0.2	-4.6
1500	54.1	15.3	1.27	53.9	1.33	0.3	-4.5
1550	54.0	15.1	1.30	53.9	1.36	0.2	-4.4
1600	53.9	15.0	1.33	53.8	1.39	0.2	-4.3
1625	53.9	14.9	1.35	53.8	1.41	0.3	-4.3
1640	53.9	14.9	1.36	53.7	1.42	0.3	-4.2
1650	53.8	14.9	1.36	53.7	1.43	0.2	-4.9
1700	53.8	14.8	1.40	53.6	1.46	0.4	-4.1
1750	53.7	14.7	1.43	53.4	1.49	0.5	-4.0
1800	53.7	14.6	1.46	53.3	1.52	0.8	-3.9
1810	53.7	14.6	1.47	53.3	1.52	0.8	-3.3
1825	53.7	14.6	1.48	53.3	1.52	0.8	-2.6
1850	53.6	14.5	1.50	53.3	1.52	0.6	-1.3
1900	53.5	14.5	1.53	53.3	1.52	0.4	0.7
1950	53.5	14.5	1.57	53.3	1.52	0.4	3.3
2000	53.4	14.4	1.60	53.3	1.52	0.2	5.3
2050	53.4	14.4	1.64	53.2	1.57	0.3	4.5
2100	53.3	14.4	1.68	53.2	1.62	0.2	3.7
2150	53.3	14.4	1.72	53.1	1.66	0.4	3.6
2200	53.2	14.4	1.76	53.0	1.71	0.3	2.9
2250	53.1	14.4	1.81	53.0	1.76	0.2	2.8
2300	53.1	14.4	1.85	52.9	1.81	0.4	2.2
2350	53.0	14.5	1.89	52.8	1.85	0.3	2.2
2400	52.9	14.5	1.94	52.8	1.90	0.2	2.1
2450	52.9	14.5	1.98	52.7	1.95	0.4	1.5
2500	52.8	14.6	2.03	52.6	2.02	0.3	0.5
2550	52.7	14.6	2.07	52.6	2.09	0.2	-1.0
2600	52.6	14.7	2.12	52.5	2.16	0.2	-1.9
3500	51.1	15.5	3.02	51.3	3.31	-0.4	-8.8
3700	50.8	15.7	3.24	51.1	3.55	-0.5	-8.8
5200	48.1	18.2	5.27	49.0	5.30	-1.8	-0.6
5250	48.0	18.3	5.34	49.0	5.36	-1.9	-0.4
5300	47.9	18.4	5.41	48.9	5.42	-2.0	-0.2
5500	47.5	18.6	5.70	48.6	5.65	-2.2	0.8
5600	47.3	18.8	5.84	48.5	5.77	-2.3	1.3
5700	47.1	18.9	5.99	48.3	5.88	-2.5	1.8
5800	47.0	19.0	6.14	48.2	6.00	-2.6	2.3



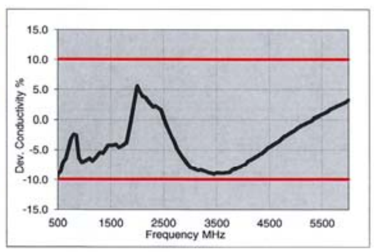


Figure B-2
600 – 5800 MHz Body Tissue Equivalent Matter

APPENDIX C: SAR SYSTEM VALIDATION

Per FCC KDB Publication 865664 D02v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

Table C-1
SAR System Validation Summary – 1g

System Validation														
SAR System	Freq. (MHz)	Date	Probe SN	Probe Cal Point		Cond. (σ)	Perm. (εr)	CW VALIDATION			MOD. VALIDATION		
								SENSITIVITY	PROBE LINEARITY	PROBE ISOTROPY	MOD. TYPE	DUTY FACTOR	PAR
AM3	750	7/21/2021	7490	750	Body	0.98	55.1	PASS	PASS	PASS	N/A	N/A	N/A
AM10	835	5/17/2021	7639	835	Body	0.99	53.7	PASS	PASS	PASS	GMSK	PASS	N/A
AM3	1750	7/16/2021	3949	1750	Body	1.497	53.249	PASS	PASS	PASS	N/A	N/A	N/A
AM3	1750	7/21/2021	7490	1750	Body	1.5	53.3	PASS	PASS	PASS	N/A	N/A	N/A
AM1	3700	5/26/2021	3837	3700	Body	3.57	49.45	PASS	PASS	PASS	TDD	PASS	N/A

NOTE: Probes have been calibrated for both CW and modulated signals. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to FCC KDB Publication 865664 D01v01r04.

APPENDIX E: TEST SEQUENCES

1. Test sequence is generated based on below parameters of the DUT:
   a. Measured maximum power (P_{max})
   b. Measured Tx_power_at_SAR_design_target (P_{limit})
   c. Reserve_power_margin (dB)
      - $P_{reserve}$ (dBm) = measured P_{limit} (dBm) – Reserve_power_margin (dB)
   d. *SAR_time_window* (100s for FCC)
2. Test Sequence 1 Waveform:

   Based on the parameters above, the Test Sequence 1 is generated with one transition between high and low Tx powers. Here, high power = P_{max}; low power = $P_{max}/2$, and the transition occurs after 80 seconds at high power P_{max}. As long as the power enforcement is taking into effective during one 100s/60s time window, the validation test with this defined test sequence 1 is valid, otherwise, select other radio configuration (band/DSI within the same technology group) having lower P_{limit} for this test. The Test sequence 1 waveform is shown below:

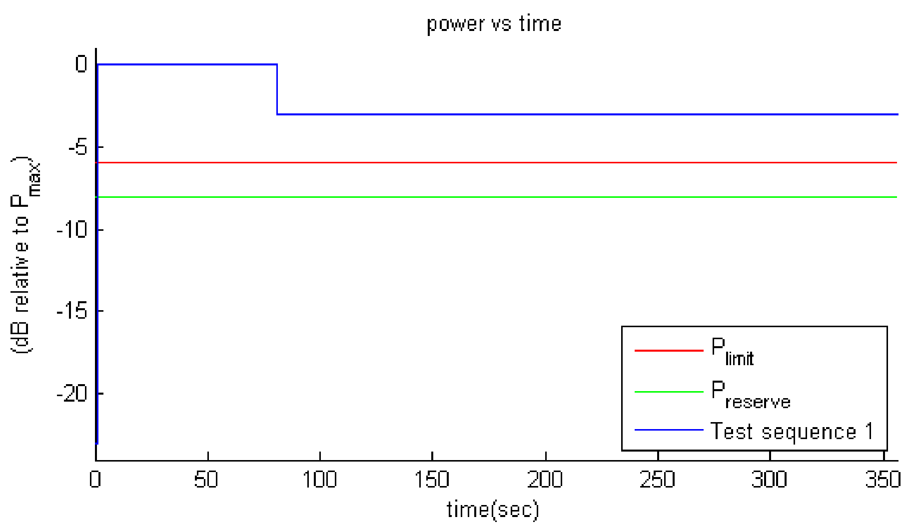


Figure E-1
Test sequence 1 waveform

3. Test Sequence 2 Waveform:

Based on the parameters described above, the Test Sequence 2 is generated as described in Table E-1, which contains two 170 second-long sequences (yellow and green highlighted rows) that are mirrored around the center row of 20s, resulting in a total duration of 360 seconds:

Table E-1
Test Sequence 2

Time duration (seconds)	dB relative to P_{limit} or $P_{reserve}$
15	$P_{reserve}$ – 2
20	P_{limit}
20	$(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step
10	$P_{reserve}$ – 6
20	P_{max}
15	P_{limit}
15	$P_{reserve}$ – 5
20	P_{max}
10	$P_{reserve}$ – 3
15	P_{limit}
10	$P_{reserve}$ – 4
20	$(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step
10	$P_{reserve}$ – 4
15	P_{limit}
10	$P_{reserve}$ – 3
20	P_{max}
15	$P_{reserve}$ – 5
15	P_{limit}
20	P_{max}
10	$P_{reserve}$ – 6
20	$(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step
20	P_{limit}
15	$P_{reserve}$ – 2

The Test Sequence 2 waveform is shown in Figure E-2.

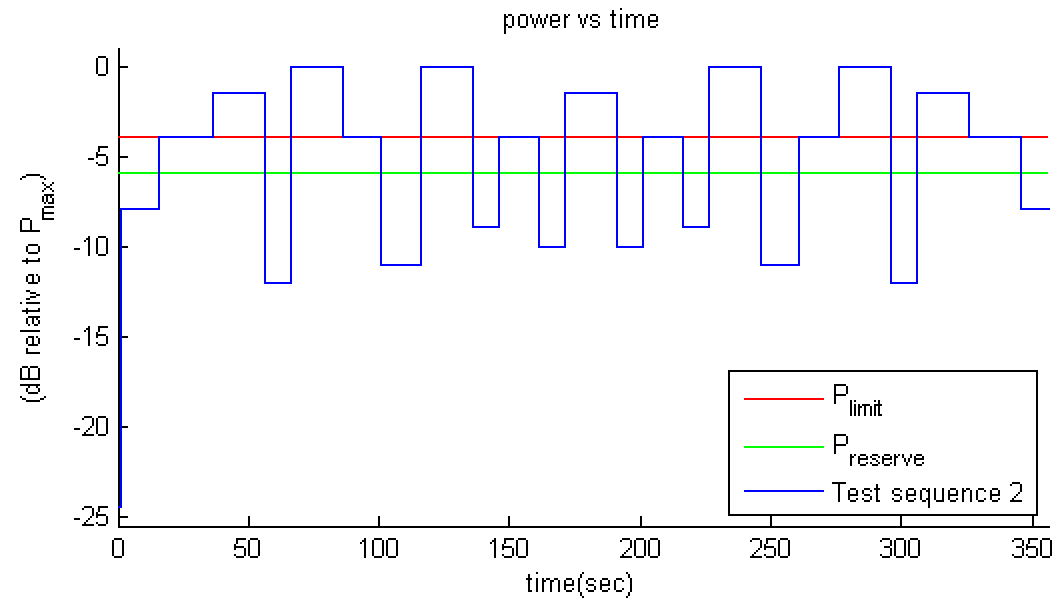


Figure E-2
Test sequence 2 waveform

APPENDIX F: TEST PROCEDURES FOR SUB6 NR + NR RADIO

Appendix F provides the test procedures for validating Qualcomm Smart Transmit feature for LTE + Sub6 NR non-standalone (NSA) mode transmission scenario, where sub-6GHz LTE link acts as an anchor, and Sub6 NR standalone mode (SA) transmission scenario.

F.1 Time-varying Tx power test for sub6 NR in NSA mode and SA mode

Follows Section 4.2.1 to select test configurations for time-varying test. This test is performed with two pre-defined test sequences (described in Section 4.1) applied to Sub6 NR NSA (with LTE on all-down bits or low power for the entire test after establishing the LTE+Sub6 NR call with the callbox) and Sub6 NR SA (with Sub6 NR connection only). Follow the test procedures described in Section 4.3.1 to demonstrate the effectiveness of power limiting enforcement and that the time averaged Tx power of Sub6 NR when converted into 1gSAR values does not exceed the regulatory limit at all times (see Eq. (1a) and (1b)). Sub6 NR response to test sequence1 and test sequence2 will be similar to other technologies (say, LTE), and are shown in Sections 7.1.5 and 7.1.6.

F.2 Switch in SAR exposure between LTE vs. Sub6 NR during transmission

This test is to demonstrate that Smart Transmit feature accurately accounts for switching in exposures among SAR for LTE radio only, SAR from both LTE radio and sub6 NR, and SAR from sub6 NR only scenarios, and ensures total time-averaged RF exposure compliance with FCC limit.

Test procedure:

1. Measure conducted Tx power corresponding to P_{limit} for LTE and sub6 NR in selected band. Test condition to measure conducted P_{limit} is:
   - □ Establish device in call with the callbox for LTE in desired band. Measure conducted Tx power corresponding to LTE P_{limit} with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.
   - □ Repeat above step to measure conducted Tx power corresponding to Sub6 NR P_{limit}. If testing LTE+Sub6 NR in non-standalone mode, then establish LTE+Sub6 NR call with callbox and request all down bits for radio1 LTE. In this scenario, with callbox requesting maximum power from Sub6 NR, measured conducted Tx power corresponds to radio2 P_{limit} (as radio1 LTE is at all-down bits)
2. Set *Reserve_power_margin* to actual (intended) value with EUT setup for LTE + Sub6 NR call. First, establish LTE connection in all-up bits with the callbox, and then Sub6 NR connection is added with callbox requesting UE to transmit at maximum power in Sub6 NR. As soon as the Sub6 NR connection is established, request all-down bits on LTE link (otherwise, Sub6 NR will not have sufficient RF exposure margin to sustain the call with LTE in all-up bits). Continue LTE (all-down bits)+Sub6 NR transmission for more than one time-window duration to test predominantly Sub6 NR SAR exposure scenario (as SAR exposure is negligible from all-down bits in LTE). After at least one time-window, request LTE to go all-up bits to test LTE SAR and Sub6 NR SAR exposure scenario. After at least one more time-window, drop (or request all-down bits) Sub6 NR transmission to test predominantly LTE

SAR exposure scenario. Continue the test for at least one more time-window. Record the conducted Tx powers for both LTE and Sub6 NR for the entire duration of this test.

3. Once the measurement is done, extract instantaneous Tx power versus time for both LTE and Sub6 NR links. Similar to technology/band switch test in Section 4.3.3, convert the conducted Tx power for both these radios into 1gSAR value (see Eq. (4a) and (4b)) using corresponding technology/band P_{limit} measured in Step 1, and then perform 100s running average to determine time-averaged 1gSAR versus time as illustrated in Figure 4-1. Note that here it is assumed both radios have Tx frequencies < 3GHz, otherwise, 60s running average should be performed for radios having Tx frequency between 3GHz and 6GHz.
4. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 2.
5. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 3, (b) computed time-averaged 1gSAR versus time determined in Step 3, and (c) corresponding regulatory $1gSAR_{limit}$ of 1.6W/kg.

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