Element Materials Technology
(formerly PCTEST)
7185 Oakland Mills Road, Columbia, MD 21046 USA
Tel. +1.410.290.6652 / Fax +1.410.290.6654
http://www.element.com

PART 2 RF EXPOSURE EVALUATION REPORT

Applicant Name:
Samsung Electronics Co., Ltd.
129, Samsung-ro, Maetan dong,
Suwon-Si, Gyeonggi-Do
16677, Korea (Republic Of)

Date of Testing:
06/16/2023 – 08/10/2023
Test Site/Location:
Element, Columbia, MD, USA
Document Serial No.:
1M2304260063-23.A3L

FCC ID:	**A3LSMS711B**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD.**

DUT Type:	Portable Handset
Application Type:	Certification
FCC Rule Part(s):	CFR §2.1093
Model:	SM-S711B/DS
Additional Model:	SM-S711B
Device Serial Numbers:	Pre-Production Samples [1366M, 1044M, 1259M]

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.

RJ Ortanez
Executive Vice President

ilac-MRA A2LA ACCREDITED CERT #2041.01

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
GSM/GPRS/EDGE 850	Voice/Data	824.20 - 848.80 MHz
GSM/GPRS/EDGE 1900	Voice/Data	1850.20 - 1909.80 MHz
UMTS 850	Voice/Data	826.40 - 846.60 MHz
UMTS 1750	Voice/Data	1712.4 - 1752.6 MHz
UMTS 1900	Voice/Data	1852.4 - 1907.6 MHz
LTE Band 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 17	Voice/Data	706.5 - 713.5 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 26 (Cell)	Voice/Data	814.7 - 848.3 MHz
LTE Band 5 (Cell)	Voice/Data	824.7 - 848.3 MHz
LTE Band 66 (AWS)	Voice/Data	1710.7 - 1779.3 MHz
LTE Band 4 (AWS)	Voice/Data	1710.7 - 1754.3 MHz
LTE Band 2 (PCS)	Voice/Data	1850.7 - 1909.3 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
NR Band n5	Voice/Data	826.5 - 846.5 MHz
NR Band n66	Voice/Data	1712.5 - 1777.5 MHz
NR Band n41	Voice/Data	2506.02 - 2679.99 MHz
NR Band n77	Voice/Data	3455.01 - 3544.98 MHz 3705 - 3975 MHz
2.4 GHz WLAN	Voice/Data	2412 - 2462 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
U-NII-4	Voice/Data	5845 - 5885 MHz
U-NII-5	Voice/Data	5935 - 6415 MHz
U-NII-6	Voice/Data	6435 - 6515 MHz
U-NII-7	Voice/Data	6535 - 6875 MHz
U-NII-8	Voice/Data	6895 - 7115 MHz
Bluetooth	Data	2402 - 2480 MHz
NFC	Data	13.56 MHz

1.2 Time-Averaging Algorithm for RF Exposure Compliance

This device is enabled with S.LSI TAS and Qualcomm® FastConnect features. These features perform their proprietary time averaging algorithms in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements at all times. Section 2.1 and 2.2 has additional details regarding the implementation of these TAS algorithms. Additional evaluation was performed in “Proprietary Analysis for TAS + TAS” to ensure TAS + TAS scenarios are compliant.

1.2.1 Time-Averaging Algorithm for Cellular RF Exposure Compliance

This process of S.LSI TAS validation is to demonstrate the DUT complies with FCC RF exposure compliance requirement under varying Tx power transmission scenarios, thus validating the Samsung S.LSI TAS algorithm feature for FCC equipment authorization of the mobile phone.
The value of P_{limit} used in this report per scenarios are determined in Part 0 SAR Report.

FCC RF exposure limits are comprised of SAR (Specific Absorption Rate) limits depending on frequency of operation. SAR regulatory specifications are defined over certain measurement duration allowing for time-averaging. The Samsung S.LSI proprietary TAS (Time Average SAR) algorithm has been designed to meet the compliance limits over the required duration, while still allowing dynamic control of transmit power for meeting system performance.

1.2.2 Time-Averaging Algorithm for WLAN RF Exposure Compliance

FastConnect TAS for Qualcomm WLAN technologies controls and manages transmit power in real time to always ensure the time averaged RF exposure is in compliance with regulatory requirements.
The purpose of this report is to demonstrate the Qualcomm® FastConnect™ time averaged SAR (TAS) feature RF exposure compliance under dynamic transmission scenariosThis test report provides reference to test results and plots using parameters is determined from for static SAR test and configurate in FastConnect TAS BDF for validating the FastConnect TAS feature.

1.3 Bibliography

Report Type	Report Serial Number
Part 0 SAR Test Report	1M2304260063-02.A3L
Part 1 SAR Test Report	1M2304260063-01.A3L
RF Exposure Compliance Summary	1M2304260063-22.A3L

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 RF Exposure Limits for Frequencies Above 6 GHz

Per §1.1310 (d)(3), the MPE limits are applied for frequencies above 6 GHz. Power Density is expressed in units of W/m^2 or mW/cm^2.

Peak Spatially Averaged Power Density was evaluated over a circular area of 4 cm^2 per interim FCC Guidance for near-field power density evaluations per October 2018 TCB Workshop notes.

Table 2-2
Human Exposure Limits Specified in FCC 47 CFR §1.1310

Human Exposure to Radiofrequency (RF) Radiation Limits		
Frequency Range [MHz]	**Power Density** [mW/cm^2]	**Averaging Time** [Minutes]
(A) Limits for Occupational / Controlled Environments		
1,500 – 100,000	5.0	6
(B) Limits for General Population / Uncontrolled Environments		
1,500 – 100,000	1.0	30

Note: 1.0 mW/cm^2 is 10 W/m^2

2.5 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 S.LSI TAS OPERATION

3.1 Background

The RF exposure limit is defined based on time-average exposure during a certain amount of time window. Basically, the length of time window is adjustable in current TAS algorithm implementation. As representative values, following time window sizes are introduced in the report. Time window size 100 seconds, 60 seconds are used for SAR (below 3GHz), SAR (3~6GHz) respectively. TAS algorithm ensures the DUT can meet the FCC compliance at all times over test duration.
Samsung S.LSI proprietary TAS algorithm considers 4G and 5G NR cellular RAT, and connectivity technologies such as Wi-Fi and BT (Bluetooth) because the DUT should keep the total amount of radiation below the level defined by regulations. To do this, modem controls transmitter power in real time.

At a very high level, the TAS algorithm consists of the following:

- Maximum Tx power limit for a particular RAT is calculated considering SAR compliance using some pre-characterization data.
- Instantaneous Tx power can go over Tx power limit but average value during any measurement window will be maintained below the Tx power limit.
- In a simultaneous multi-RAT scenario, TAS algorithm also has to meet TER (Total Exposure Ratio), which is sum of actual SAR to the compliance limits across all RATs. TER of the DUT will be equal to or less than 1 at all time.
- To preserve the radio link quality and call connection, TAS algorithm provides the concept of priority of each RAT's transmit power. For instance, a certain minimum value of max transmit power limit will be ensured for anchor RAT such as LTE in EN-DC.

3.2 Algorithm Operation

Samsung S.LSI proprietary TAS algorithm operates as follows:

- Define the minimum duration of SAR calculation. This duration is the 'SAR average window' consists of N slots. Any measurement duration or time-averaging duration as specified by FCC for the particular RAT will then consist of M such windows. The product of FCC limit of SAR limit (or equivalently the Tx power for this limit as used in the algorithm) and M is then defined as a SAR budget for such measurement durations.
- For a particular window, calculate the amount of average SAR consumed during the window duration by computing average of instantaneous transmit power value per slot. Because SAR value isn't given directly, Tx power value is used to calculate consumed SAR value.
- Estimates the total SAR consumed during the SAR measurement duration in the past which includes the above window. This value will be the sum of SAR consumed by all windows in the measurement duration.
- Monitor the remaining SAR budget continuously for every window and control the maximum Tx power for the next window to comply with SAR regulation

3.3 Configurable Parameters

To determine the parameters for the TAS algorithm operation, the terms in Table 3-1 was used.

Table 3-1
Definitions for TAS algorithm

Term	Description
$Pmax$	Maximum Tx power that can be transmitted physically from RFIC for a given RAT
$SAR\_regulatory\_limit$	SAR value limit specified by FCC
SAR_design_target	Target SAR level using in TAS algorithm. This SAR value should be less than above regulatory limit and should be determined after accounting for all uncertainties and other design considerations.
$Plimit$	Power level corresponds to the SAR design target.

$P_{limit} = P_{max} + 10 \times \log_{10}(SAR\_design\_target/SAR@P_{max})$

For sub 6GHz and legacy modem, maximum Tx power (P_{max}) and allowable limit power (P_{limit}) has to be defined. The design target value should themselves be determined to ensure that DUT can comply with FCC SAR regulation limit even after accounting all device uncertainties. This is the bare minimum of design target value and additional offset can be considered to have more margin.

$SAR\_design\_target = SAR\_regulatory\_limit \times 10^{-total\_uncertainty\_SAR/10}$

Table 3-1
Definitions of uncertainty and design target

Term	Description
$SAR\_regulatory\_limit$	1.6 W/Kg (Body)
$total\_uncertainty\_SAR$	1.0 dB (Tx power variation, part to part deviation, etc.)
SAR_design_target	SAR_design_target should be less than 1.2 W/Kg Considering safety margin, 1.0 W/Kg is used as the value of SAR_design_target

4 FASTCONNECT TAS OPERATION

4.1 Background

Regulatory RF exposure limits are defined with respect to time-averaged RF exposure. Qualcomm FastConnect TAS algorithm performs transmit power control to ensures at all times the wireless device is in compliance with the configured limit of RF exposure averaged over a defined time window denoted as T_{SAR} for SAR.

The FastConnect TAS supports maximum time-averaging windows (denoted as ***TSAR***) as defined by the FCC and ISED that:

- For FCC, a 30 second time-averaging window is used by FastConnect TAS for WLAN operation in 2.4GHz, 5GHz, and 6GHz WLAN bands.
- For ICNIRP 1998, the time-averaging window for radios operating <10GHz is 360 seconds. FastConnect TAS uses a 360s window for regions outside the U.S (e.g., ISED Canada).

Table 4-1
Frequencies of operation and time-averaging windows used by FastConnect TAS

FCC[1]		ICNIRP 1998	
WLAN band	**Time-averaging window length**	**WLAN band**	**Time-averaging window length**
2.4GHz, 5GHz, 6GHz	30s	2.4GHz, 5GHz, 6GHz	360s

1The FCC time-averaging window table is based on FCC interim guidance.

4.2 Basic Concept of the Feature

FastConnect TAS manages the instantaneous transmit power to maintain the time-averaged power and associated RF exposure is below the regulatory compliance limit.

- If the time-averaged transmit power approaches the SAR compliance power, then the instantaneous transmit power is limited to ensure the time-averaged transmit power does not exceed the SAR compliance power in any ***TSAR*** time window (i.e., the time-averaged RF exposure complies with the FCC or ICNIRP RF exposure limit in any time window).
- The wireless device can instantaneously transmit at high transmit powers for a short time durations before limiting the power to maintain time-averaged SAR compliance.

4.3 Supported WLAN Operations

- IEEE 802.11 – Operation in 2GHz, 5GHz, and 6GHz U-NII frequencies.
- SISO – Operation using a single antenna. The transmit chain may switch during operation. While using a single antenna, a design may support transmitting WLAN packets in 2GHz, 5GHz, or 6GHz channels.

NOTE: SISO operation depends on implementation in software. SISO mode may not be supported when software enables cyclic delay diversity (CDD). In this case WLAN always transmits in MIMO mode.

- MIMO – Operation using two antennas with one or more spatial streams.

- Dual band simultaneous (DBS) and/or High Band simultaneous (HBS) – Packets are transmitted in separate frequencies at the same time. A device may operate in DBS using MIMO or SISO.

NOTE: DBS operation support depends on implementation in software.

4.4 Configurable Parameters

This section defines the key parameters required for FastConnect TAS Validation.
The following inputs are key parameters required for functionality of the FastConnect TAS feature.

NOTE: The OEM must configure these parameters in the board data file (BDF).

- Time-Averaged Exposure Mode (FCC or ICNIRP) or Peak exposure mode, configurable for a given region/country: When enabled in Peak Exposure mode, FastConnect TAS limits instantaneous Tx power not to exceed P_{lim} in both simultaneous and single antenna case.
- P_{lim} per WLAN band/ant/DSI/regulatory limit (FCC or ICNIRP limit). Either FCC or ICNIRP limits can be chosen for a given region/country.
- Antenna group (AG) table: Optional feature to group transmit antennas such that the antennas in each group have RF exposure that is mutually exclusive (either have sum of SAR less than regulatory limit or meet SPLSR criteria) with antennas belonging to a different group.
- Reserve margin (in dB).

Dynamic inputs:

- Country of operation (location-based awareness).
- Device state index (DSI).

Non-configurable parameters (fixed entries):

- P_{max} values per each WLAN operating state.

4.4.1 *Plim*

P_{lim} (in dBm) is the power corresponding to the SAR_{target} for FastConnect WLAN. In other words, P_{lim} is the maximum time-average transmit power setting for FastConnect TAS, at which this radio configuration (i.e., antenna, band and DSI state) reaches the SAR_{target}. The Fast Connect TAS algorithm uses P_{lim} to and the real time transmit power to ensure the real time-averaged SAR is below the SAR_{target} in real time and thus ensure device RF Exposure compliance.

4.4.2 *Pmax*

P_{max} for FastConnect WLAN represents the maximum WLAN transmit power from other power setting in board data file. The P_{max} value could be identified by compare the target power (Rate-to-Power) and compliance transmit (CTL) and other power limit.
P_{max} = min {CTL, Regdomain, TPE/TPC, Rate-to-Power}

4.4.3 Reserve Margin

FastConnect TAS allows minimum reserve power $P_{reserve}$ (= P_{lim} - *reserve margin*) for WLAN radio to transmit, which can be used to maintain the link. The *reserve margin* is a global parameter, meaning it applies to all the

radio configurations. When the *reserve margin* is set to zero dB, the FastConnect TAS effectively allows minimum transmit power $P_{reserve} = P_{lim}$ at all times, in other words, the EUT transmits continuously at P_{lim}.
The value is chosen by the OEM and stored in the board data file (BDF). It is in 0.1 dB increments. A single value is applied to all bands and modes.

5 TIME VARYING TRANSMISSION TEST CASES

5.1 Cellular S.LSI Time-Varying Transmission 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 S.LSI TAS feature accounts for Tx power variations in time accurately.
2. During a call disconnect and re-establish scenario: To prove that the S.LSI TAS feature accounts for history of past Tx power transmissions accurately.
3. During a technology/band handover: To prove that the S.LSI TAS feature functions correctly during transitions in technology/band.
4. During an RSI (Radio SAR Index) change: To prove that the S.LSI TAS feature functions correctly during transition from one device state (RSI) to another.
5. During time averaging window change: To prove that the S.LSI TAS 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.

As described in SAR_Char.Report, the RF exposure is proportional to the Tx power for both FR1. Thus, we rely on conducted power measurements (FR1 in each dynamic case to demonstrate that overall RF exposure is within the FCC limit.

The overall procedure for validating the test is summarized below:

1. Measure conducted power (FR1) over time, denoted as *TxPower(t)*, with time index *t*.
2. Convert measured powers to RF exposure values using linear relationship shown below. In below expression, $P_{limit,FR1}$ would be the measured power at which FR1 technology meets measured SAR level of *SAR_design_target* as described in SAR_Char Report.

$$SAR(t) = \frac{TxPower(t)}{P_{limit,FR1}} \times SAR\_design\_target$$

Eqn. (1)

$$PD(t) = \frac{EIRP(t)}{P_{limit,FR2}} \times PD\_design\_target$$

Eqn. (2)

3. Compute the average RF exposure over the most recent measurement duration which are denoted as *TSAR* and for FR1 and, respectively. These durations are as specific by FCC. This measurement duration interval is then given by [*t* – *T*SAR, *t*] and for FR1.

4. Divide the RF exposure for FR1 by corresponding FCC limits and ensure the sum denoted as TER (total exposure ratio) is less than 1 for all *t*. Please refer to the following equations which describe the calculation of TER and its target restraint. The expressions below are general considering a number of FR1 and radios in general denoted by *L*SAR and.

   For sub6 transmission only:

$$\sum_{lSAR=0}^{LSAR-1} \frac{SARavr,lSAR}{FCC\ SAR} \leq 1$$

5.2 WLAN FastConnect Time-Varying Cases

5.2.1 Validation Strategy

The following scenarios cover validation tests to prove FastConnect TAS accounts for the history of transmission power accuracy at all times including before, during, and after transition in each scenario.

Since RF exposure is proportional to the Tx power for a SAR wireless device, time-averaging algorithm validation can be effectively performed through conducted power measurements outlined below.

Also, to have high confidence in validation, but also be practical, the strategy for the **Time-Varying Test Sequence** including both conducted power measurement and RF exposure measurement is outlined as specified in Section 6.4 and Section 6.6.

In addition, since FastConnect TAS feature operates at the same averaged algorithm to all WLAN bands (2.4GHz, 5GHz, and 6GHz), test selection criteria described in Section 6.4 was used for time varying validation.

1. Time-Varying Test Sequence: This test proves the FastConnect TAS accounts for Tx power variations in time accurately. In addition, this test is performed to capture the maximum time-averaged results in at least two time-averaging windows duration.

2. Change in antenna (applicable when the software supports SISO diversity operation): This test is to prove that FastConnect functions correctly during transitions in Plim (at different antennas) within the same WLAN band and same Antenna Group. If device supports SISO and transmission diversity between an Antenna to another antenna, then this test is applicable. If WLAN MIMO CDD is implemented, then device is always under MIMO transmission, in this case, this test is NOT applicable.

3. Change in device state (DSI) (applicable when the device supports multiple DSI): This is to prove that FastConnect TAS performs power enforcements to maintain compliance during transitions in the device state.

4. Change in WLAN band: This is to prove that the FastConnect TAS functions correctly during transitions in radios and bands.

5. Simultaneous Transmission: This is to prove that the FastConnect TAS functions in transition from 1st standalone WLAN radio to simultaneous WLAN radios and back to 2nd standalone WLAN radio.

5.2.2 Conducted Power Measurement

This section provides general procedures to perform conducted power measurement under dynamic transmission scenarios and apply to all test scenarios described in section 5.2.2.

1. Measure conducted power.
2. Convert it into RF exposure and divide by respective limits to get normalized exposure use equation as described in this section.
3. Perform time-averaging over predefined time windows.
4. Demonstrate that the total normalized time-averaged RF exposure is <1 for all transmission scenarios.

- For frequency below 6GHz or if regulator requires SAR for WLAN 6GHz band.

$$1g\_or\_10gSAR(t) = \frac{Conducted\_Tx\_power\,(t)}{Conducted\_Tx\_power\_Plim} * 1g\_or\_10gSAR\_Plim \qquad (1a)$$

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

- For frequency greater than 6GHz if regulator requires APD. (Applicable for ISED)

$$4cm^2\ PD(t) = \frac{Conducted\_Tx\_power\,(t)}{Conducted\_Tx\_power\_Plim} * 4cm^2\ PD\_Plim \qquad (1c)$$

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 4cm^2\ PD(t)\,dt}{APD\ 4cm^2\ PD\ limit} \leq 1 \qquad (1d)$$

where, $conducted\_Tx\_power(t)$, $conducted\_Tx\_power\_Plim$ and $1g\_or\_10gSAR\_Plim$ correspond to the measured instantaneous conducted Tx power and conducted Tx power at P_{lim} of DUT, and $1g\_or\_10gSAR$ values at P_{lim} for the worst-case radio configuration within the tested band/Antenna/DSI. Similarly, $4cm^2\ PD\_Plim$ correspond to the APD values at P_{lim} for the worst-case radio configuration within the tested band (greater than 6GHz)/Antenna/DSI.

The equations (1a) & (1b) are applicable if SAR is required by regulator to address RF exposure for the band greater than 6GHz.

NOTE: The ratio circled in red square is obtained from the measurement on the radio configuration is selected for validation test while the $1g\_or\_10gSAR\_P_{lim}$ and $4cm^2\ PD\_Plim$ must be from the SAR value in the worst-case radio configuration within the tested band/Antenna/DSI in static SAR report and scale to the $conducted\_Tx\_power\_Plim$ level is measured from DUT used in validation test.

5.2.3 RF Exposure Measurement

This section provides the general procedure to demonstrate the FastConnect TAS comply SAR limit in radiated test setup. Through pointSAR measurement for only test scenario **Time-Varying Test Sequence** to add confidence in the FastConnect TAS feature validation, while avoiding the complexity in SAR measurement.

1. Choose worst case EUT orientation of SAR measurement per according to Static SAR test report and perform pointSAR measurement use cDASY6
2. Measure instantaneous SAR versus time and demonstrate total normalized time-averaged RF exposure is <1.0 at all times.

- For frequency below 6GHz or if regulator requires SAR for WLAN 6GHz band.

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

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

- For frequency greater than 6GHz if regulator requires APD. (Applicable for ISED)

$$4cm^2\ PD(t) = \frac{pointSAR\ (t)}{pointSAR\_P_{lim}} * 4cm^2\ PD\_\ Plim \qquad (2c)$$

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 4cm^2\ PD(t)\,dt}{APD\ 4cm^2 PD\ limit} \leq 1 \qquad (2d)$$

where, $pointSAR(t)$, $pointSAR\_P_{lim}$, and $1g\_or\_10gSAR\_\ Plim$ correspond to the measured instantaneous point SAR and point SAR at P_{lim} of DUT, and $1g\_or\_10gSAR$ values at P_{lim} for the worst-case radio configuration within the tested band/Antenna/DSI. Similarly, 4cm$_2$ PD_ $Plim$ is the APD values at P_{lim} for the worst-case radio configuration within the tested band (greater than 6GHz)/Antenna/DSI.

The equations (2a) & (2b) are applicable if SAR is required by regulator to address RF exposure for the band greater than 6GHz.

NOTE: The ratio circled in red square is obtained from the measurement on the radio configuration is selected for validation test while the $1g\_or\_10gSAR\_\ Plim$ and 4cm$_2$ PD_ $Plim$ must be from the SAR value in the worst-case radio configuration within the tested band/Antenna/DSI in static SAR report and scale to the $conducted\_Tx\_power\_\ Plim$ level is measured from DUT used in validation test.

6 FCC MEASUREMENT PROCEDURES (FREQ < 6 GHZ)

This chapter provides the test plan and test procedure for validating S.LSI TAS and WLAN FastConnect features 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 and 30 second time-window for operating WLAN.

6.1 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 A is generated with two power levels. One is maximum power level P_{max} and the other is a lower power level. The lower power level is defined as 3dB lower than the maximum power level. T first, maximum power level is applied for 120 seconds (1.2 * T_{SAR}). After this, the lower power level is used until this test is finished.
- Test sequence B is generated at multiple power levels that are specified in the Appendix as a function of P_{max} and P_{limit}.

6.2 Test configuration selection criteria for validating Cellular S.LSI TAS feature

For validating the S.LSI TAS feature, this section provides the general guidance to select test cases.

6.2.1 Test configuration selection for time-varying Tx power transmission

The Samsung S.LSI TAS algorithm is independent of bands, modes, and channels for a given technology. Hence, we can validate using one or two combinations of band/mode/channel per technology. The criteria for selecting these would be based on the relative value of P_{limit} and P_{max} as determined in SAR Char Report Char Report. Essentially, we need to pick the combination such that P_{limit} is less than P_{max} so that the TAS algorithm will enforce power restriction.

6.2.2 Test configuration selection for change in call

The criteria to select the technology/band for transition between call setup and call drop is to choose the one with least P_{limit} among all supported technologies/bands. This test is performed with the DUT requested power at maximum power so the Samsung S.LSI TAS feature enforces power restriction for the longest duration. The call change is performed when the DUT is operating with restricted power. One such test is sufficient since behavior is not dependent on band/technology.

6.2.3 Test configuration selection for change in technology/band/window

FCC specifies different measurement durations for time averaging based on operating frequency. The change of operating frequency can result in change of time window for averaging, for e.g. change from 100s time-averaging window for frequency below 3GHz to 60s time-averaging window for frequency above 3GHz in FR1. The criteria for selecting the test case to demonstrate compliance across time window change is to pick a technology/band corresponding to each time window such that P_{limit} is less than P_{max}. However, to show the performance of the TAS algorithm in this document, the case of low P_{limit} is considered, which is shown in SAR Char Report Char Report.

6.2.4 Test configuration selection for change in RSI

The criteria to select a test configuration for RSI change test is to select technology/band with two RSI sates from SAR_Char Report such that P_{limit} is less than P_{max} for both states.

However, to show the performance of the TAS algorithm in this document, the case of lowest P_{limit} is considered, which is shown in Table 8-3.

6.2.5 Test configuration selection for SAR exposure switching

The criteria for selecting the test case is to pick an LTE band and an NR band with P_{limit} lower than P_{max} in each case. The test is performed with both RATs connected in an EN-DC scenario. In the first portion of the test, DUT is requested to transmit at maximum power for NR and minimum power for LTE. In the second portion of the test, maximum power is requested for both NR and LTE. In the final portion of the test, minimum power is requested for NR and maximum power is requested for LTE.

6.2.6 Spatial TAS test

The criteria of selecting these tests configuration is to demonstrate the compliance of the TAS algorithm while transmitting on multiple antennas with a coupling factor of 0. This spatial TAS algorithm will show that we can achieve enhanced performance based on the antenna coupling while ensuring compliance with FCC target level.

6.3 Test procedures for Cellular S.LSI 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.

6.3.1 Time-varying Tx power transmission scenario

This test is performed with the two pre-defined test sequences described in Section 5.1 for all the technologies and bands applying to both LTE and NR selected in Section 5.2.1. 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.

Test procedure

1. Using the P_{max} and P_{limit} obtained in Table 8-3, generate the test sequence of power levels for each selected technology/band. Both test sequences A and B are generated. Maximum power can be changed according to DUT test results.
2. Establish the connection of the DUT to the call box in the selected RAT, with the call box requesting the DUT Tx power to be according to the sequence determined in step 1. An initial value of Tx power will be set to 0dBm for 100s before the desired test sequence starts to help with post-processing of the time-average value with the very first value of the sequence. This is illustrated in the figure below:
3. Release connection.
4. After completion of the test, prepare one plot with the following information:
    a. Instantaneous Tx power versus time measured in Step 2
    b. Requested Tx power versus time used in Step 2

c. Time-averaged power over 100s using instantaneous values from Step 2

d. Power level Plimit which is determined as meeting SAR target in Table 8-1 (Pmax Plimit Table)

5. Make another plot containing:

a. Computed time-averaged 1gSAR versus time determined in Step 2

b. FCC $1gSAR_{limit}$ of 1.6W/kg

The pass condition is to demonstrate time-averaged 1gSAR versus time shown in Step 5 value versus time does not exceed the FCC limit of 1.6 W/kg throughout the test duration. We would also demonstrate that time-averaged power does not exceed the Plimit at anytime in the plot in Step 4.

6.3.2 Change in call scenario

This test is to demonstrate that Samsung S.LSI TAS feature accurately accounts for the past Tx powers during time-averaging when a new call is established. The call change has to be carried out when the power limit enforcement is ongoing.

Test procedure

1. Establish radio connection of the DUT with callbox in the selected technology/band.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 100s.
3. Configure call box to send “ALL UP” power control commands and continue transmission from DUT so that maximum power Pmax is achieved.
4. After 60s of transmission at Pmax level, release the call from call box.
5. After 10s, re-establish the LTE connection from call box to the DUT and repeat sending “ALL UP” power control command to bring the Tx power to Pmax level again.
6. Continue LTE transmission at Pmax level for another 110s.
7. Release the LTE connection.
8. After completion of the test, make one plot containing: (a) instantaneous Tx power versus time, (b) requested power, (c) computed time-averaged power, (d) power level Plimit which is is determined as meeting the SAR target
9. Make another plot containing: (a) computed time-averaged 1gSAR versus time, and (b) FCC limit of 1.6 W/kg for 1gSAR.

Pass condition is to demonstrate time-averaged 1gSAR value versus time does not exceed the FCC limit of 1.6 W/kg throughout the test duration. It is required to check if SAR calculation is accounting for call drop and connection. Current TAS algorithm software makes the UE estimate the exact amount of Tx power and average SAR even during call drop and call re-establishment event. The UE stores time information when it goes into a sleep mode and wake-up to calculate Tx power on/off duration.

6.3.3 Change in technology/band/window

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle change of technology/band and consequently time window as necessary during handover scenarios. Since both

Plimit and window duration can change across bands, we have to use separate equations below for converting Tx power to SAR as well as apply some combined SAR exposure criteria as shown below.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2$$

Where *Plimit,1,FR1* would correspond to measured power at which first technology/band meets measured SAR level of *SAR_design_target1* as described in Table 8-3 with time-averaging duration of *T1,SAR*.. Similarly, the quantities *Plimit,2,FR1*, *SAR_design_target2*, *T2,SAR* are defined for the second technology/band. When a first band is chosen below 3GHz, we would have *T1,SAR* = 100s, and by choosing a second band to be above 3GHz, we would use *T1,SAR* = 60s. On the other hand, when a first band is chosen above 3GHz and a second band below 3GHz, we would use *T1,SAR* = 60s and *T1,SAR* = 100s.

6.3.3.1 Test Procedure for switching from 100s and 60s and vice-versa

1. Establish radio connection of the DUT with callbox in the selected technology/band.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 100s.
3. Configure call box to send “ALL UP” power control commands and continue LTE transmission from DUT so that maximum power Pmax is achieved. Continue transmission at the maximum power for at least 105s.
4. Change band from band A to another LTE band B, which should correspond to a change in averaging duration from 100s to 60s. Continue call in band B with call box requesting maximum power for at least 60s.
5. Change the band from band B back to the first band A and continue the call at maximum power for at least 100s.
6. Release LTE connection
7. After the completion of the test, prepare one plot with the following information for each band: (a) Instantaneous Tx power versus time (b)Time-averaged power for each band according to their averaging duration and (c) Plimit corresponding to each band.
8. Make a second plot containing the following information: (a) Computed time-averaged 1gSAR versus time for each band (b) Sum of time-averaged SAR computed according to below equations and (c) FCC 1gSAR limit of 1.6W/kg.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2$$

Pass condition is to demonstrate total time-averaged 1gSAR value versus time does not exceed the FCC limit of 1.6 W/kg throughout the test duration. It is required to check if power limiting enforcement is operated as expected when band change occurs in-between.

6.3.3.2 Test Procedures for switching from 60s and 100s and vice versa

1. Establish radio connection of the DUT with callbox e.g. using LTE technology in band B which has 60s averaging duration.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 100s.
3. Configure call box to send “ALL UP” power control commands and continue LTE transmission from DUT so that maximum power Pmax is achieved. Continue transmission at the maximum power for at least 65s.
4. Change band from band B to another LTE band A, which should correspond to a change in averaging duration from 60s to 100s. Continue call in band A with call box requesting maximum power for at least 100s.
5. Change the band from band A back to the first band B and continue the call at maximum power for at least 60s.
6. Release LTE connection
7. After the completion of the test, prepare one plot with the following information for each band: (a) Instantaneous Tx power versus time (b)Time-averaged power for each band according to their averaging duration and (c) P_{limit} corresponding to each band.
8. Make a second plot containing the following information: (a) Computed time-averaged 1gSAR versus time for each band (b) Sum of time-averaged SAR computed according to below equations and (c) FCC 1gSAR limit of 1.6W/kg.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2$$

Pass condition is to demonstrate total time-averaged 1gSAR value versus time does not exceed the FCC limit of 1.6 W/kg throughout the test duration. It is required to check if power limiting enforcement is operated as expected when band change occurs in-between.

6.3.4 SAR exposure switching

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle change of dominant SAR exposure radio in the case of two simultaneous active RATs. It involves changing the required power of both radios such that either one or both of the RATs becomes dominant contributor to total exposure ratio at different times of the test.

Test procedure:

1. Establish LTE and NR radio connection in NSA case with the callbox.

2. Configure the LTE call box to send “ALL DOWN” power control commands for LTE and configure the NR call box to send “ALL UP” power control commands. This would correspond to NR dominant SAR scenario and continue this stage for about 110s.
3. In the second part of the test, configure the LTE call box to send “ALL UP” power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE and NR. This stage of the test is continued for another 110s.
4. In the third part of the test, configure the NR call box to send “ALL DOWN” power control commands so that LTE becomes the dominant SAR radio. This stage is continued for another 110s.
5. Finally, both LTE and NR connections are released.

6.3.5 Spatial TAS test

6.3.5.1 Test procedure for NR FR1 Antenna switching with spatial TAS

1. Establish radio connection of DUT with call box e.g. using NR FR1 technology (Band n41 on Ant B)
2. Configure call box to set DUT Tx power to a low value of -10dBm for 100s.
3. Configure call box to send “ALL UP” power control commands and continue NR FR1 transmission from DUT so that maximum power of Pmax is achieved for 240s.
4. Change the bands so that the transmitting antenna changes from n41 Ant B (AG0) to n77 Ant F (AG1) and continue transmission for 90s.
5. Change the bands that the transmitting antenna changes from n77 Ant F (AG1) to n41 Ant B (AG0) and continue transmission till the end of the test.
6. Release NR FR1 connection

6.3.5.2 Test procedure for NSA antenna switching with spatial TAS

1. Establish LTE and NR radio connection in NSA case with both call boxes (LTE Band 12 Ant A and n41 ant B)
2. Configure the LTE call box to send “ALL Down” power control commands for LTE and configure the NR call box to send “ALL Down” power control commands and continue for 150s.
3. Configure the LTE call box to send “ALL Up” power control commands for LTE while keeping the configuration of the NR call box at “ALL Down” power control commands. This would correspond to LTE dominant SAR scenario and continue this stage for about 200s.
4. Configure the NR call box to send “ALL UP” power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE and NR. This stage of test is continued for another 200s.

5. Change the band from Band n41 to Band n77 so that the transmitting antenna changes from Ant B (AG0) to Ant F (AG1) and continue transmission at “ALL UP” Tx power for 200s.
6. Configure the LTE call box to send “ALL DOWN” power control commands so that NR becomes the dominant SAR radio and continue transmission for 200s.
7. . Release LTE connection

6.3.5.3 Test procedure for NSA with spatial TAS

1. Establish LTE and NR radio connection in NSA case with both call boxes, e.g. LTE in Band 2 on Ant A and NR in band n66 on Ant F.
2. Configure the LTE call box to send “ALL Down” power control commands for LTE and configure the NR call box to send “ALL Down” power control commands and continue for 150s.
3. Configure the LTE call box to send “ALL Up” power control commands for LTE while keeping the configuration of the NR call box at “ALL Down” power control commands. This would correspond to LTE dominant SAR scenario and continue this stage for about 200s.
4. Configure the NR call box to send “ALL UP” power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE and NR. This stage of test is continued for another 200s.
5. Configure the LTE call box to send “ALL DOWN” power control commands so that NR becomes the dominant SAR radio and continue transmission till the end of the test.
6. Finally, both LTE and NR connections are released.

6.4 Test selection criteria for validating WLAN FastConnect feature

The conducted power measurement method is used for all validation test scenarios. These tests demonstrate the power enforcement by FastConnect TAS where ***Plim*** could vary before and after transition.

6.4.5 Test selection for Time-Varying Test Sequence

Select one representative test channel from all the available radio configurations (band/ant(s)/DSI) that has Pmax > Plim + device uncertainty.

- If Pmax < Plim + device uncertainty for all radio configurations, then select radio configuration with largest (Pmax dBm – Plim dBm) value.
- If Pmax > Plim + device uncertainty for more than one radio configuration. Then, order of preference is given by:
    - If multiple radio configurations (band/ant(s)/DSI) meet this criteria, then SISO is preferred over MIMO due to simplified test setup.

- After determining SISO vs. MIMO configuration, then select the configuration that has largest (Pmax dBm – Plim dBm) dB delta.

- Test to be performed at two bands for Time-Varying Test sequence test. If only one band within a configuration has Pmax > Plim and Plim > Pmax in all other configurations, then only one band needs to be tested.
- Test is not required if Plim > Pmax for all radio configurations.

NOTE: The same selection criteria are applicable for both conducted & radiated tests.

6.4.6 Test selection for Change in Antenna

This test scenario does not apply if SISO mode diversity is not supported. (e.g., CDD is enabled and always use MIMO). The criteria to select test configuration for Change in Antenna measurement is:

- The antennas selected for this test should be in the same antenna group.
- Whenever possible and supported by the EUT, first select antenna switch configuration within the same band/DSI (i.e., same band and DSI combination), and having different Plim, and having both Pmax > Plim + device uncertainty where possible. Otherwise, select at least one antenna having Pmax > Plim + device uncertainty.
    - If multiple radio configurations (band/DSI) meet Pmax > Plim + device uncertainty, then select the configuration that has largest (Pmax dBm – Plim dBm) dB delta.
    - If Pmax < Plim + device uncertainty for all radio configurations, then select radio configuration with largest (Pmax dBm – Plim dBm) value.
- If the EUT does not support antenna switch within the same band, but has multiple transmitting antennas to support different frequency bands, then antenna switch test should be performed in combination with Change in WLAN band test scenario.
- Test for Change in Antenna is not required if all Plim > Pmax for all radio configurations

6.4.7 Test selection for Change in device state index (DSI)

This test scenario does not apply if multiple DSIs is not supported in the device. The criteria to select test configuration for Change in DSI measurement is:

- Select a band/antenna having the Pmax > Plim + device uncertainty within any DSI, and for the same band/antenna(s) having a different Plim in any other DSI. Both the selected DSIs should have Pmax > Plim + device uncertainty where possible. Otherwise, select at least one DSI having Pmax > Plim + device uncertainty.
- If Pmax < Plim + device uncertainty for all band/antenna(s), then select radio configuration with largest (Pmax dBm – Plim dBm) value.
- If Pmax > Plim + device uncertainty for more than one radio configuration, then order of preference is given by:

- If multiple radio configurations (band/ant(s)/DSI) meet this criteria and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
- After determining SISO vs. MIMO configuration, then select the configuration that has largest (Pmax dBm – Plim dBm) dB delta.

- Test for Change in DSI is not required if all Plim > Pmax for all radio configurations.

6.4.8 Test selection for Change in WLAN band

The criteria to select test configuration for Change in WLAN band measurement is:

- First select both bands in a DSI having Pmax > Plim + device uncertainty where possible. Otherwise, select at least one band having Pmax > Plim + device uncertainty.
- If Pmax < Plim + device uncertainty for all radio configurations, then select radio configuration with largest (Pmax dBm – Plim dBm) value.
- If Pmax > Plim + device uncertainty for more than one radio configuration. Then, order of preference is given by:
  - If multiple radio configurations (band/ant(s)/DSI) meet this criteria and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
  - After determining SISO vs. MIMO configuration, then select the configuration that has largest (Pmax dBm – Plim dBm) dB delta.
- The antennas corresponding to the selected bands should be in the same antenna group.
- Test for Change in WLAN band is not required if all Plim > Pmax for all radio configurations.

6.4.9 Test selection for Simultaneous Transmission

This test scenario does not apply if simultaneous transmission within WLAN bands is not supported in the device. The criteria to select test configuration for Simultaneous Transmission measurement is:

- The bands must be selected from supported Simultaneous Transmission configuration. (e.g., WLAN DBS and/or HBS)
- First select both bands in a DSI having $P_{max} > P_{lim}$ + device uncertainty where possible. Otherwise, select at least one band having $P_{max} > P_{lim}$ + device uncertainty.
- If $P_{max} < P_{lim}$ + device uncertainty for all radio configurations, then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If $P_{max} > P_{lim}$ + device uncertainty for more than one radio configuration. Then, order of preference is given by:
  - If multiple radio configurations (band/ant(s)/DSI) meet this criteria and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
  - After determining SISO vs. MIMO configuration, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.

- The antennas corresponding to the selected bands should be in the same antenna group.
- Even if a device has $P_{lim} > P_{max}$ for all radio configurations, then "Simultaneous Transmission" test scenario should still be performed for validation of FastConnect TAS device.

6.5 Test Procedure for validating WLAN FastConnect feature

1. Measure Plim for modes at validation antenna ports, bands and/or DSIs with FastConnect TAS Peak Exposure Mode enabled with callbox to establish the chosen mode for test. Denote this measured power value as Conducted_Tx_power_Plim.

NOTE: The measurement of Peak Exposure Mode should be performed with 70% or higher WLAN duty cycle (for example, using iPerf to generate UL traffic).

2. Set EUT to the intended FastConnect TAS mode.

3. Establish radio link with the callbox in the selected band.

NOTE: For the purpose of collecting repeatable time averaged power data, it is recommended to include a section of 30s at the beginning of every test with the device WLAN connection disconnected or turned off or transmitting at a very low duty cycle.

4. Request EUT to transmit in following Transition sequence:

    a. Time-Varying Test Sequence – Request EUT to transmit maximum power for at least 30s with 100% duty cycle and 50% duty cycle for 60s to determine time-averaged 1gSAR versus time.

Time duration (seconds)	Duty Cycle (%)
30	100%
60	50%

    b. Change in antenna – EUT operates at Antenna 1 (e.g., Main antenna port) and requests to transmit at maximum power for at least 60s. Then switch to operation on Antenna 2 (e.g., Aux antenna port), followed by at least 120s of observation.

    c. Change in device state (DSI) – EUT operates at DSI 1 and requests to transmit at maximum power for at least 60s. Then switch to operation on DSI 2, followed by at least 120s of observation (observation period includes transition time).

    d. Change in WLAN band – EUT operates at Band 1 and requests to transmit at maximum power for at least 60s. Then it switches to Band 2 using the same antenna port and observes another 120s (observation period includes transition time).

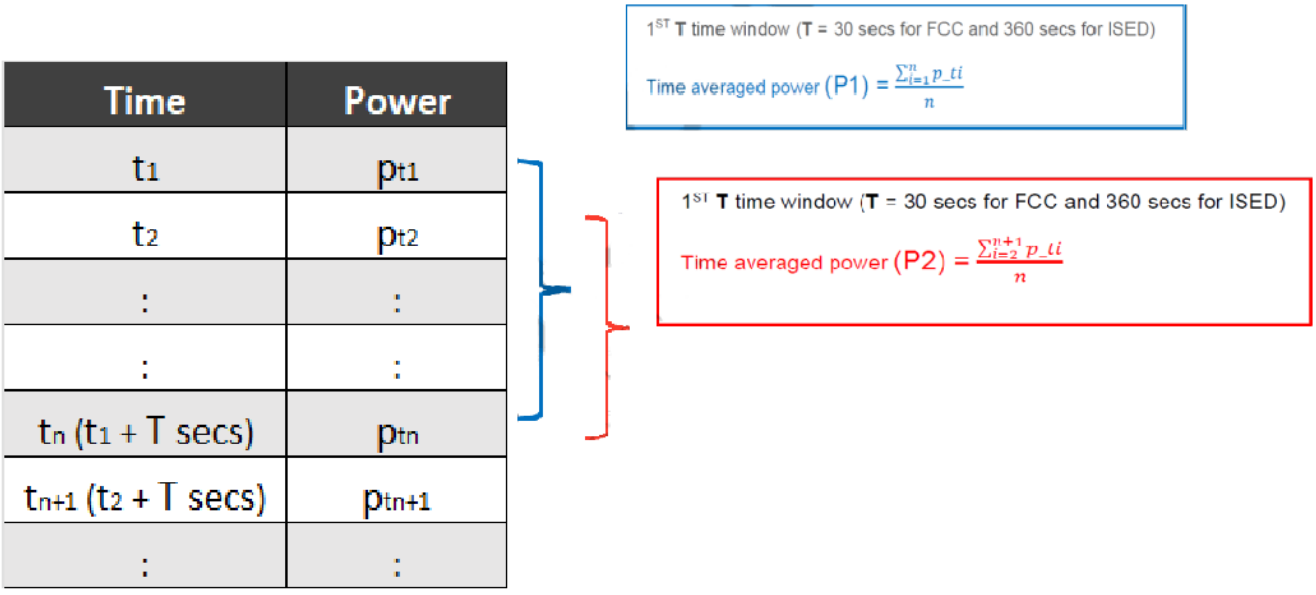
e. Simultaneous Transmissions: First establish WLAN connection with the callbox in radio2 configuration and request radio2 configuration to transmit at maximum duty cycle for at least 120s to test predominantly radio2 SAR exposure scenario. Then add radio1 configuration to the existing radio2 configuration call, and request both radio1 and radio2 to transmit at maximum duty cycle to test radio1 and radio2 SAR exposure scenario for at least 120s. Then drop (or request low duty cycle) for radio2 configuration to test predominantly radio1 SAR exposure scenario for another at least 120s. Record the conducted Tx powers for both radio1 and radio2 configurations for the entire duration of this test.

Note: radio1 and radio2 should operate at different band.

5. Measure and record Tx power versus time.

a. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1g_or_10g SAR value, see Eq. (1a), using Step 1 result.

b. Then perform 30s moving average to determine time-averaged 1g_or_10gSAR versus time as illustrated in Figure 6-2.



Time	Power
t_1	p_{t1}
t_2	p_{t2}
:	:
:	:
t_n (t_1 + T secs)	p_{tn}
t_{n+1} (t_2 + T secs)	p_{tn+1}
:	:

Figure 6-2 Time running/moving average illustration

The following normalization is used to convert 1g_or_10gSAR exposure using Equation (1a) and (1c) in section 5.2.3 to validate the continuity of RF exposure limits during the transition. The procedures from step1 and step 2 in this section should be completed for each configuration under test and use below equations to validate the RF exposure during the transition.

- if tested with both radio configurations below 6GHz:

$$1g\_or\_10gSAR_1(t) = \frac{Conducted\_Tx\_power\_1\,(t)}{Conducted\_Tx\_power\_Plim\_1} * 1g\_or\_10gSAR\_Plim\_1 \quad (4a)$$

$$1g\_or\_10gSAR_2(t) = \frac{Conducted\_Tx\_power\_2\,(t)}{Conducted\_Tx\_power\_Plim\_2} * 1g\_or\_10gSAR\_Plim\_2 \quad (4b)$$

$$\frac{\frac{1}{TSAR}[\int_{t-TSAR}^{t1} 1g\_or\_10gSAR1(t)\,dt + \int_{t-TSAR}^{t} 1g\_or\_10gSAR2(t)\,dt]}{FCC\ or\ ICNIRP\ SAR\ limit} \leq 1 \quad (4c)$$

where, conducted_Tx_power_1(t), conducted_Tx_power_ $Plim$ _1, and 1g_or_10gSAR_ $Plim$ _1 correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_1 of DUT, and compliance 1g_or_10gSAR values of Antenna 1 (or Band 1 or DSI1) at P_{lim}_1; conducted_Tx_power_2(t), conducted_Tx_power_ $Plim$ _2, and 1g_or_10gSAR_ $Plim$ _2 correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_2 of DUT, and compliance 1g_or_10gSAR values of Antenna 2 (or Band 2 or DSI2) at P_{lim}_2.

Transition from the Antenna 1 (or Band 1 or DSI1) to the Antenna 2 (or Band 2 or DSI2) happens at time-instant 't_1'.

- if tested with radio configuration: 2.4/5GHz WLAN assessed using SAR + 6GHz WLAN band assessed using APD (e.g., applicable for ISED):

$$1g\_or\_10gSAR_1(t) = \frac{Conducted\_Tx\_power\_1\,(t)}{Conducted\_Tx\_power\_Plim\_1} * 1g\_or\_10gSAR\_Plim\_1 \quad (5a)$$

$$4cm^2\ PD_2(t) = \frac{Conducted\_Tx\_power\_2\,(t)}{Conducted\_Tx\_power\_Plim\_2} * 4cm^2\ PD\_Plim\_2 \quad (5b)$$

$$\frac{\frac{1}{TSAR}[\int_{t-TSAR}^{t1} 1g\_or\_10gSAR(t)\,dt}{ICNIRP\ SAR\ limit} + \frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 4cm2\ PD(t)\,dt}{APD\ 4cm^2\ PD\ limit} \leq 1 \quad (5c)$$

where, $conducted_Tx_power$_1(t), $conducted_Tx_power_Plim$_1 and 1g_or_10$gSAR_Plim$_1 correspond to the measured instantaneous conducted Tx power and conducted Tx power at P_{lim}_1 of DUT, and 1g_or_10$gSAR$ values at P_{lim}_1 for the worst-case radio configuration within the tested 2.4/5GHz WLAN band;

conducted_Tx_power_2(t), conducted_Tx_power_ $Plim$ _2, and 4cm2 PD_ $Plim$_2 correspond to the instantaneous Tx power, conducted Tx power at Plim_2 of DUT, and 4cm2 PD values (APD) of at Plim_2 for the worst-case radio configuration within the tested 6GHz WLAN band.

Transition from the Band1 to the Band2 happens at time-instant 't_1'.

- if tested with both radio configurations greater than 6GHz bands that are assessed using APD (e.g., applicable for ISED):

$$4cm^2\ PD_1(t) = \frac{Conducted\_Tx\_power\_1\ (t)}{Conducted\_Tx\_power\_Plim\_1} * 4cm^2\ PD\_Plim\_1 \qquad (6a)$$

$$4cm^2\ PD_2(t) = \frac{Conducted\_Tx\_power\_2\ (t)}{Conducted\_Tx\_power\_Plim\_2} * 4cm^2\ PD\_Plim\_2 \qquad (6b)$$

$$\frac{\frac{1}{TSAR}\left[\int_{t-TSAR}^{t_1} 4cm2\ PD1(t)\,dt + \int_{t-TSAR}^{t} 4cm2\ PD2(t)\,dt\right]}{APD\ \ 4cm^2 PD\ limit} \leq 1 \qquad (6c)$$

where, conducted_Tx_power_1(t), conducted_Tx_power_ $Plim$ _1, and 4cm2 PD_ $Plim$_1 correspond to the instantaneous Tx power, conducted Tx power at Plim_1 of DUT, and compliance 4cm2 PD values (APD) of Band 1 (or Antenna 1) at Plim_1;

conducted_Tx_power_2(t), conducted_Tx_power_ $Plim$ _2, and 4cm2 PD_ $Plim$_2 correspond to the instantaneous Tx power, conducted Tx power at Plim_2 of DUT, and compliance 4cm2 PD values (APD) of Antenna Band 2 (or Antenna 2) at Plim_2.

Transition from the Band 1 (or Antenna 1) to the Band 2 (or Antenna 2) happens at time-instant 't_1'.

6. Make one plot containing:

    a. Computed time-averaged 1g_or_10gSAR (and/or 4cm2 PD) versus time from above procedure.

    b. Corresponding regulatory 1g_or_10gSAR (and/or 4cm2 PD) limit.

The validation criteria is, at all times, the combined time-averaged 1g_or_10gSAR (and/or 4cm2 PD) versus time shall not exceed the regulatory 1g_or_10gSAR limit.

6.6 Test Procedure for pointSAR measurement test sequence

The pointSAR test is performed only with Time-Varying Test Sequence to provide high confidence in the algorithm validation. The radio configuration for this test is selected by following the selection criteria described in Section 6.4.1.

1. For a given radio configuration:

a. Enable WLAN connection with callbox **in FastConnect TAS Peak Exposure Mode** and enable high duty cycle Tx while performing the following steps.

b. Perform the area scan.

c. Conduct pointSAR measurement at peak location of the area scan for 120s.

This pointSAR value, $pointSAR\_Plim$ corresponds to pointSAR at the measured Plim.

NOTE: The measurement of Peak Exposure Mode should be performed with 70% or higher WLAN duty cycle (for example, using iPerf to generate UL traffic).

2. Conduct pointSAR measurement at peak location of the area scan for 120s.

   a. Perform Time-averaged point SAR measurements at the same peak location as Peak Exposure Point SAR measurement for 120s. Note this includes initial 30s with WLAN with very low duty cycle (or WLAN is disconnected) and 90s of high duty cycle (WLAN has to be connected with high uplink traffic).

   b. Once the measurement is done, extract instantaneous pointSAR versus time data, *pointSAR(t)*

   c. Convert it into instantaneous 1gSAR versus time by using Equation (2a) and (2c) in Section 5.2.4:

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

   where, $pointSAR\_Plim$ corresponds to the value determined in Step 1, and pointSAR(t) corresponds to instantaneous pointSAR determined in Step 2 in this section.

   d. Then perform 30s moving average to determine time-averaged 1gSAR versus time.

3. Make one plot containing:

   a. Computed time-averaged 1g_or_10gSAR versus time determined from Step 2.

   b. Regulatory *1g_*or*_10gSAR* limit.

   The validation criteria for pointSAR measurement is, at all times, the time averaged 1g_or_10gSAR (or 4cm2 PD) versus time shall not exceed the regulatory 1g_or_10gSAR (or 4cm2 PD) limit.

7 MEASUREMENT TEST SETUP (FREQ < 6 GHZ)

7.3 Cellular 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 7-1a (Appendix D – Test Setup Photo 1 and 2) for measurements with a single antenna of DUT, and in Figure 7-1b (Appendix D – Test Setup Photo 3) for measurements involving antenna switch. For single antenna measurement, one port (RF1 COM) of the callbox is connected to the RF port of the DUT using a directional coupler. For technology/band switch measurement, one port (RF1 COM) of the callbox used for signaling two different technologies is connected to a combiner, which is in turn connected to a directional coupler. The other end of the directional coupler is connected to a splitter to connect to two RF ports of the DUT corresponding to the two antennas of interest. In the setups, power meter is used to tap the directional coupler for measuring the conducted output power of the DUT. For all legacy conducted tests, only RF1 COM port of the callbox is used to communicate with the DUT.

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

The test setup schematic is shown in Figure 7-1e (Appendix D – Test Setup Photo 8) for measurements involving Inter-band ULCA. For Inter-band ULCA measurements, two ports, (RF1 COM & RF3 COM) of the callbox used for signaling the PCC band and SCC band respectively are each connected to the PCC and SCC RF ports of the DUT using two directional couplers. In the setups, power meters are used to tap the directional couplers for measuring the conducted output power of the DUT.

Sub6 NR test setup:

The Anritsu MT8000A callbox was used in this test. The test setup schematic is the same as the Legacy Test Setup shown in Figure 7-1a (Appendix D – Test Setup Photo 4 and 5). 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.

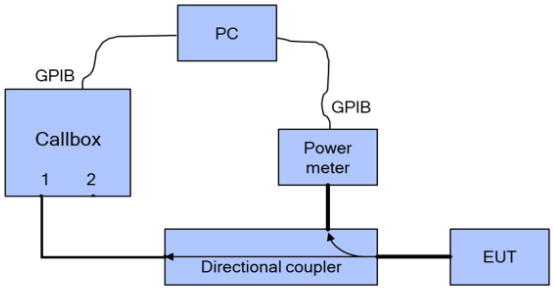
All the path losses from RF port of DUT to the callbox RF COM port and to the power meter are calibrated and automatically entered as offsets in the callbox and the power meter via test scripts on the PC used to control callbox and power meter.

LTE+Sub6 NR test setup:

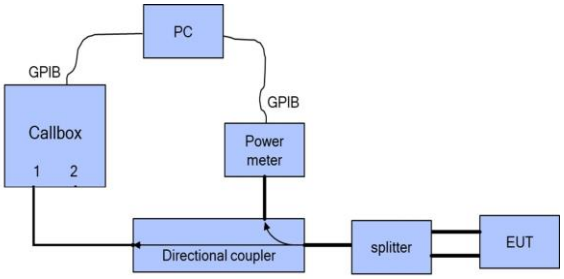
LTE conducted port and Sub6 NR conducted port are the same on this EUT, therefore, the LTE and Sub6 NR signals for power meter measurement are performed on separate paths as shown below in Figure 7-1c (Appendix D – Test Setup Photo 6).

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 7-1d (Appendix D – Test Setup Photo 7 and 9).

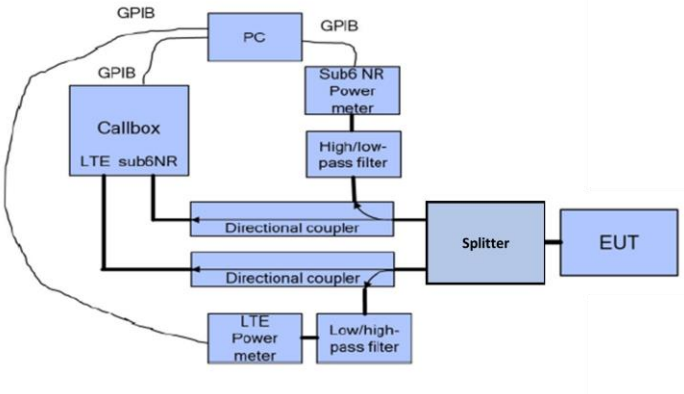
All the path losses from RF port of DUT to the callbox RF COM port and to the power meter are calibrated and automatically entered as offsets in the callbox and the power meter via test scripts on the PC used to control callbox and power meter.



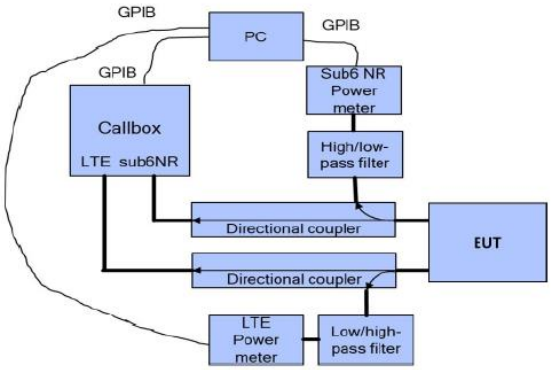
(a) Appendix D – Test Setup Photo 1, 2, 4, and 5



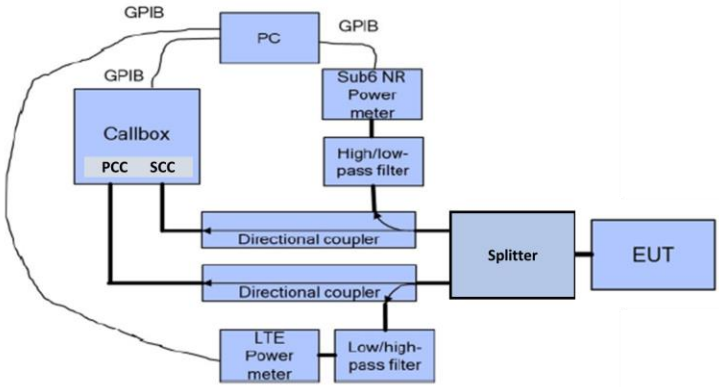
(b) Appendix D – Test Setup Photo 3



(c) Appendix D – Test Setup Photo 6



(d) Appendix D – Test Setup Photo 7



(e) Appendix D – Test Setup Photo 8

Figure 7-1
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 A or test sequence B (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 RSI 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 RSI 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 RSI switch test.

7.4 WLAN Conducted Measurement Test Setup

This section provides the setup diagram that is performed in this test report. The test setup depends on the test mode selection. The test setup instruction is provided in Qualcomm® FastConnect™ User Guide (80-39282-2) Qualcomm document.

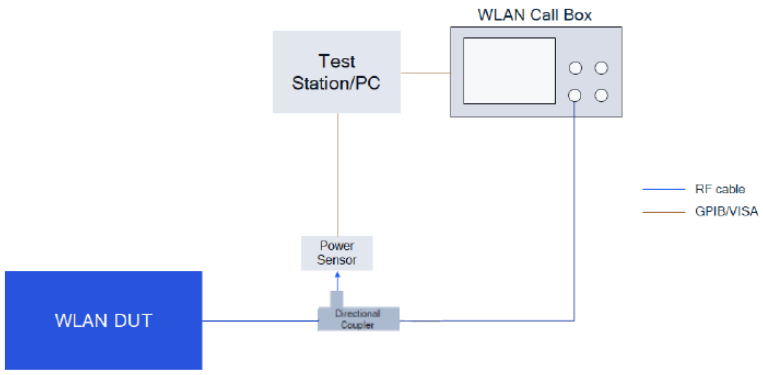


Figure 7-2 SISO (Time-Varying Test Sequence, Change in DSI) – Validation test setup photo 10

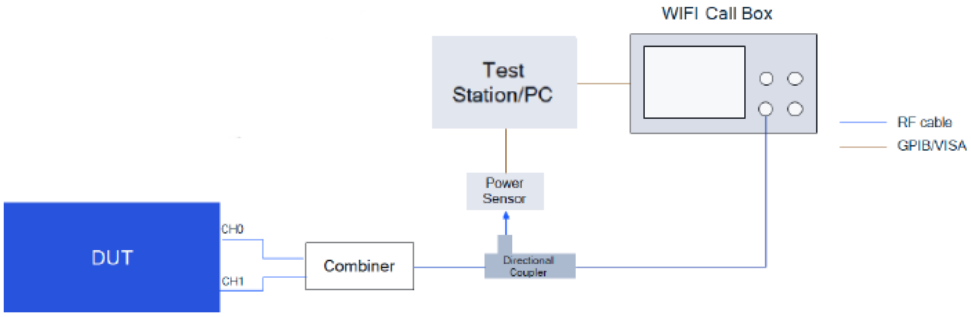


Figure 7-3 SISO (Change in Antenna) – Validation test setup photo 12

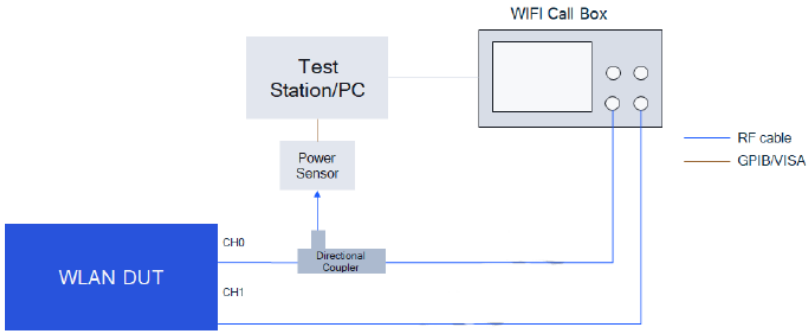


Figure 7-4 MIMO (Change in WLAN band) – Validation test setup photo 11

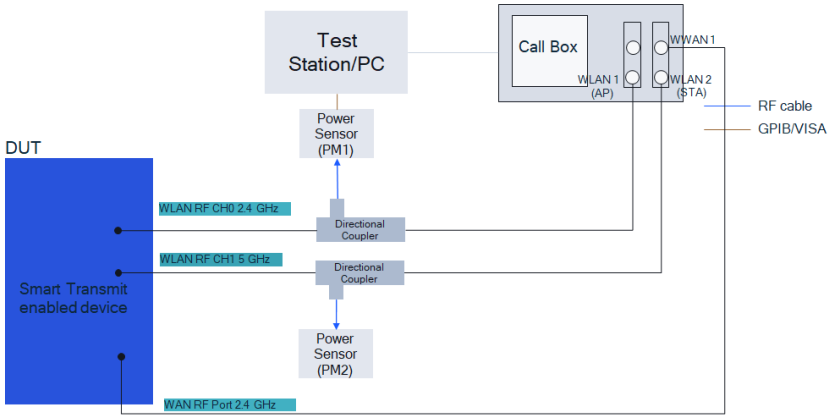


Figure 7-5 SISO (Simultaneous Transmission) – Validation test setup test setup photo 12

7.5 Point SAR test setup

To provide higher confidence in the validation test, the FastConnect TAS Validation test plan includes radiated measurements.

In this test, the measurement setup is similar to the normal SAR measurements:

- The EUT is positioned against the flat section of the SAM Twin phantom and wirelessly connected with the callbox.
- The EUT is placed in worst-case position as determined from the static SAR test report.

The same test script from Time-Varying Test Sequence is also used here for SAR measurements.

This section provides the setup diagram that is performed in this test report.

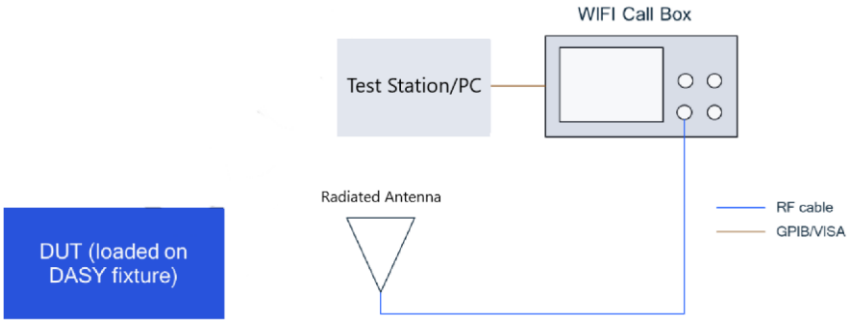


Figure 7-6 cDASY6 System Measurement setup 15

8 TEST CONFIGURATIONS (FREQ < 6 GHZ)

8.3 WWAN (sub-6) transmission

The P_{limit} values, corresponding to 0.8 W/kg (1gSAR) and 2.0 W/kg (10gSAR) of *SAR_design_target*, for technologies and bands supported by DUT are derived in Part 0 report and summarized in Table 8-1. Note all P_{limit} power levels entered in Table 8-1 correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes.

Table 8-1
P_{limit} for supported technologies and bands (P_{limit} in EFS file)

Exposure Scenario		Maximum Tune-Up Output Power*	Body-Worn	Phablet	Head	Hotspot	Earjack
Averaging Volume			1g	10g	1g	1g	1g/10g
Spacing			10 mm	0 mm	0 mm	10 mm	10 mm, 0 mm
RSI			Free	Free	RCV	Hotspot	Earjack
Technology/Band	Antenna	Pmax					
GSM 850	A	24.3	27.3		30.3	27.3	27.3
GSM 1900	A	21.3	17.8		17.8	17.8	17.8
UMTS 850	A	24.5	25.1		30.6	25.1	25.1
UMTS 1750	A	23.0	17.5		17.5	17.5	17.5
UMTS 1900	A	23.5	18.0		18.0	18.0	18.0
LTE Band 12	A	24.0	27.8		31.5	27.8	27.8
LTE Band 17	A	23.5	27.8		31.5	27.8	27.8
LTE Band 13	A	24.0	25.0		29.2	25.0	25.0
LTE Band 26 (Cell)	A	24.0	25.2		29.9	25.2	25.2
LTE Band 5 (Cell)	A	24.5	25.8		30.4	25.8	25.8
LTE Band 66/4 (AWS)	A	23.5	19.0		31.7	19.0	19.0
LTE Band 66/4 (AWS)	F	23.0	16.0		16.0	16.0	16.0
LTE Band 2 (PCS)	A	23.5	19.0		30.7	19.0	19.0
LTE Band 2 (PCS)	F	23.0	17.5		17.5	17.5	17.5
LTE Band 41 (PC3)	B	22.0	20.0		32.3	20.0	20.0
LTE Band 41 (PC2)	B	21.4	20.0		32.3	20.0	20.0
NR Band n5	A	24.0	26.3		31.1	26.3	26.3
NR Band n66	A	23.5	18.5		30.9	18.5	18.5
NR Band n66	F	23.0	16.0		16.0	16.0	16.0
NR Band n41	B	24.0	17.0		17.0	17.0	17.0
NR Band n41	F	23.5	16.5		16.5	16.5	16.5
NR Band n41	E	24.0	17.0		17.0	17.0	17.0
NR Band n41	D	22.0	16.0		16.0	16.0	16.0
NR Band n77	F	24.5	14.0		14.0	14.0	14.0
NR Band n77	C	24.5	12.0		12.0	12.0	12.0
NR Band n77	I	24.5	12.0		12.0	12.0	12.0
NR Band n77	D	23.0	9.5		9.5	9.5	9.5

Table 8-2
P_{limit} for supported WLAN technologies and bands (P_{limit} in EFS file)

Exposure Scenario		Maximum Tune-Up Output Power*	Free	RCV	NR Active	RCV + NR Active
Averaging Volume			1g/10g	1g	1g/10g	1g
Spacing			10 mm, 0 mm	0 mm	10, 0 mm	0 mm
DSI			0	1	8	9
Technology/Band	Antenna	Pmax				
2.4 GHz WLAN	2	17.0	15.5	13.0	13.0	13.0
2.4 GHz WLAN	MIMO	17.0	15.5	13.0	13.0	13.0
5 GHz WLAN	MIMO	15.0	12.0	12.0	12.0	12.0
6 GHz WLAN	MIMO	9.0	18.8	14.9	14.9	14.9

Note: For the WLAN Plimit values, corresponding to 0.4 W/kg (1gSAR) and 1.0 W/kg (10gSAR) of SAR_design_target, for technologies and bands supported by DUT are derived in Part 0 report and summarized in Table 8-2.

* Maximum tune up target power, P_{max}, is configured in DUT to limit maximum transmitting power. This power is converted into peak power 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 8-1.

The radio configurations used in Part 2 test for selected technologies, bands, RSIs and antennas are listed in Table 8-3. The corresponding worst-case radio configuration 1gSAR values for selected technology/band/RSI are extracted from Part 1 report and are listed in the last column of Table 8-3.

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/RSI. 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.

The measured P_{limit} for all the selected radio configurations are listed in below Table 8-3. 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 5.1 and Section 6.1.

Table 8-3
Radio configurations selected for Part 2 test

Test Case #	Test Scenario	Tech	Band	Antenna	RSI	Channel	Frequency [MHz]	Test Configurations	SAR Exposure Scenario	Part 1 Worst Case Measured SAR at Plimit (W/kg)	EFS Plimit [dBm]	Tune-up Pmax [dBm]	Measured Plimit [dBm]	Measured Pmax [dBm]
1	Test Sequence A Test Sequence B	GSM	1900	A	Hotspot	661	1880	4Tx Slot	Bottom Edge, 10mm	0.397	16.8	21.3	17.05	21.85
2	Test Sequence A Test Sequence B	WCDMA	4	A	Hotspot	1413	1745	RMC -	Bottom Edge, 10mm	0.247	17.5	23.0	17.57	23.72
3	Test Sequence A Test Sequence B	WCDMA	2	A	Hotspot	9400	1880	RMC -	Bottom Edge, 10mm	0.456	18.0	23.5	17.93	24.00
4	Test Sequence A Test Sequence B	LTE	66	Main 1 (A)	Hotspot	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.417	19.0	23.5	19.23	24.13
5	Test Sequence A Test Sequence B	LTE	41 (PC3)	Main 2 (B)	Hotspot	40620	2593	QPSK 1/50/20 MHz BW	Back Side, 10mm	0.364	20.0	22.0	20.09	21.68
6	Test Sequence A Test Sequence B	NR	n66	Main 1 (A)	Hotspot	349000	1745	DFT-s-OFDM, QPSK 1/1/40 MHz BW	Bottom Edge, 10mm	0.510	18.5	23.5	18.87	24.14
7	Test Sequence A Test Sequence B	NR	n77	Sub2 (F)	Hotspot	650000	3750	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Top Side, 10mm	0.117	14.0	24.5	14.02	23.95
8	Test Sequence A Test Sequence B	WLAN	2.4	SISO Ant2	Head	6	2347	802.11b DSSS	Left, Cheek	0.487	13.0	17.0	12.96	16.98
9	Test Sequence A Test Sequence B	WLAN	5	MIMO Ant 1	Head	40	5200	802.11ac OFDM, MIMO	Right, Cheek	0.404	12.0	15.0	12.66	15.85
10	Change in Call	NR	n77	Sub2 (F)	Hotspot	650000	3750	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Top Side, 10mm	0.117	14.0	24.5	14.02	23.95
11	Change in Technology / Band	LTE	66	Main 1 (A)	Hotspot	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.417	19.0	23.5	19.23	24.13
		WCDMA	2	Main1 (A)	Hotspot	9400	1880	RMC -	Bottom Edge, 10mm	0.456	18.0	23.5	17.93	24.00
12	Change in Antenna	LTE	66	Main 1 (A)	Hotspot	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.417	19.0	23.5	19.23	24.13
		LTE	41 (PC3)	Main 2 (B)	Hotspot	40620	2593	QPSK 1/50/20 MHz BW	Back Side, 10mm	0.364	20.0	22.0	20.09	21.68
13	SAR Exposure Switching EN-DC	LTE	5	Main1 (A)	Hotspot	20525	836.5	QPSK 1/25/10 MHz BW	Back Side, 10mm	0.427	25.8	24.5	24.15	24.15
		Sub6 NR	n66	Main 1 (A)	Hotspot	349000	1745	DFT-s-OFDM, QPSK 1/1/40 MHz BW	Bottom Edge, 10mm	0.510	18.5	23.5	18.67	23.74
14	TAS to nonTAS H.O	LTE	66	Main 1 (A)	Hotspot	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.417	19.0	23.5	19.23	24.13
		WCDMA	4	A	Hotspot	1413	1745	RMC -	Bottom Edge, 10mm	0.247	17.5	23.0	17.57	23.72
15	WLAN Change in Device State	WLAN	2.4	SISO Ant2	Hotspot	6	2347	802.11b DSSS	Front Side, 10mm	0.183	15.5	17.0	15.48	16.98
		WLAN	2.4	SISO Ant2	Head	6	2347	802.11b DSSS	Left, Cheek	0.487	13.0	17.0	12.96	16.98
16	WLAN Change in Band	WLAN	2.4	MIMO Ant 2	Head	6	2347	802.11n DSSS	Left, Cheek	0.487	13.0	17.0	13.05	16.75
		WLAN	5	MIMO Ant 1	Head	40	5200	802.11n DSSS	Right, Cheek	0.404	12.0	15.0	12.66	15.72
17	WLAN Simultaneous Transmission (DBS)	WLAN	2.4	MIMO Ant 2	Head	6	2347	802.11b DSSS	Right, Cheek	0.416	13.0	17.0	13.28	16.48
		WLAN	5	MIMO Ant 1	Head	40	5200	802.11ac OFDM, MIMO	Right, Cheek	0.404	12.0	15.0	12.66	15.85
18	SAR Exposure Switching ULCA	LTE	66	Main 1 (A)	Hotspot	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.417	19.0	23.5	19.23	24.13
		LTE	5	Main1 (A)	Hotspot	20525	836.5	QPSK 1/25/10 MHz BW	Back Side, 10mm	0.427	25.8	24.5	24.15	24.15
19	Antenna Switching with Spatial TAS	NR	n41	Main2 (B)	Hotspot	518598	2593	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Bottom Edge, 10mm	0.178	17.0	24.0	17.36	23.37
		NR	n77	Sub2 (F)	Hotspot	650000	3750	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Top Side, 10mm	0.117	14.0	24.5	14.02	23.95
20	NSA with Spatial TAS	LTE	2	Main1 (A)	Free	18900	1880	QPSK 1/50/20 MHz BW	Bottom Edge, 10mm	0.586	19.0	23.5	18.74	23.84
		Sub6 NR NSA	n66	Sub2 (F)	Free	349000	1745	DFT-S-OFDM, QPSK 1/1/40 MHz BW	Bottom Edge, 10mm	0.510	16.0	23.0	16.33	22.95
21	NSA Antenna Switching with SpatialTAS	LTE	12	Main1 (A)	Free / Hotspot	23095	707.5	QPSK 1/25/10 MHz BW	Back Side, 10mm	0.313	31.5	24.0	23.80	23.80
		Sub6 NR NSA	41	Main 2 (B)	Free / Hotspot	518598	2593	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Bottom Edge, 10mm	0.178	17.0	24.0	17.59	23.71
		Sub6 NR NSA	77	Sub2 (F)	Free / Hotspot	650000	3750	DFT-s-OFDM, QPSK 1/136/100 MHz BW	Top Side, 10mm	0.117	14.0	24.5	14.12	23.76

Note: The above P_{max}, P_{lim} values for GPRS1900 are for 4 Tx Slots.

Table 8-4
RSI and Corresponding Exposure Scenarios

Scenario	Description	SAR Test Cases
Head	Device positioned next to head Receiver Active	*Head SAR per KDB Publication 648474 D04*
Hotspot	Device transmits in hotspot mode near body Hotspot Mode Active	*Hotspot SAR per KDB Publication 941225 D06*
Phablet	Device is held with hand and grip sensor is triggered Distance grip sensor not triggered	*Phablet SAR per KDB Publication 648474 D04 & KDB Publication 616217 D04*
Body-worn	Device being used with a body-worn accessory	*Body-worn SAR per KDB Publication 648474 D04*

Based on the selection criteria described in Section 6.2 and Section 6.4, 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 1~9 listed in Table 8-3 are selected to test with the test sequences defined in Section 5.1 and Section 6.1 in time-varying conducted power measurement.
2. Technology and band for change in call test: NR n77, ant F having the lowest P_{limit} among all technologies and bands (test case 10 in Table 8-3), is selected for performing the call drop test in conducted power setup.
3. Technologies and bands for change in technology/band test: Test case 11 in Table 8-3 is selected for handover test from a technology/band within one technology group (LTE Band 66, hotspot, antenna A), to a technology/band in the same RSI within another technology group (WCDMA Band 2, hotspot, antenna A) in conducted power setup.
4. Technologies and bands for change in antenna: For a given RSI hotspot, test case 12 in Table 8-3 is selected for antenna switch between antenna B (LTE Band 41) and antenna A (LTE Band 66) in conducted power setup.
5. Technologies and bands for switch in SAR exposure: Test case 13 in Table 8-3 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. Test case 18 in Table 8-3 is selected for SAR exposure switching test in one of the supported simultaneous LTE transmission scenarios, i.e., LTE ULCA, in conducted power setup.
6. Technologies and bands for TAS to nonTAS switching: For a given RSI hotspot, test case 14 in Table 8-3 is selected for a switch between LTE Band 66 TAS ON to WCDMA Band 4 TAS OFF in conducted power setup.
7. Technologies and bands for change in WLAN DSI: Based on selection criteria in Section 6.4, for a given technology and band, test case 15 in Table 8-3 is selected for DSI switch test by establishing a call in WLAN 2.4GHz, antenna 2, in Hotspot, and then handing over to Head exposure scenario in conducted power setup.
8. Technologies and bands for change in WLAN band test: Test case 16 in Table 8-3 is selected for handover test from a band within one technology group (WLAN 2.4GHz, head, antenna 2), to a band

in the same DSI within another technology group (WLAN 5GHz, head, antenna 1) in conducted power setup.

9. Technologies and bands for switch in WLAN SAR exposure: Test case 17 in Table 8-3 is selected for SAR exposure switching test in one of the supported simultaneous DBS WLAN transmission scenario, i.e., WLAN + WLAN active in the same 30s time window, in conducted power setup.

10. Technologies and bands for Spatial TAS: Test case 19, 20, 21 in Table 8-3 are selected for SAR exposure switching with spatial TAS. Three antennas (A, B, F) with two antenna groups (AG0, AG1) are considered where each antenna group consists of one/multiple antenna and one/multiple bands.

    Note: Test cases #11 - #18 were done with modes/bands within the same antenna group.

9 CONDUCTED TX CASES (FREQ < 6 GHZ)

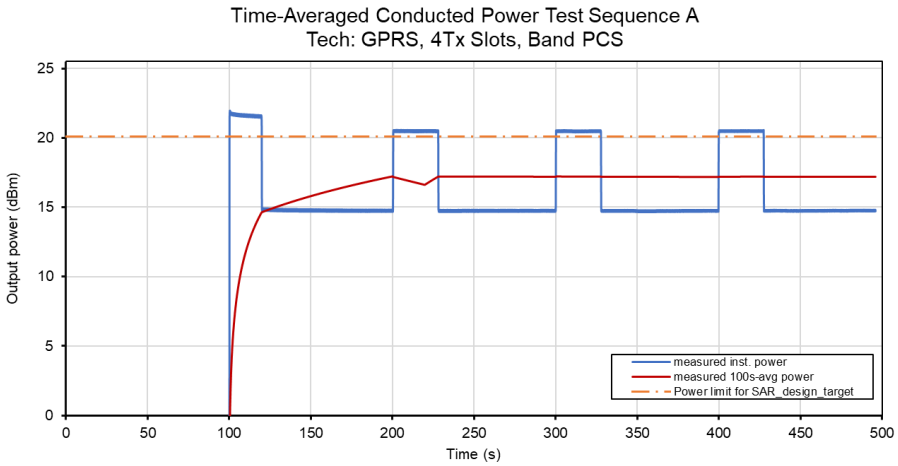
9.3 Time-varying Tx Power Case

Following the test procedure in Section 4.3.1, the conducted Tx power measurement results for all selected test cases are listed in this section. In all conducted Tx power plots, the blue line shows the measured instantaneous power using the power meter, the red line shows the time-averaged Tx power and yellow line shows the Plimit value corresponding to the design target. In all SAR plots, the dotted blue line shows the time-averaged 1g SAR while the red line shows the corresponding FCC limit of 1.6 W/kg.

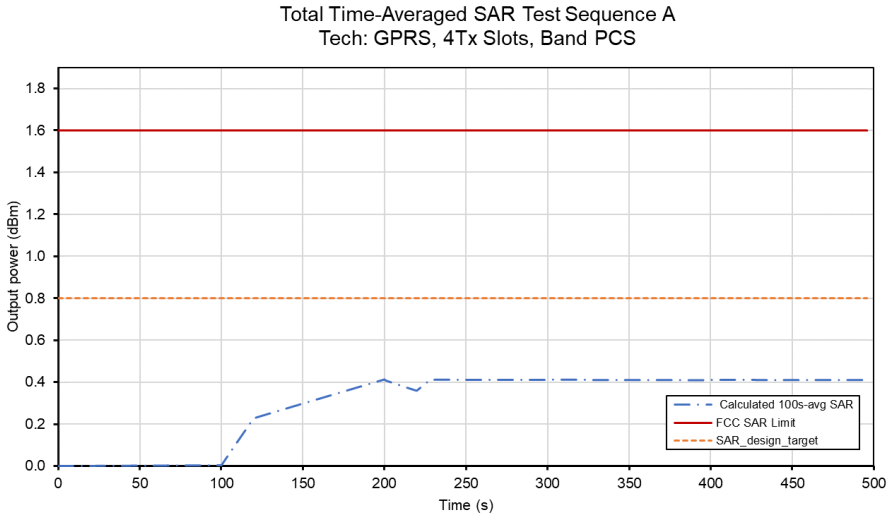
Time-varying Tx power measurements were conducted on test cases #1 ~ #9 in Table 8-3, by generating test sequence A, test sequence B, and test sequence 1 given in APPENDIX E: using measured P_{limit} and measured P_{max} (last two columns of Table 8-3) for each of these test cases. Measurement results for test cases #1 ~ #9 are given in Sections 9.1.1-9.1.9.

9.3.5 GSM/GPRS/EDGE 1900

Test result for test sequence A:

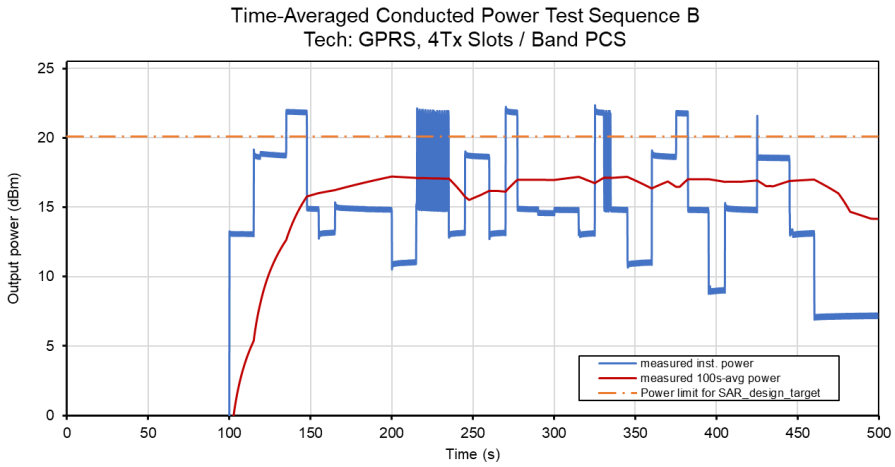


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

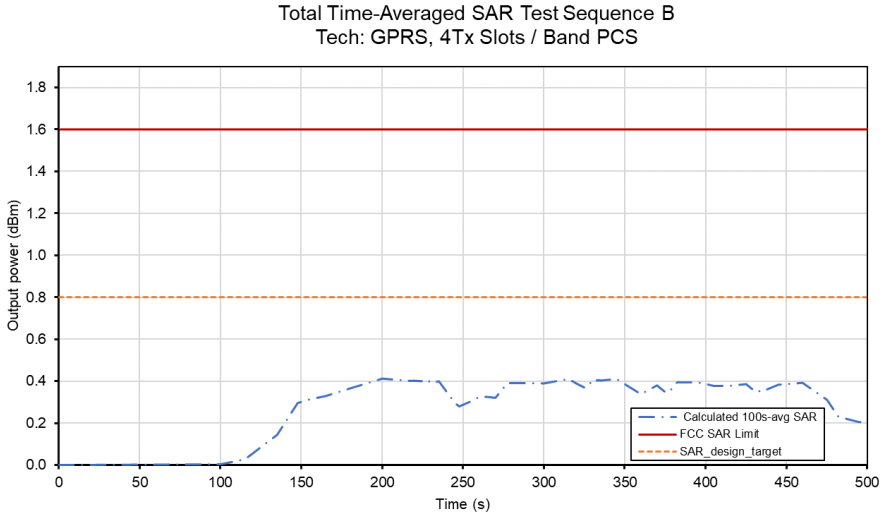


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.413
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



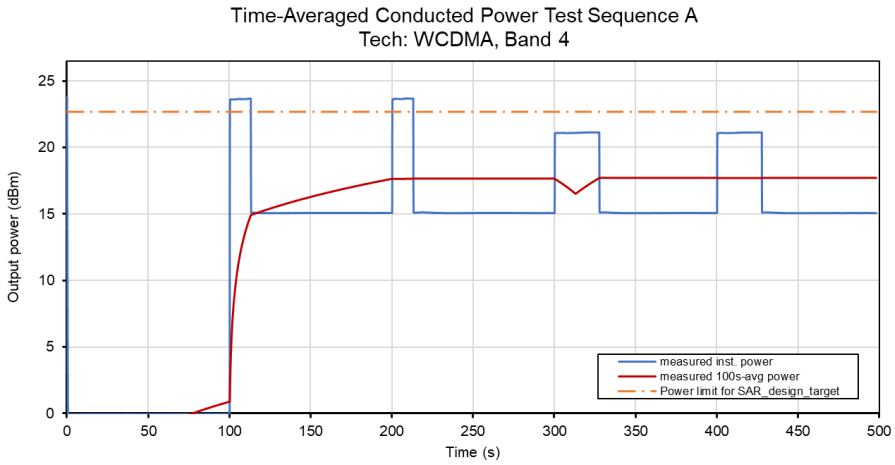
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



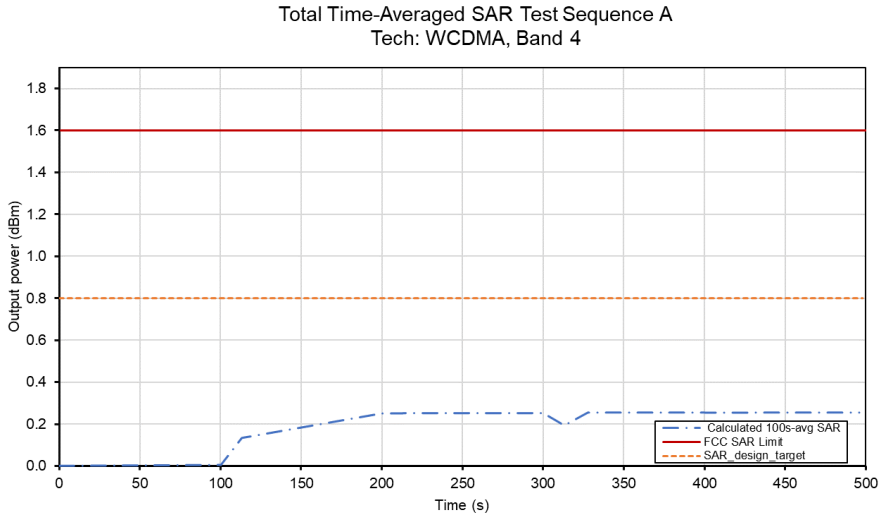
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.412
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.6 WCDMA Band 4

Test result for test sequence A:

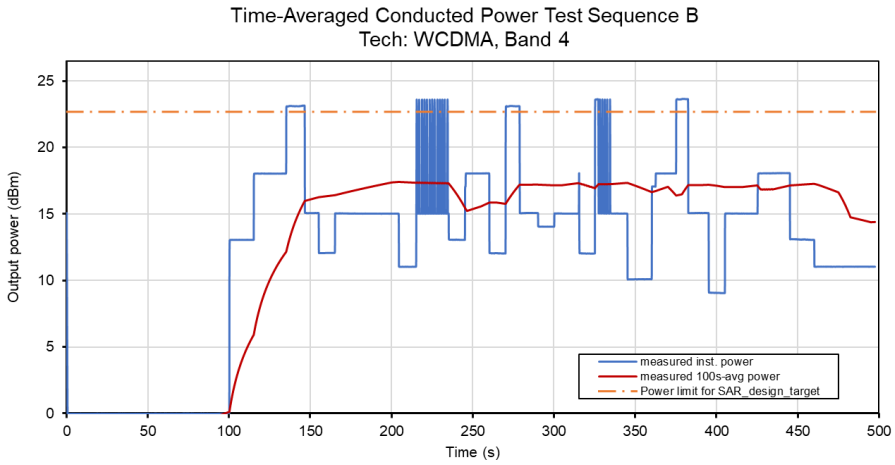


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

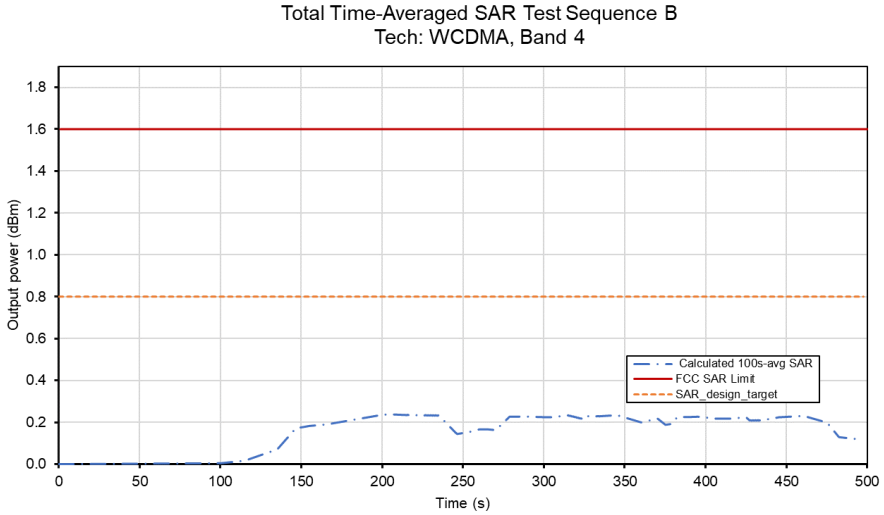


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.255
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



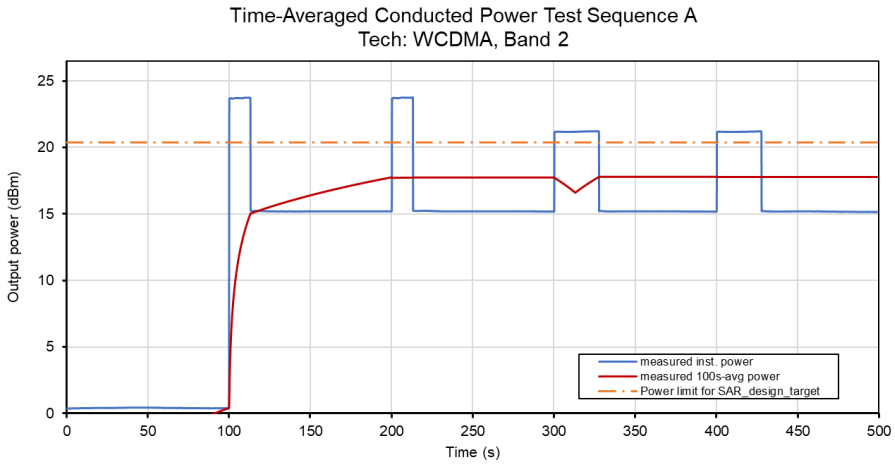
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



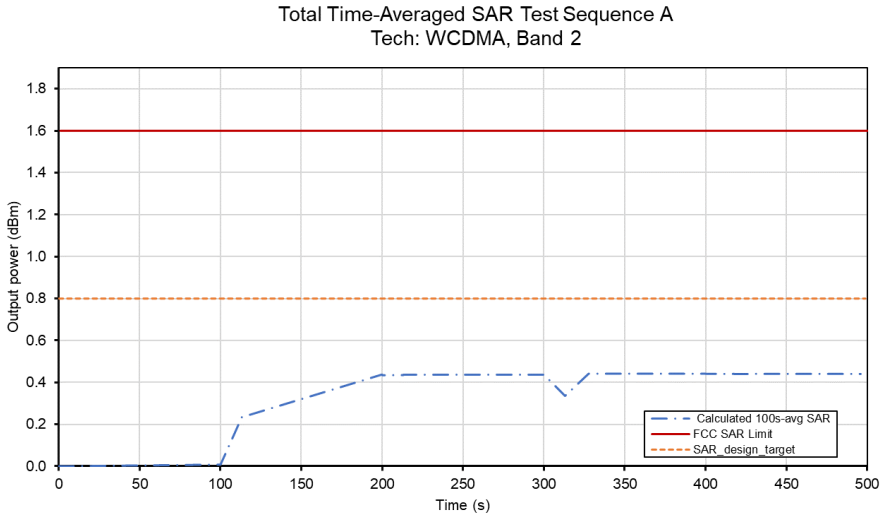
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.238
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.7 WCDMA Band 2

Test result for test sequence A:

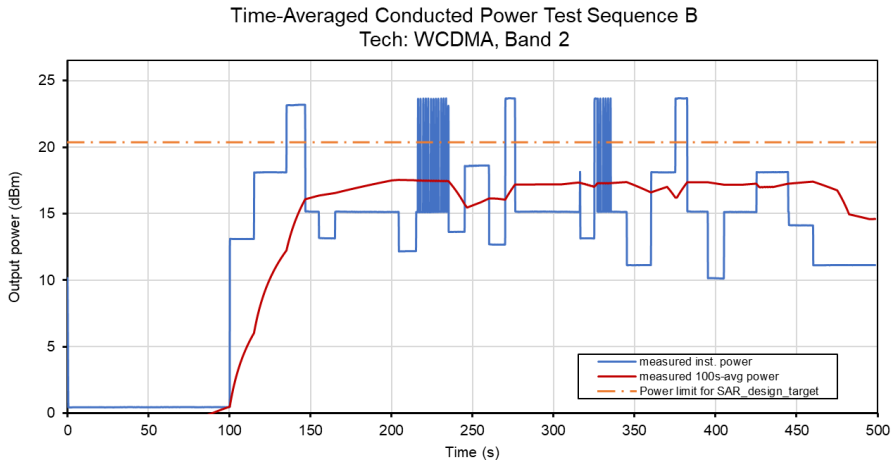


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

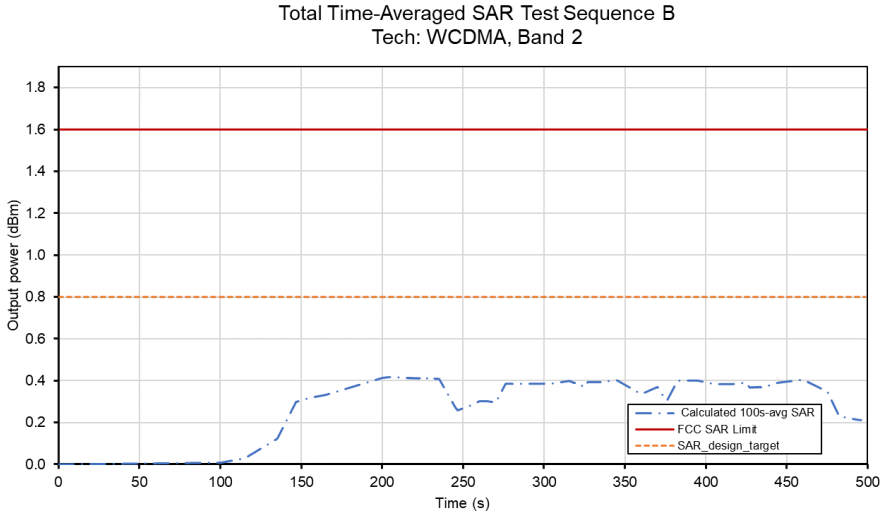


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.442
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



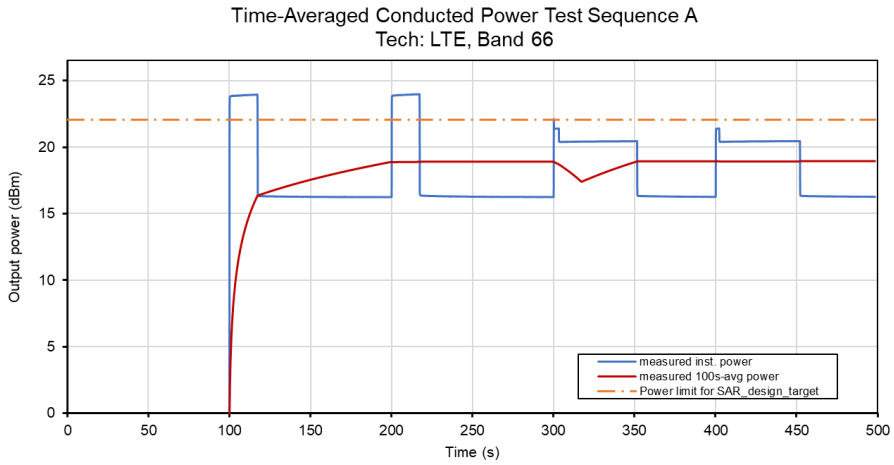
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



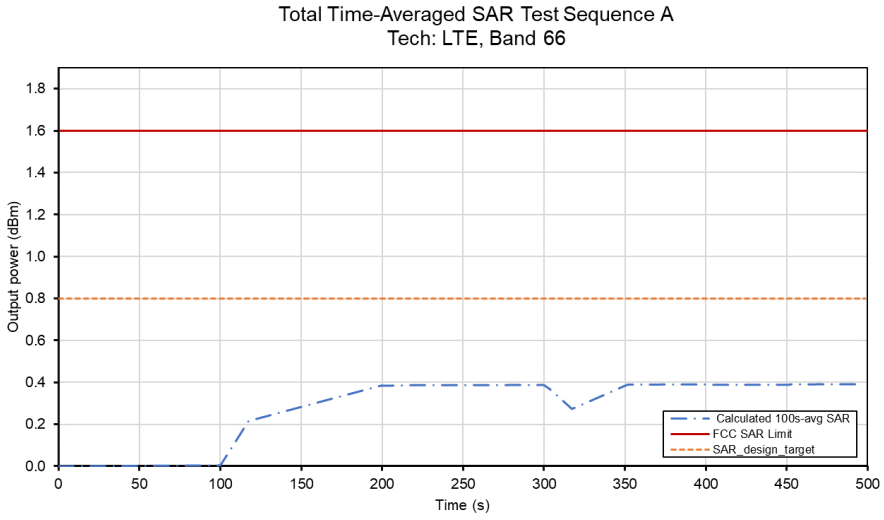
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.417
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.8 LTE Band 66, Antenna A

Test result for test sequence A:

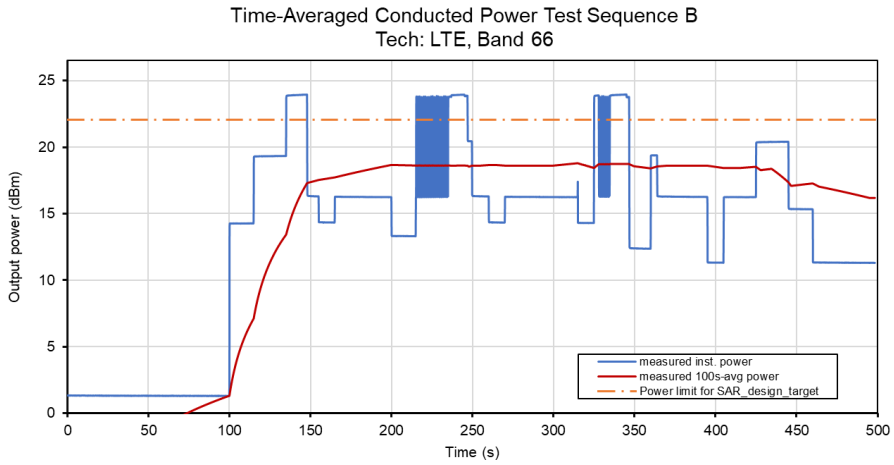


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

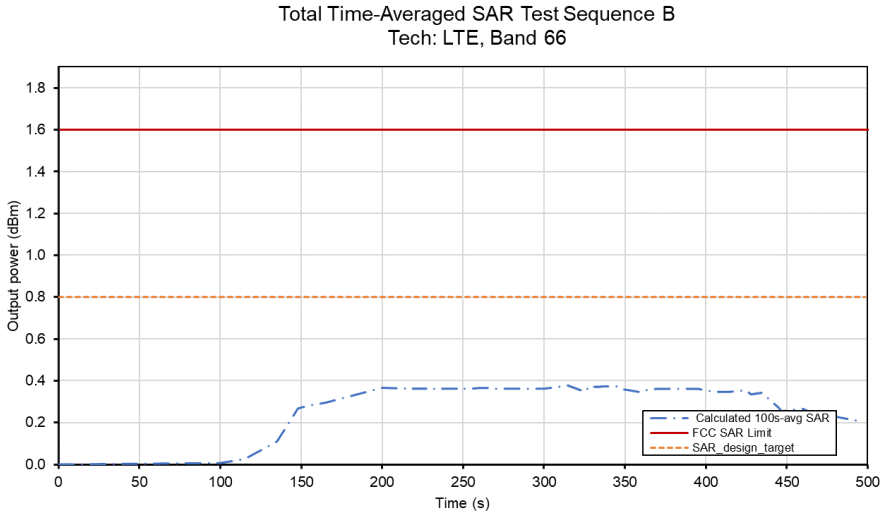


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.391
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



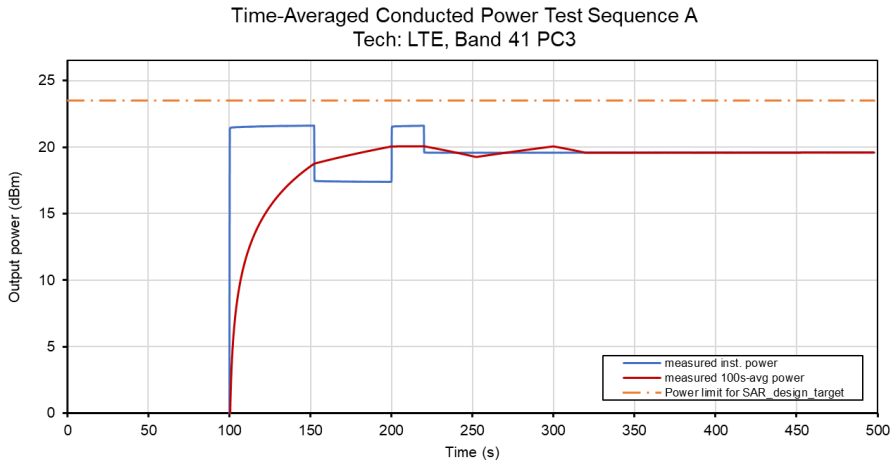
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



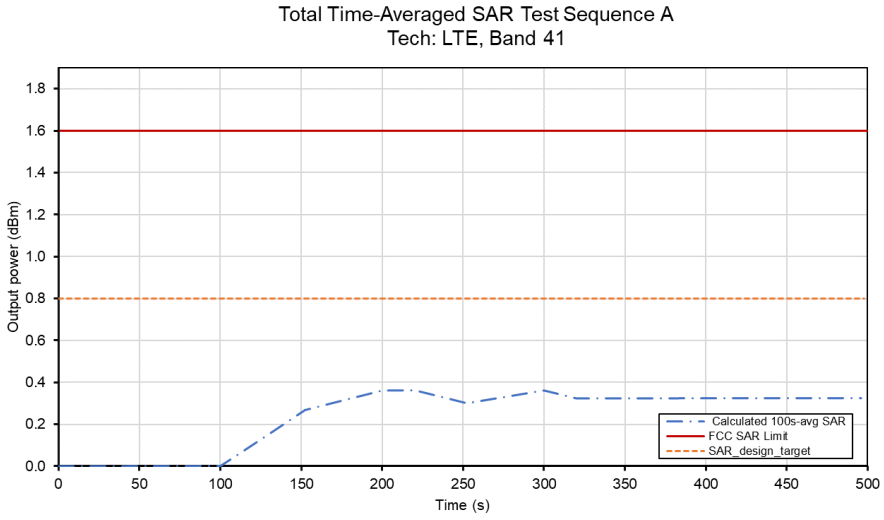
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.377
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.9 LTE Band 41, Antenna B

Test result for test sequence A:

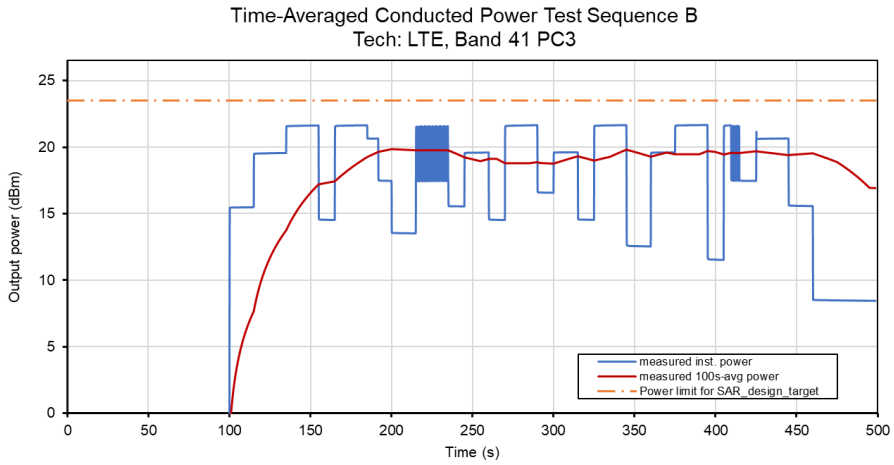


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

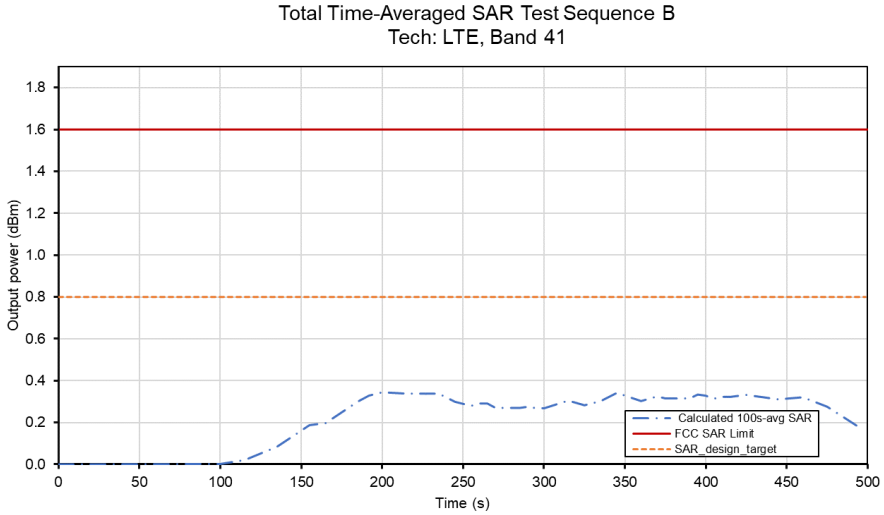


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.362
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



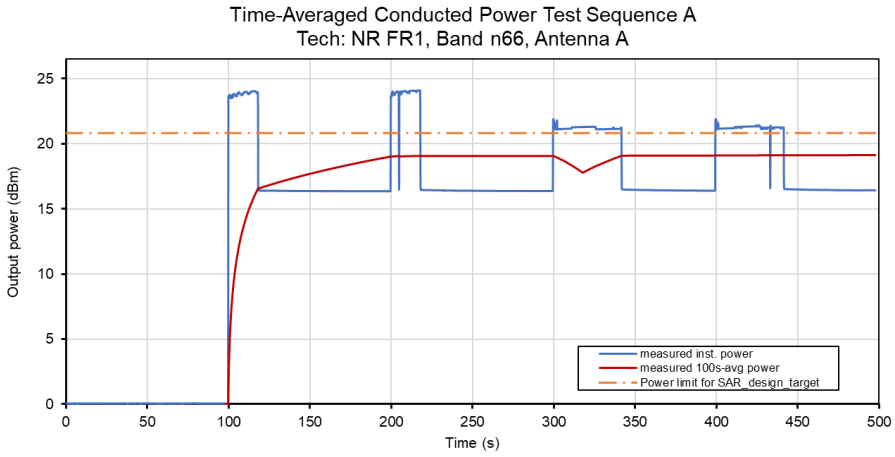
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



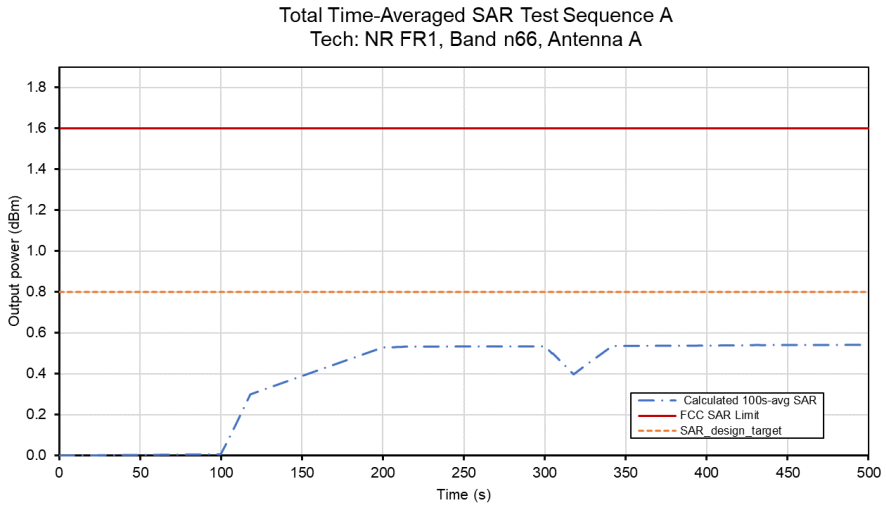
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.345
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.10 NR n66 SA, Antenna A

Test result for test sequence A:

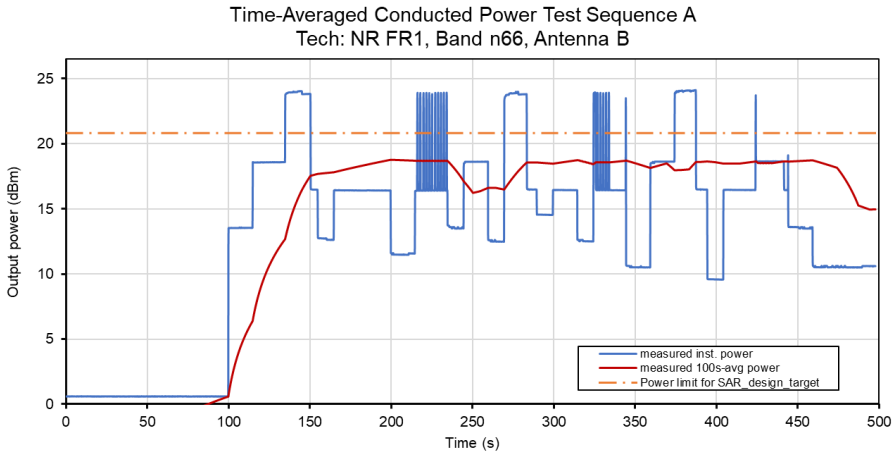


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

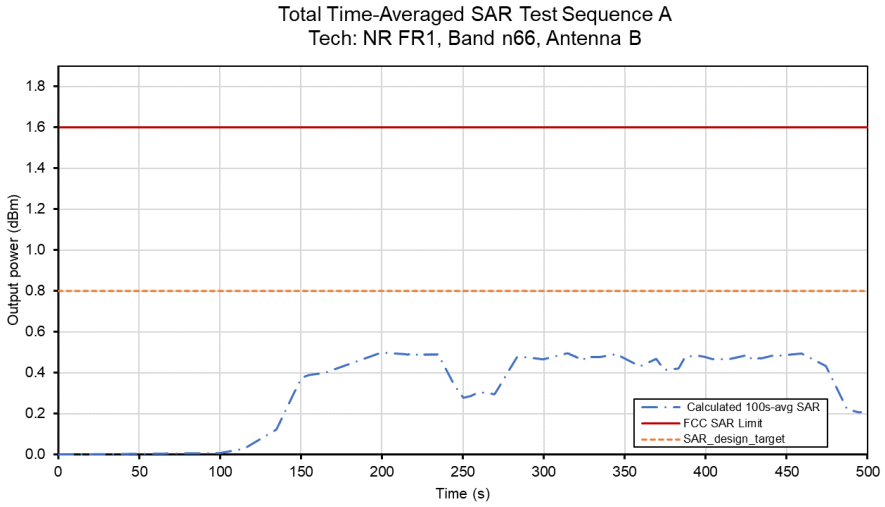


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.541
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



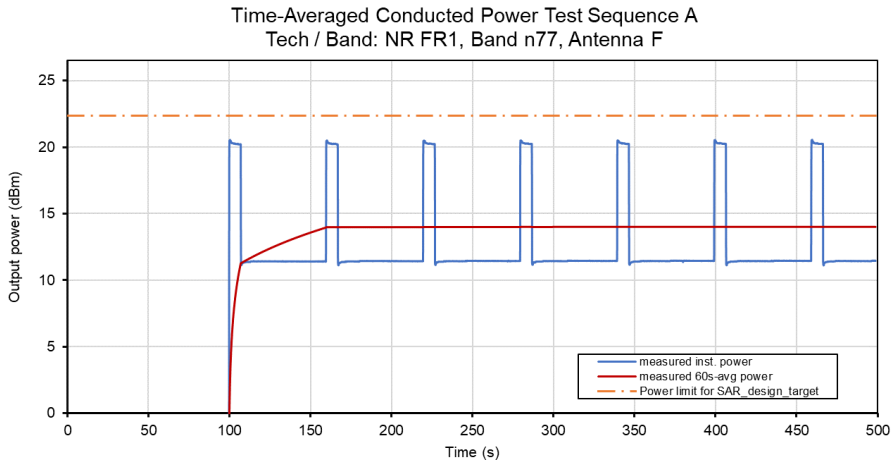
Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



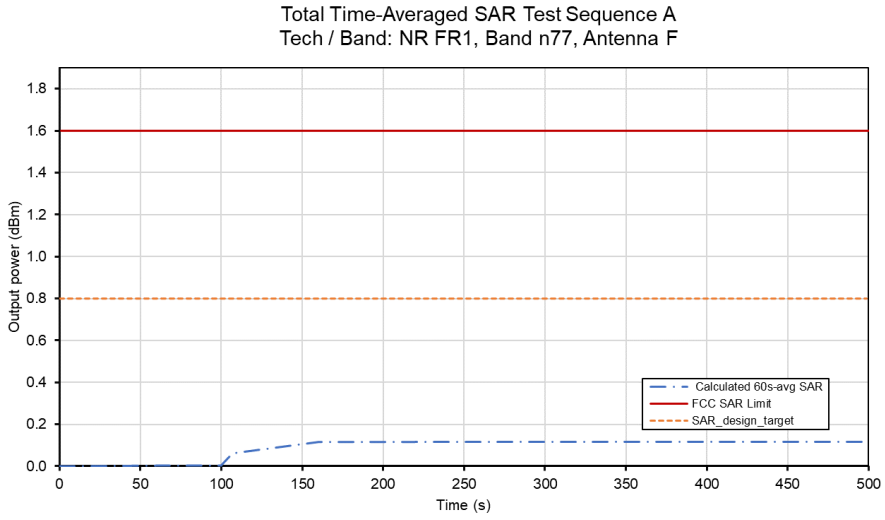
	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (blue curve)	0.499
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.11 NR n77 SA, Antenna F

Test result for test sequence A:

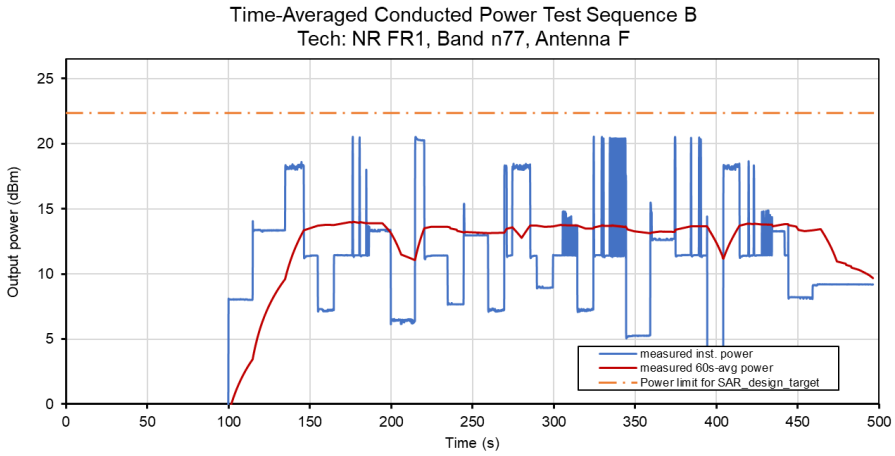


Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

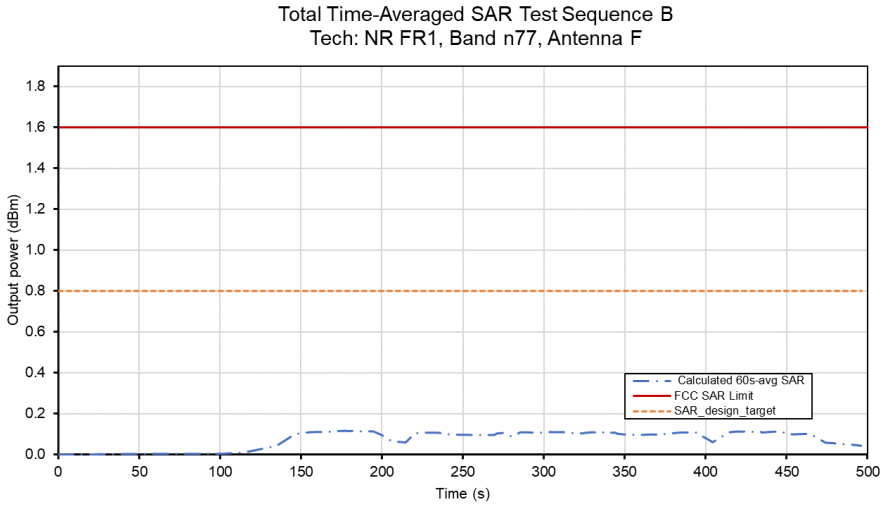


	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (blue curve)	0.117
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

Test result for test sequence B:



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

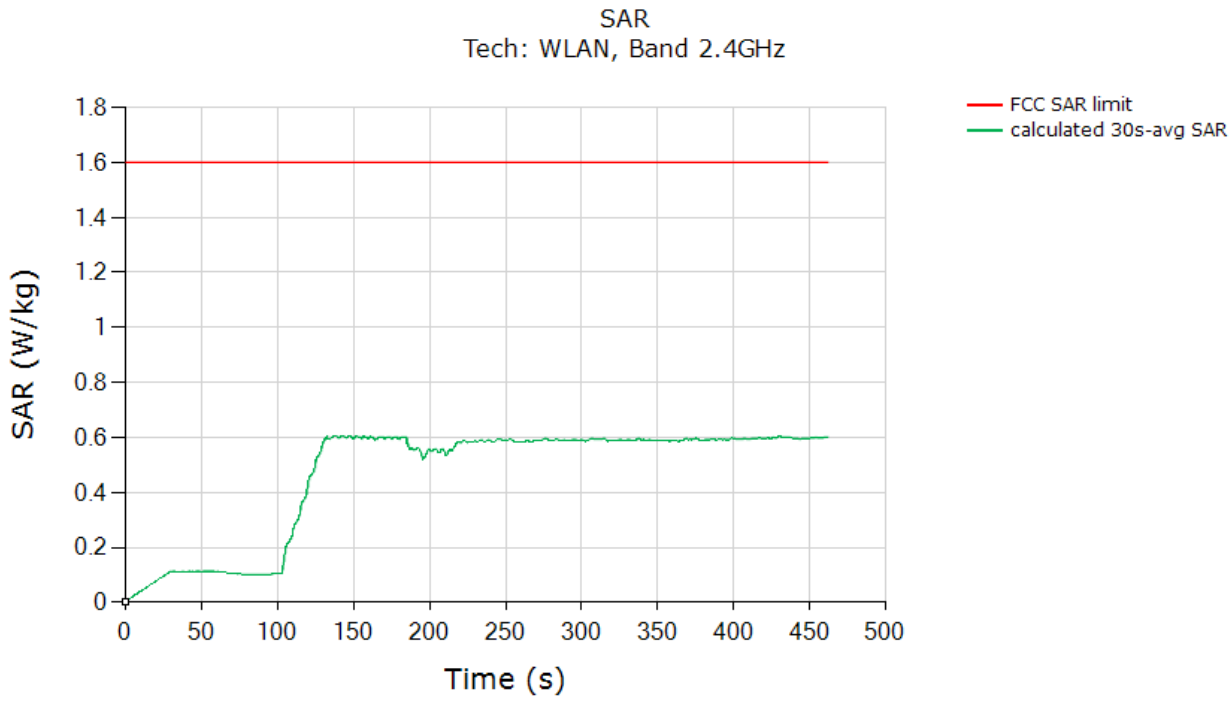


	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (blue curve)	0.117
Validated: Max time averaged SAR (blue curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.12 WLAN 2.4 GHz, SISO, Antenna 2

Test result for test sequence:

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

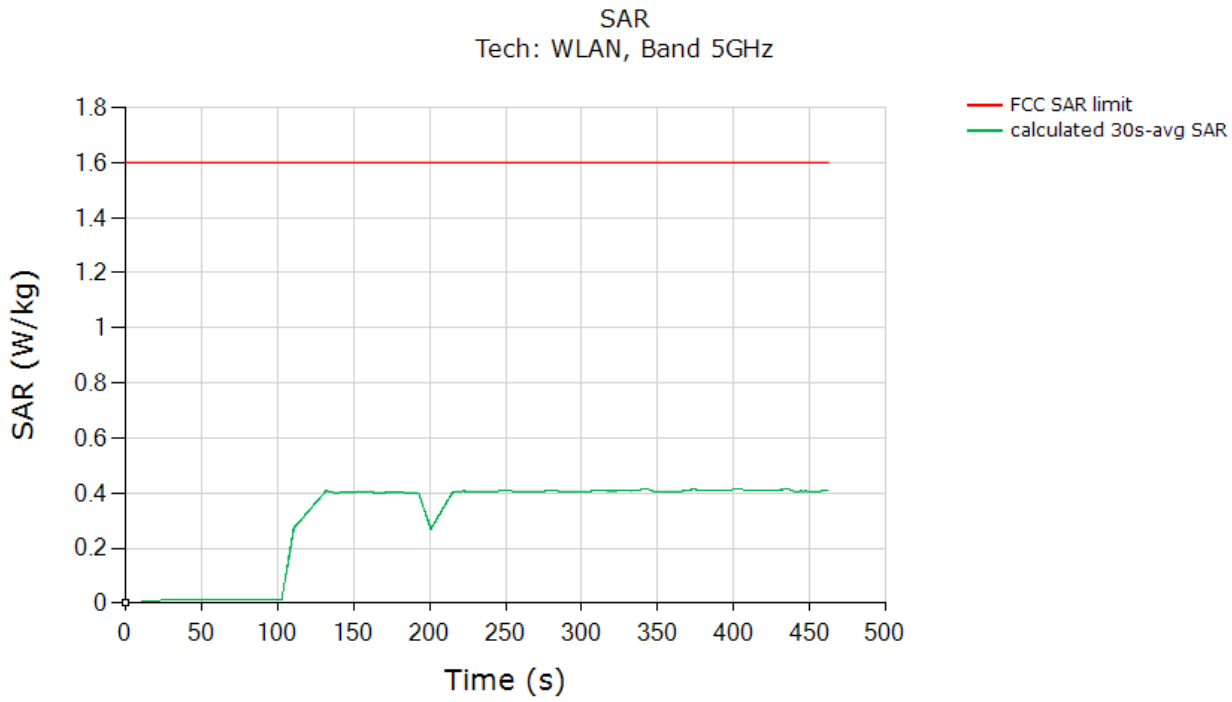


	(W/kg)
FCC 1gSAR limit	1.6
Max 30s-time averaged 1gSAR (green curve)	0.604
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

9.3.13 WLAN 5 GHz, MIMO

Test result for test sequence:

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

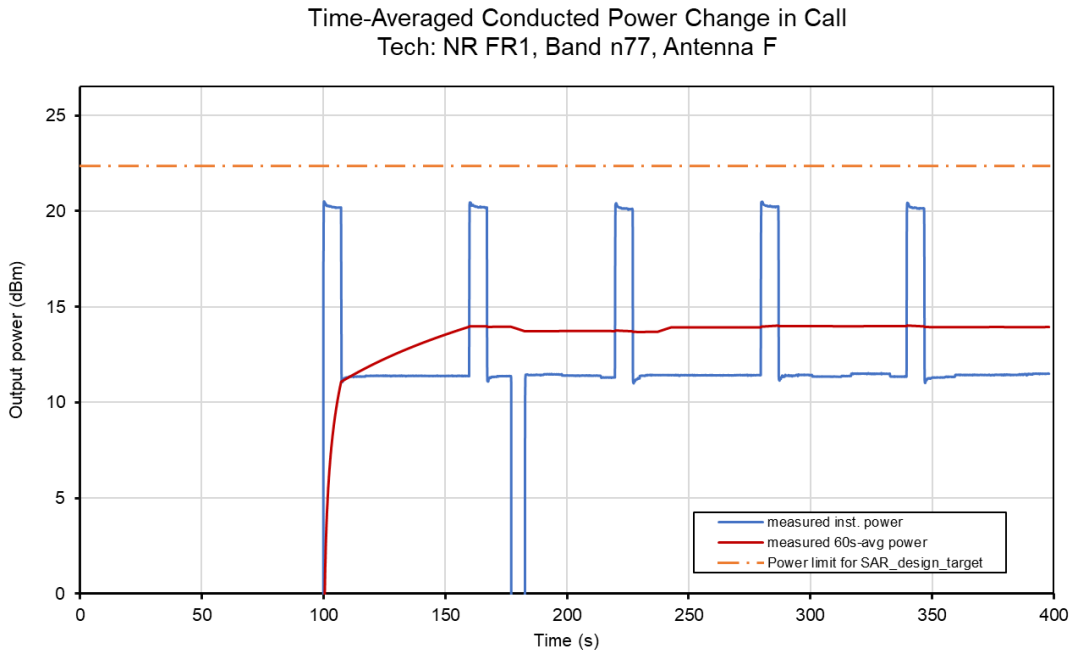


	(W/kg)
FCC 1gSAR limit	1.6
Max 30s-time averaged 1gSAR (green curve)	0.414
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

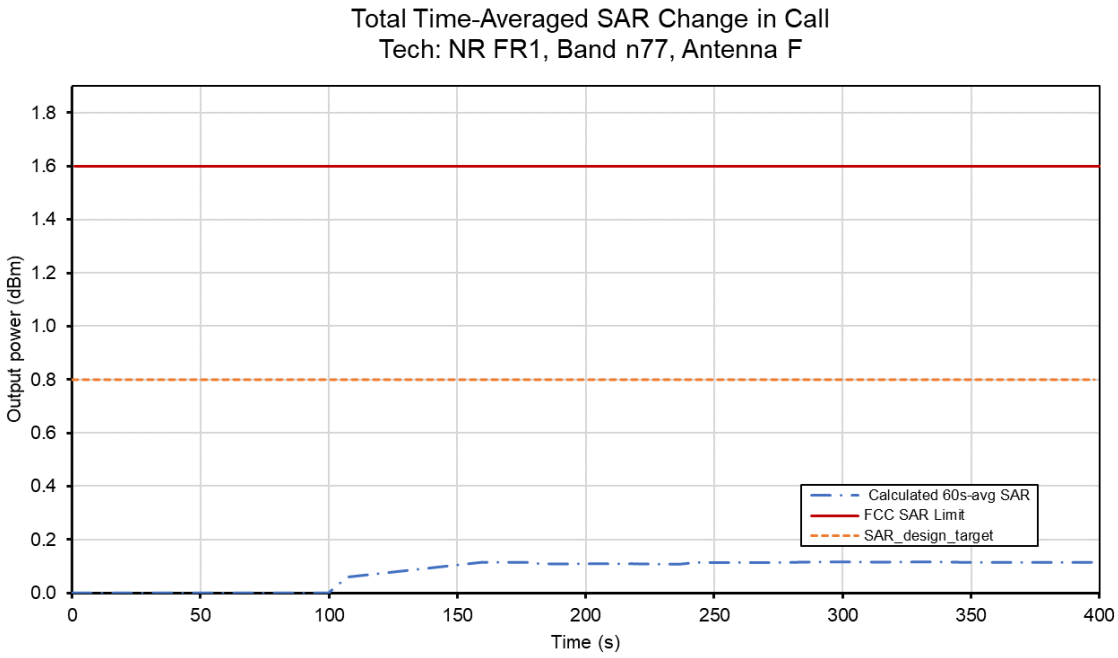
9.4 Change in Call Test Case

This test was measured NR n77 SA, antenna F, Head, and with callbox requesting maximum power. The call drop was manually performed at around 177s and resumed after 10s as shown in the plot below. The measurement setup is shown in Figure 7-1.

Call drop test result:



Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg while also being under the FCC limit of 1.6 W/kg for 1gSAR:



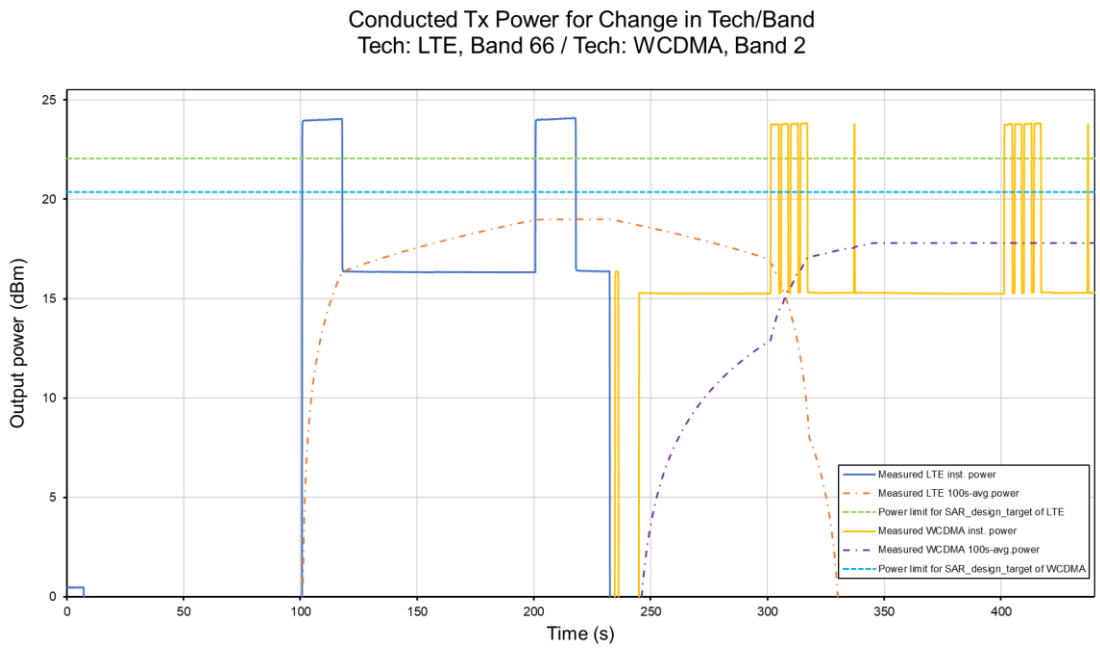
	(W/kg)
FCC 1gSAR limit	1.6
Max 60s-time averaged 1gSAR (blue curve)	0.116
Validated	

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

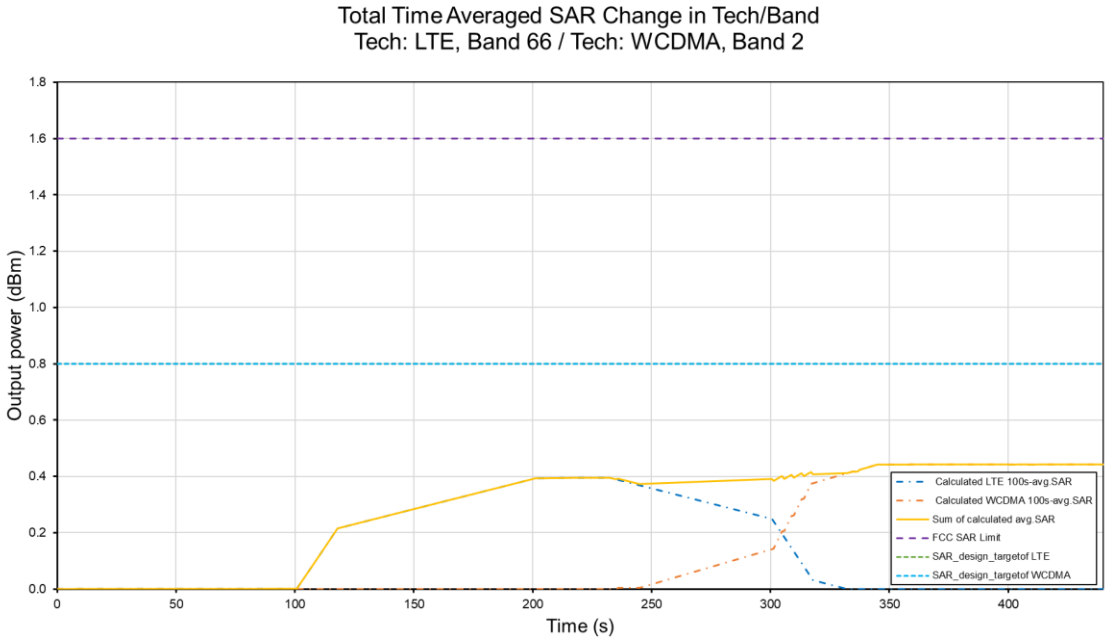
9.5 Change in Technology/Band Test Case

This test was conducted with callbox requesting maximum power, and with a technology switch from LTE Band 66, Antenna A, Hotspot, to WCDMA Band 2, Antenna A, Hotspot. Using the measurement setup shown in Figure 7-1, the technology/band switch was performed around 232s as shown in the plot below.

Test result for change in technology/band:



Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg while also being under the FCC limit of 1.6 W/kg for 1gSAR:



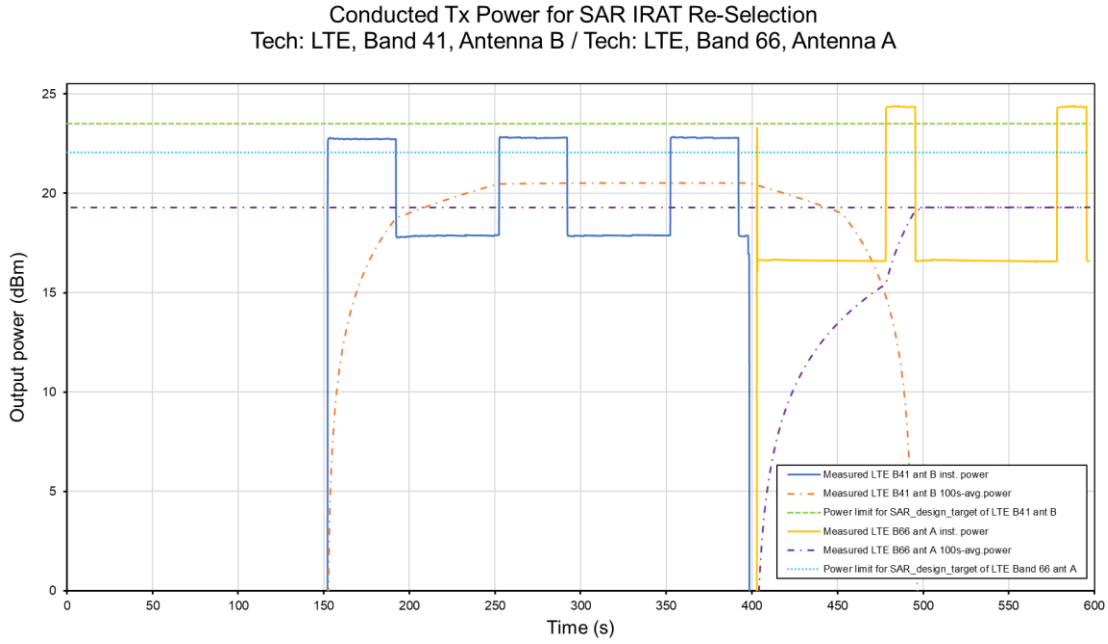
	(W/kg)
FCC 1gSAR limit	1.6
Max sum of calculated averaged 1gSAR (yellow curve)	0.442
Validated	

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

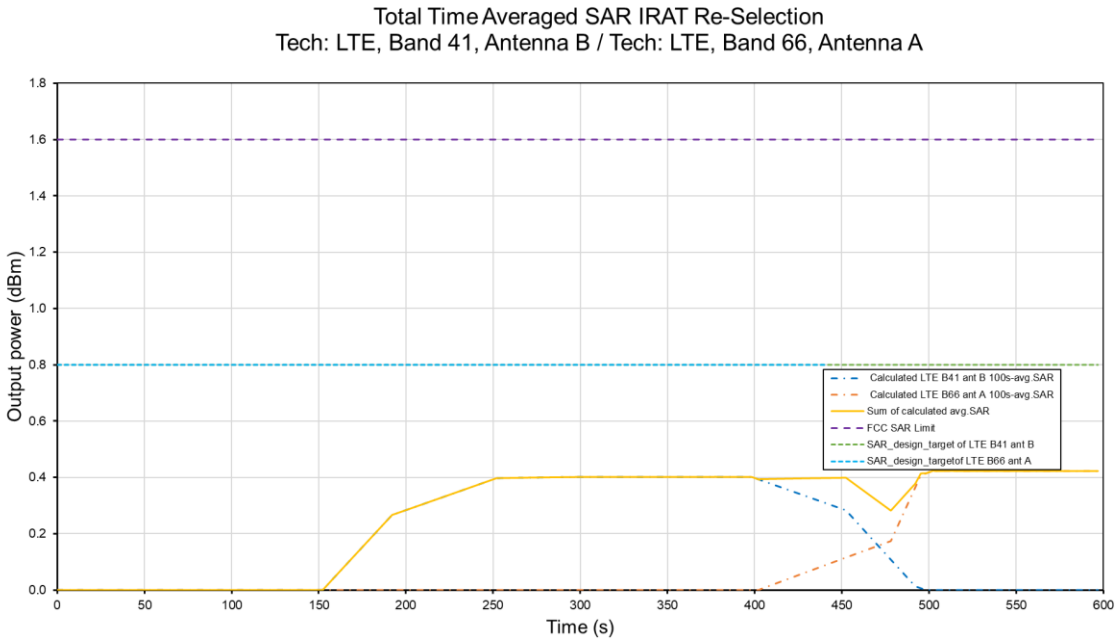
9.6 Change in Antenna Test Results

This test was conducted with callbox requesting maximum power, and with an antenna switch from LTE Band 41, Antenna B, Hotspot, to LTE Band 66, Antenna A, Hotspot. Using the measurement setup shown in Figure 7-1, the technology/band switch was performed around 400s as shown in the plot below.

Test result for change in antenna:



Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg while also being under the FCC limit of 1.6 W/kg for 1gSAR:

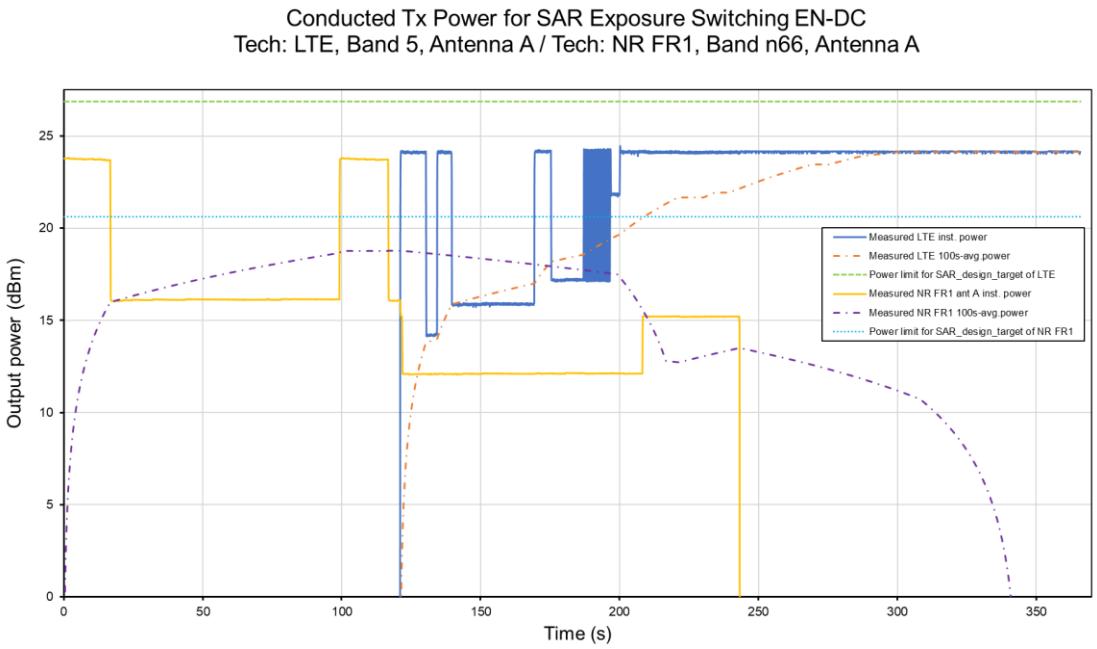


	(W/kg)
FCC 1gSAR limit	1.6
Max sum of calculated averaged 1gSAR (yellow curve)	0.425
Validated	

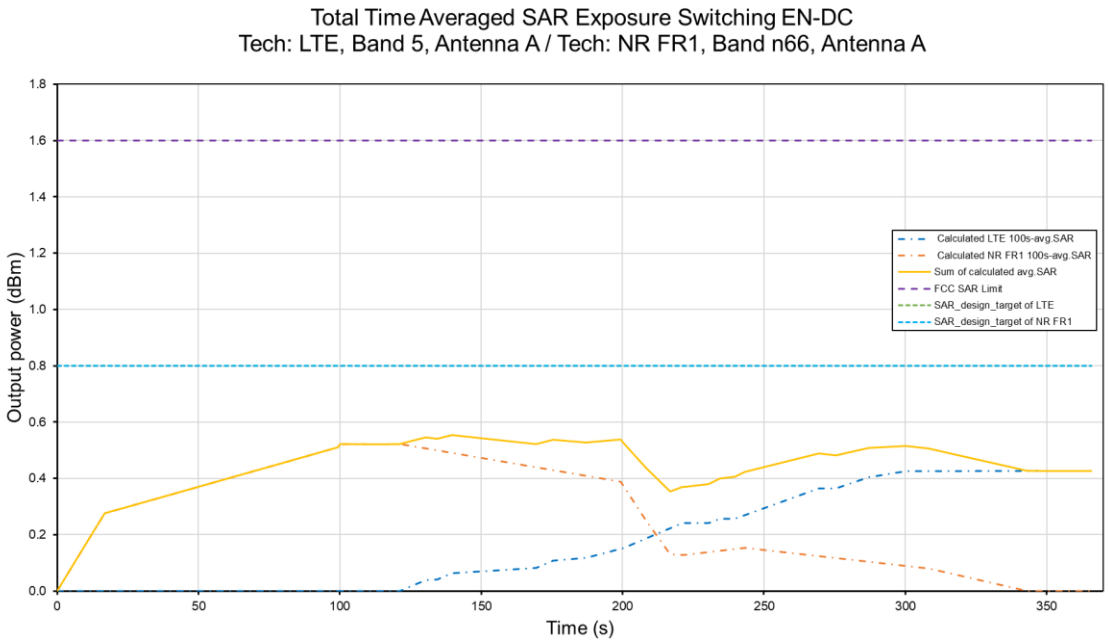
The test result validated the continuity of power limiting in antenna switch scenario.

9.7 SAR Exposure Switching Test Results (ENDC)

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 5 + Sub6 NR Band n66 call. Using the measurement setup shown in Figure 7-1(c) since LTE and Sub6 NR are sharing 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).



Plot Notes: All the conducted Tx power measurement results were converted into time-averaged SAR values using Equation (7a), (7b) and (7c), and plotted below to demonstrate that the time-averaged SAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg, while also being under FCC limit of 1.6W/kg. Equation (7a) is used to convert the LTE Tx power of device to obtain 100s-averaged SAR in LTE Band 5 as shown in blue curve. Similarly, equation (7b) is used to obtain 100s-averaged SAR in Sub6 NR n66 as shown in orange curve. Equation (7c) is used to obtain total time-averaged SAR as shown in yellow curve (i.e., sum of blue and orange curves).



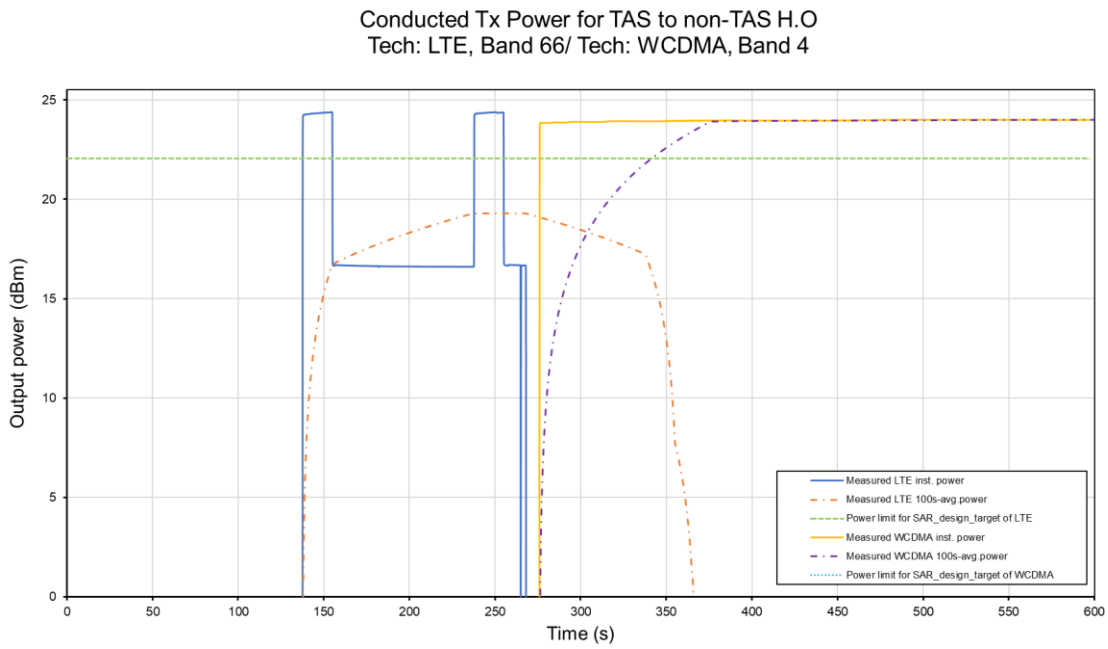
	(W/kg)
FCC 1gSAR limit	1.6
Max time averaged normalized SAR (yellow curve)	0.533
Validated	

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. In this test, time-averaged SAR for both LTE and FR1 as well as the sum are under the total SAR_design_target limit of 0.8W/kg, while also being under the FCC limit of 1.6 W/kg at all times.

9.8 TAS to non-TAS Handover

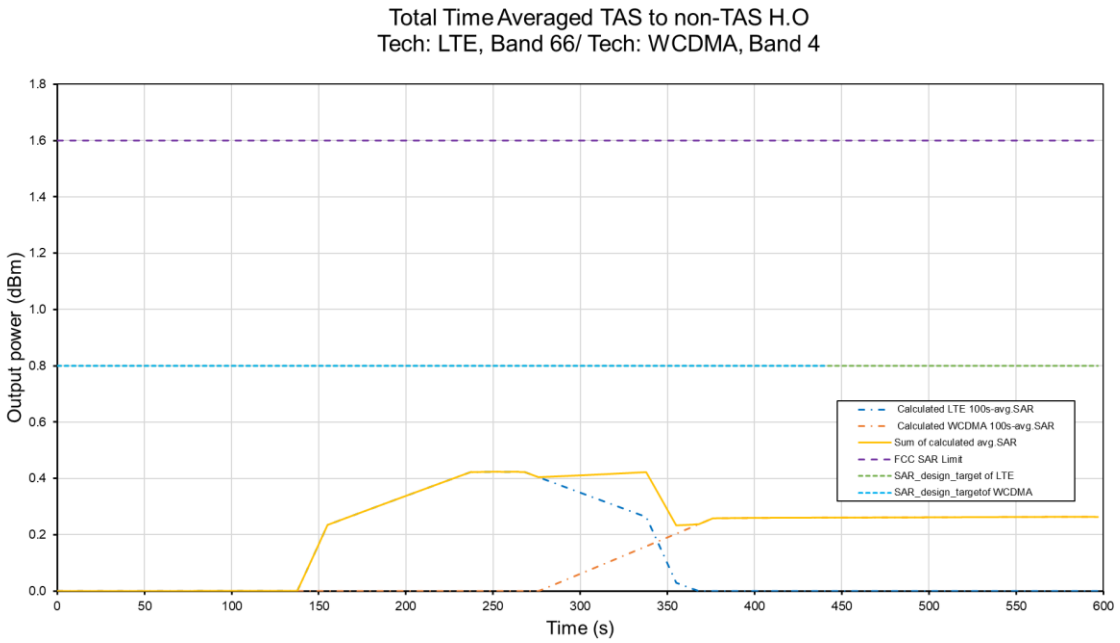
This test was conducted with callbox requesting maximum power, and with a technology switch from LTE Band 66, Antenna A, Hotspot, TAS ON to WCDMA Band 4, Antenna A, Hotspot, TAS OFF. Using the measurement setup shown in Figure 7-1, the technology/band switch was performed around 270s as shown in the plot below.

Test result for TAS to nonTAS H.O:



Plot note: The plot above shows the the instantaneous and time-averaged conducted Tx power for both LTE Band 66 with Plimit of 19dBm and WCDMA Band 4 with Plimit of 17.5dBm. At around 270s time stamp of LTE Band 66 was manually handovered to WCDMA Band 4, resulting in reduction of time-averaged power of LTE Band 66 and simultaneous increase in time-averaged power of WCDMA Band 4. As WCDMA is a nonTAS RAT, its transmission shall be fixed at Pmax of 23.0dBm.

Time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR and is plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg while also being under the FCC limit of 1.6 W/kg for 1gSAR:



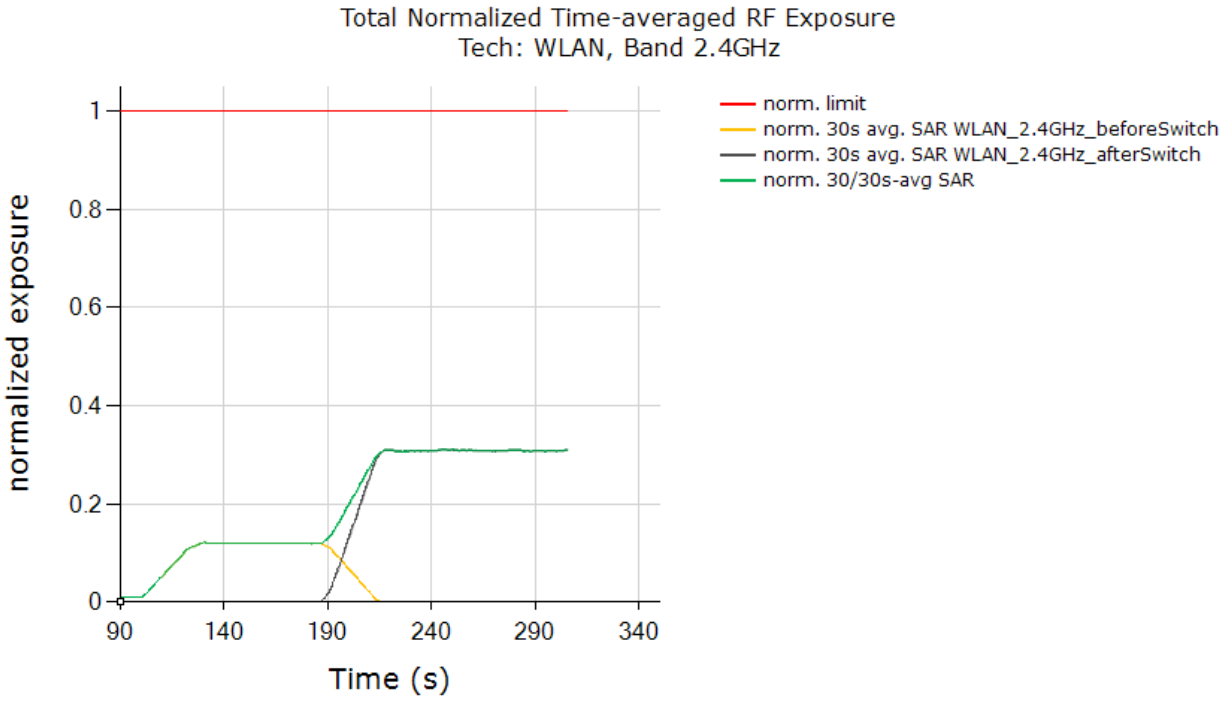
	(W/kg)
FCC 1gSAR limit	1.6
Max sum of calculated averaged 1gSAR (yellow curve)	0.424
Validated	

The test result validated the continuity of power limiting in TAS to nonTAS H.O scenario.

9.9 WLAN Change in Device State

This test was conducted with callbox requesting maximum power, and with an antenna switch from WLAN 2.4GHz, Antenna 2, Hotspot, to 2.4GHz, Antenna 2, Head. Using the measurement setup shown in Figure 7-4, the technology/band switch was performed around 187s.

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



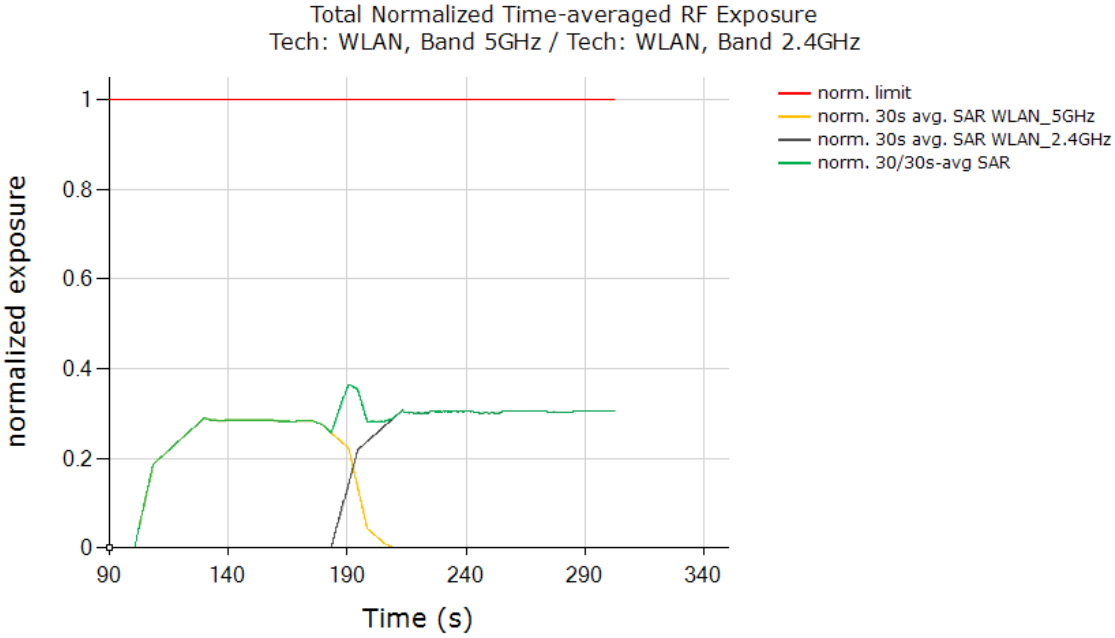
	(W/kg)
FCC normalized SAR limit	1.0
Max sum of calculated averaged 1gSAR (yellow curve)	0.311
Validated	

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

9.10 Change in WLAN Band/Antenna

This test was conducted with callbox requesting maximum power, and with an antenna switch from WLAN 5GHz, Antenna 1, Head, to 2.4GHz, Antenna 2, Head. Using the measurement setup shown in Figure 7-3 the technology/band switch was performed around 190s.

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



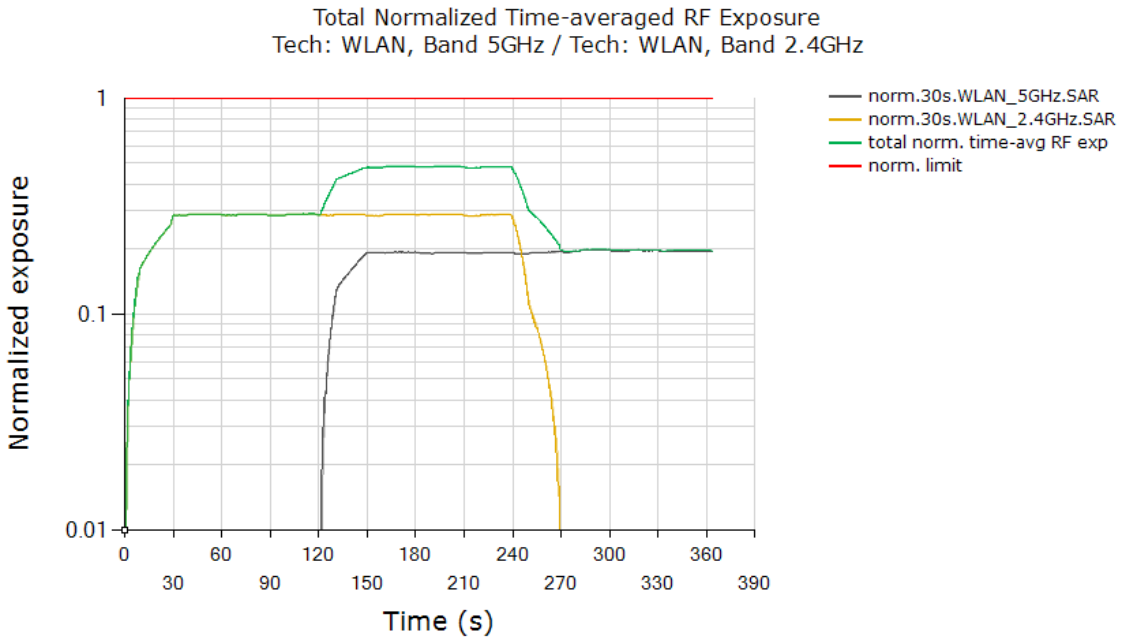
	(W/kg)
FCC normalized SAR limit	1.0
Max sum of calculated averaged 1gSAR (yellow curve)	0.365
Validated	

The test result validated the continuity of power limiting in change in WLAN band/antenna scenario.

9.11 WLAN Simultaneous Transmissions

This test was conducted with callbox requesting maximum power, and with the EUT in WLAN 2.4GHz + WLAN 5GHz call. Following procedure detailed in Section 4.3.7, and using the measurement setup shown in Figure 7-5 since WLAN channels are sharing the same antenna port, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios, i.e., in $SAR_{WLAN\ 2.4GHz}$ only scenario (t =0s ~120s), $SAR_{WLAN\ 2.4GHz}$ + $SAR_{WLAN\ 5GHz}$ scenario (t =120s ~ 240s) and $SAR_{WLAN\ 5GHz}$ only scenario (t > 240s).

Plot Notes: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (7a), (7b) and (7c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (7a) is used to convert the WLAN Tx power of device to obtain 30s-averaged normalized SAR in WLAN 5GHz as shown in black curve. Similarly, equation (7b) is used to obtain 30s-averaged normalized SAR in WLAN 2.4GHz as shown in orange curve. Equation (7c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).

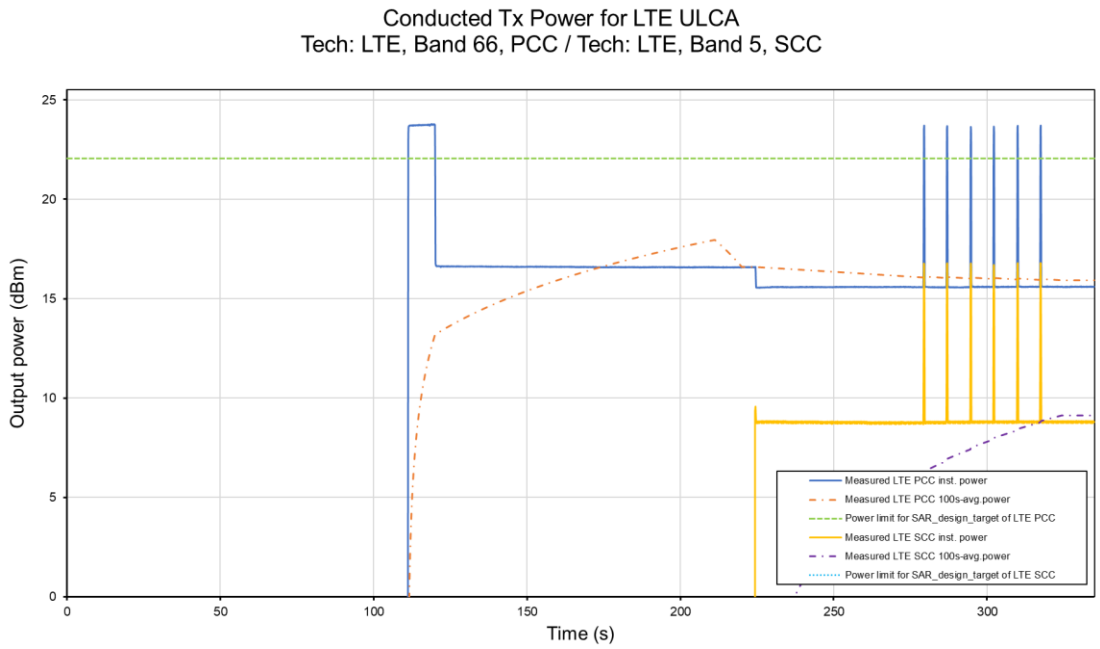


	(W/kg)
FCC normalized total exposure limit	1.0
Max time averaged normalized SAR (green curve)	0.484
Validated	

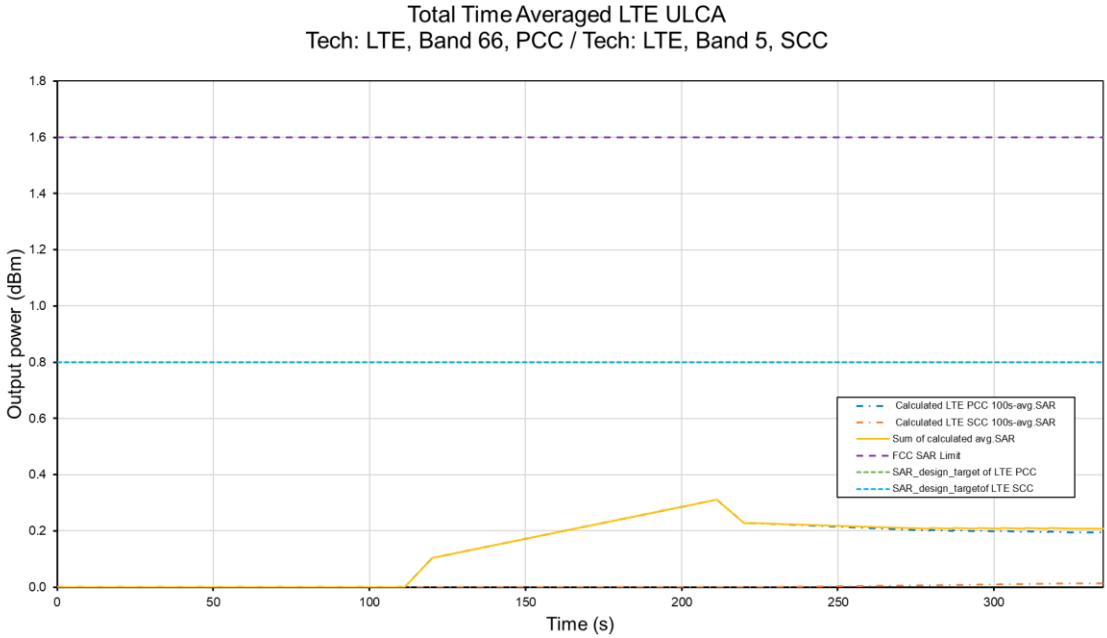
Plot Notes: In this test, the total time-averaged normalized RF exposure (green curve) did not exceed normalized limit of 1.0 at all times, the above test result validated the continuity of power limiting in SAR exposure switch scenario.

9.12 SAR Exposure Switching ULCA

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 66 (PCC), Antenna A + LTE Band 5 (SCC), Antenna A call. The measurement setup shown in Figure 7-1(e) 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_{PCC} + SAR_{SCC} min scenario (t =0s ~110s), SAR_{PCC} max scenario (t =110s ~ 220s) and SAR_{PCC} + SAR_{SCC} max scenario (t > 220s).



All the conducted Tx power measurement results were converted into time-averaged SAR values using Equation (3a), (3b) and (3c), and plotted below to demonstrate that the time-averaged SAR versus time does not exceed the total SAR_design_target limit of 0.8 W/kg while also being under the FCC limit of 1.6 W/kg for 1gSAR.

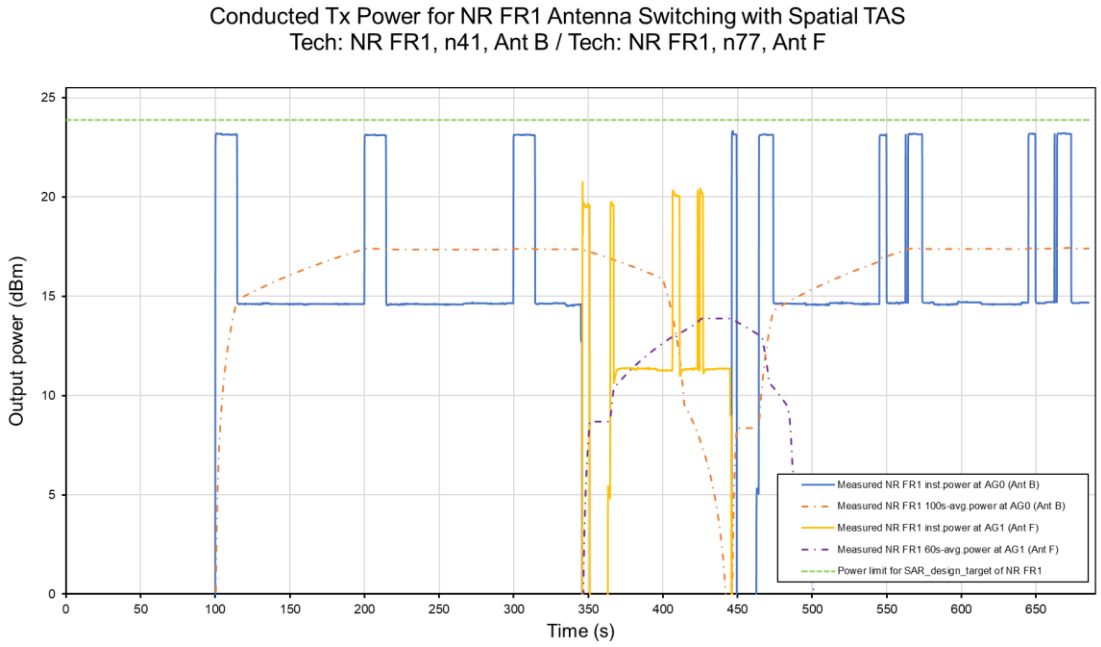


	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR (yellow curve)	0.311
Validated	

Plot Notes: Device starts predominantly in LTE Band 66 (PCC) SAR exposure scenario between 110s and 220s, and in LTE B66 (PCC) SAR + LTE B5 (SCC) SAR exposure scenario between 220s and 330s. In this test, time-averaged SAR for both LTE PCC and LTE SCC as well as the sum are under the total SAR_design_target limit of 0.8W/kg, while also being under the FCC limit of 1.6 W/kg at all times.

9.13 Antenna Switch with Spatial TAS

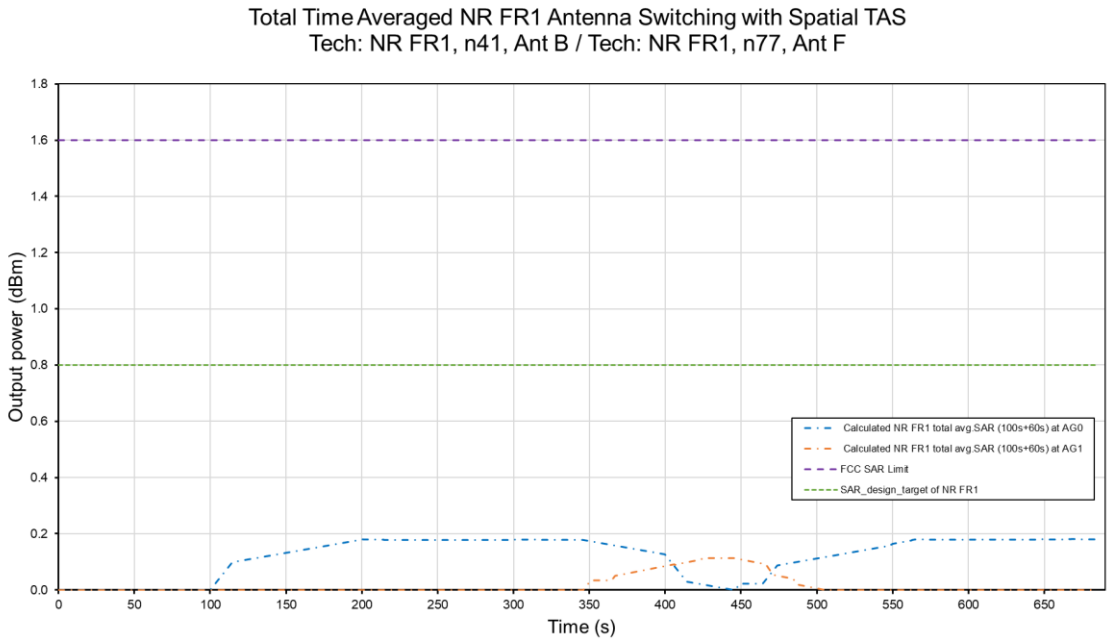
This test was conducted with callbox requesting maximum power, and with a band switch from NR n41, Antenna B, Hotspot, to NR n77, Antenna F, Hotspot, then switch back to NR n41, Antenna B, Hotspot. Using the measurement setup shown in Figure 7-1(a), the technology/band switch was performed around 350s and 450s as shown in the plot below:



Plot note: The plot above shows the instantaneous and time-averaged conducted Tx power at antenna B with SA FR1 band n41 (AG0) and at antenna F with SA FR1 band n77 (AG1). Transmission is initialized on AG0 where it was set for very low power for ~100s. After that, a maximum power of 23.0dBm is requested and the TAS starts to cycle. After ~240s a band change happens to SA FR1 n77 which operates at antenna F (AG1) and a maximum power of 22.0dBm is requested. Since the coupling between AG0 and AG1 is 0, then transmission at antenna F will start from maximum power regardless of the transmission at antenna B and will continue transmission for ~90s. Next, another band change is done to the first band n41 and so an antenna switching to antenna B happens where a maximum power of 30dBm is requested. Since AG1 and

AG0 are uncoupled and there is no transmission on AG1 for more than 60s, then the transmission will start with maximum power.

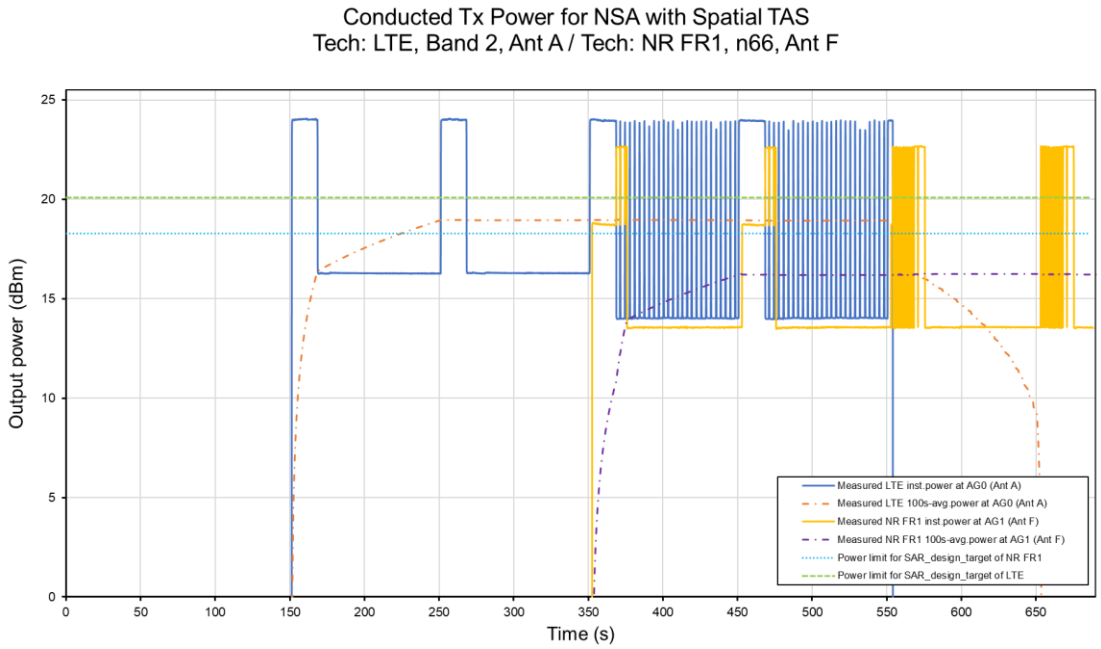
As shown below, the total average SAR at each AG is below 0.8W/kg, while also being below the FCC limit of 1.6W/kg.



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR at AG0 (blue curve)	0.180
Max 60s-time averaged 1gSAR at AG1 (orange curve)	0.114
Validated	

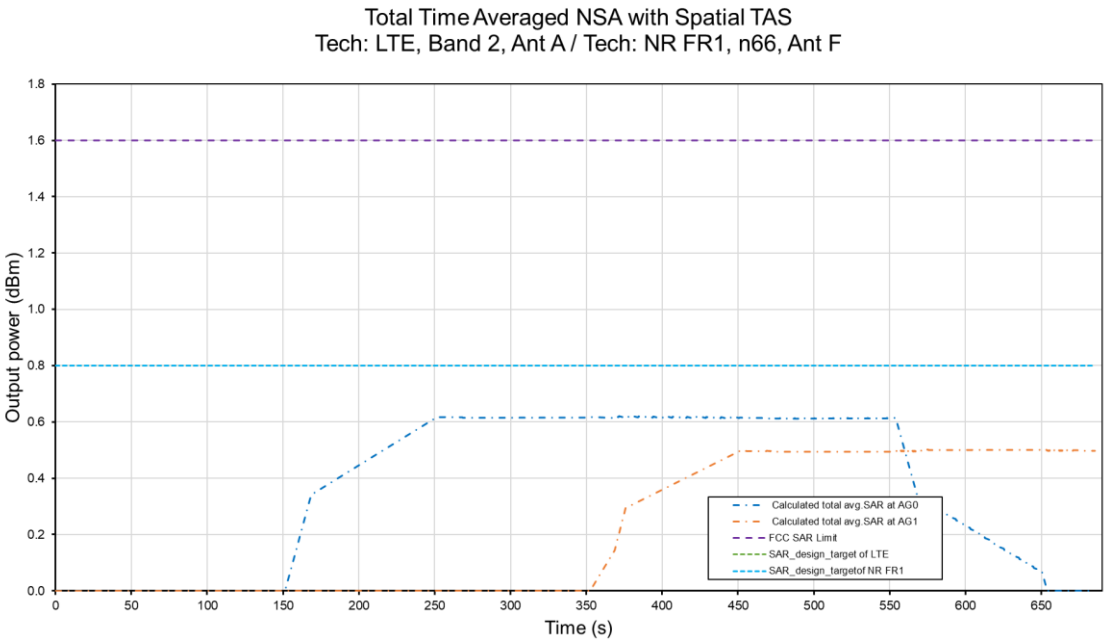
9.14 NSA with Spatial TAS

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 2 + Sub6 NR Band n66 call. Using the measurement setup shown in Figure 7-1(d) since LTE and Sub6 NR are in different antenna ports, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios as shown in the plot below:



Plot note: The plot above shows the instantaneous and time-averaged conducted Tx power at antenna A with LTE band 2 (AG0) and at antenna F with SA FR1 band n66 (AG1). After the ENDC connection establishment, Both LTE and FR1 are set to no transmission for ~150s. Next, a transmission starts with LTE requesting full max power of 23.5dBm and no transmission for FR1 and continue for 200s. After that, a maximum power of 23.0dBm is requested for FR1 band n66 and for 200s. Since both AGs are fully uncoupled, each RAT will operate with full Plimit, where the 100s average power of LTE and 100s average power of FR1 are close to Plimit of 16dBm. Next, the LTE transmission is down while FR1 continues transmission.

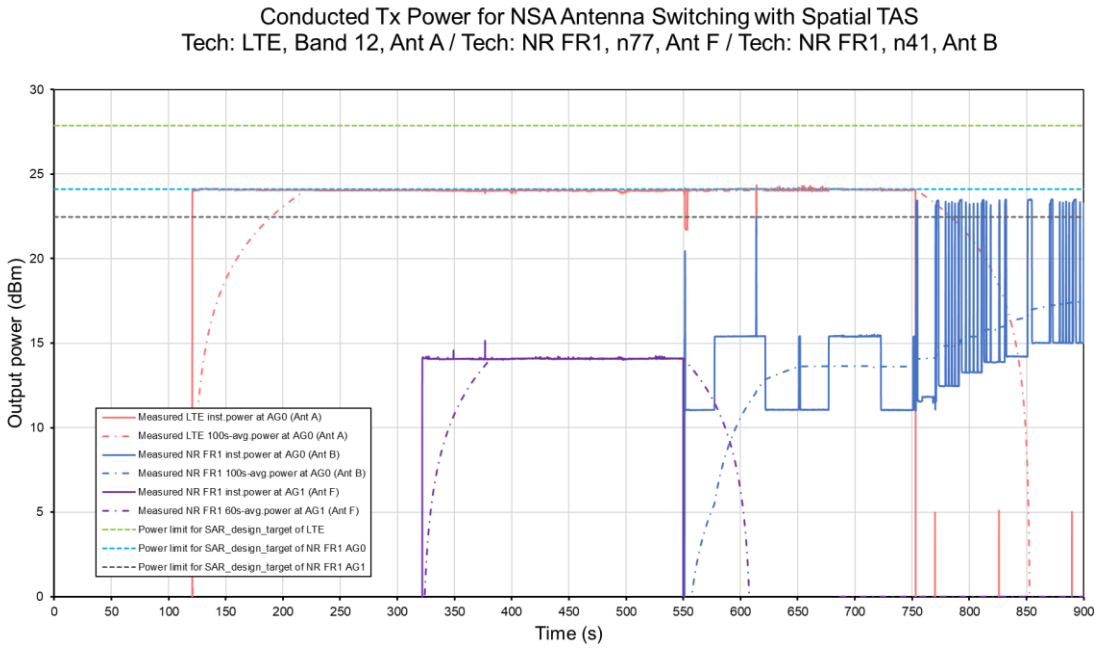
As shown below, the total average SAR at each AG is below 0.8W/kg, while also being below the FCC limit of 1.6W/kg.



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR at AG0 (blue curve)	0.621
Max 100s-time averaged 1gSAR at AG1 (orange curve)	0.502
Validated	

9.15 NSA Antenna Switching with Spatial TAS

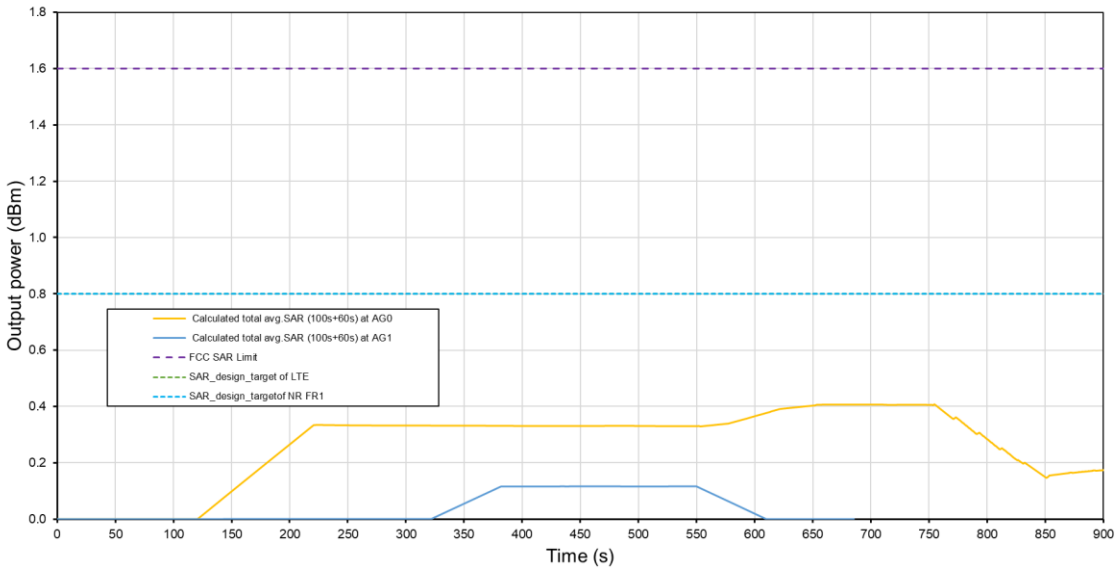
This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 12 + Sub6 NR Band n77 and LTE Band 12 + Sub6 NR Band n41 call. Using the measurement setup shown in Figure 7-1(d) since LTE and Sub6 NR are in different antenna ports, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios as shown in the plot below:



Plot note: The plot above shows the instantaneous and time-averaged conducted Tx power for a NSA operation where LTE is transmitting at antenna A band B12 (AG0) and FR1 at antenna F and B with bands n41(AG0) and n77 (AG1) respectively. After the ENDC connection establishment, Both LTE and FR1 are set to no transmission for ~150s. Next, a transmission starts with LTE requesting full max power of ~23.0dBm and no transmission for FR1 and continue for ~200s. After that, a maximum power of 22.0dBm is requested for FR1 band n77 and transmission is done on antenna F and continues for ~200s. Since AG0 and AG1 are fully uncoupled, each RAT will operate with full Plimit. Next, FR1 will switch to band n41 which will require and antenna switch to antenna B (AG0) where FR1 requests maximum power 23.0dBm and transmission continues for ~200s. Next, the LTE transmission is down while FR1 continues transmission.

As shown below, the total average SAR at each AG is below 0.8W/kg, while also being below the FCC limit of 1.6W/kg.

Total Time Averaged NSA Antenna Switching with Spatial TAS
Tech: LTE, Band 12, Ant A / Tech: NR FR1, n77, Ant F / Tech: NR FR1, n41, Ant B



	(W/kg)
FCC 1gSAR limit	1.6
Max 100s-time averaged 1gSAR at AG0 (blue curve)	0.408
Max 60s-time averaged 1gSAR at AG1 (orange curve)	0.116
Validated	

10 SYSTEM VERIFICATION (FREQ < 6GHZ)

10.3 Tissue Verification

Table 10-1
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
08/01/2023	2450 Head	20.1	2400	1.784	40.747	1.756	39.289	*1.59%*	*3.71%*
			2450	1.827	40.658	1.800	39.200	*1.50%*	*3.72%*
			2480	1.853	40.613	1.833	39.162	*1.09%*	*3.71%*
			2500	1.869	40.584	1.855	39.136	*0.75%*	*3.70%*
			2510	1.878	40.567	1.866	39.123	*0.64%*	*3.69%*
			2535	1.899	40.517	1.893	39.092	*0.32%*	*3.65%*
08/01/2023	5250 Head	20.4	5180	4.476	35.938	4.635	36.009	*-3.43%*	*-0.20%*
			5190	4.490	35.923	4.645	35.998	*-3.34%*	*-0.21%*
			5200	4.505	35.912	4.655	35.986	*-3.22%*	*-0.21%*
			5210	4.519	35.905	4.666	35.975	*-3.15%*	*-0.19%*
			5220	4.529	35.895	4.676	35.963	*-3.14%*	*-0.19%*
			5240	4.548	35.861	4.696	35.940	*-3.15%*	*-0.22%*
			5250	4.558	35.850	4.706	35.929	*-3.14%*	*-0.22%*
			5260	4.568	35.832	4.717	35.917	*-3.16%*	*-0.24%*
			5270	4.580	35.806	4.727	35.906	*-3.11%*	*-0.28%*
			5280	4.595	35.767	4.737	35.894	*-3.00%*	*-0.35%*
			5290	4.608	35.736	4.748	35.883	*-2.95%*	*-0.41%*

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 1528-3013 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.

10.4 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 10-2
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	DAE	Measured SAR_{1g} (W/kg)	1 W Target SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	Deviation n_{1g} (%)
M	2450	HEAD	8/1/2023	22.2	20.5	0.100	981	7670	1681	5.130	53.900	51.300	-4.82%
G	5250	HEAD	8/1/2023	19.3	20.4	0.050	1191	7417	665	3.740	80.400	74.800	-6.97%

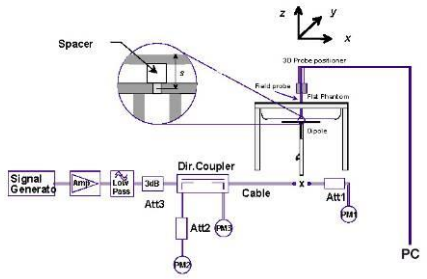


Figure 10-1
System Verification Setup Diagram

Figure 10-2
System Verification Setup Photo

11 POINTSAR TEST

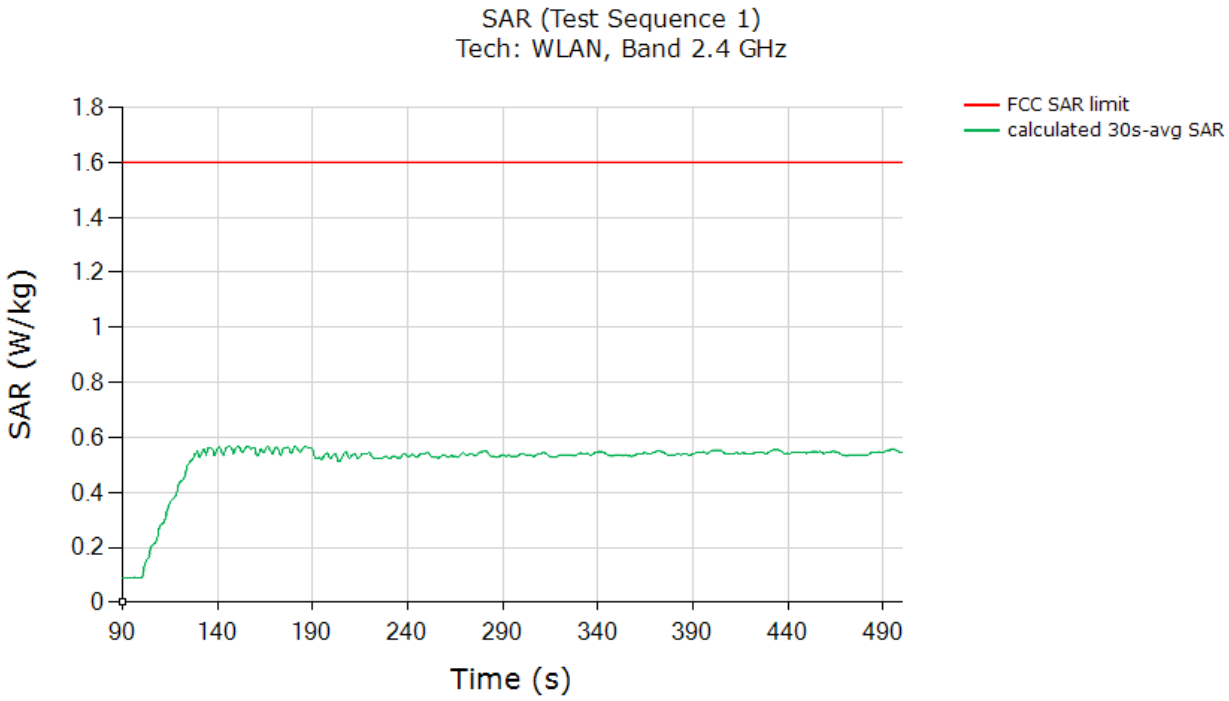
Following Section 5.6 procedure, time-averaged SAR measurements are conducted using a SAR probe at peak location of area scan over 500 seconds. cDASY6 system verification for SAR measurement is provided in Section 9, and the associated SPEAG certificates are attached in Appendix G.

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.

11.3 WLAN 2.4 GHz, SISO, Antenna 2

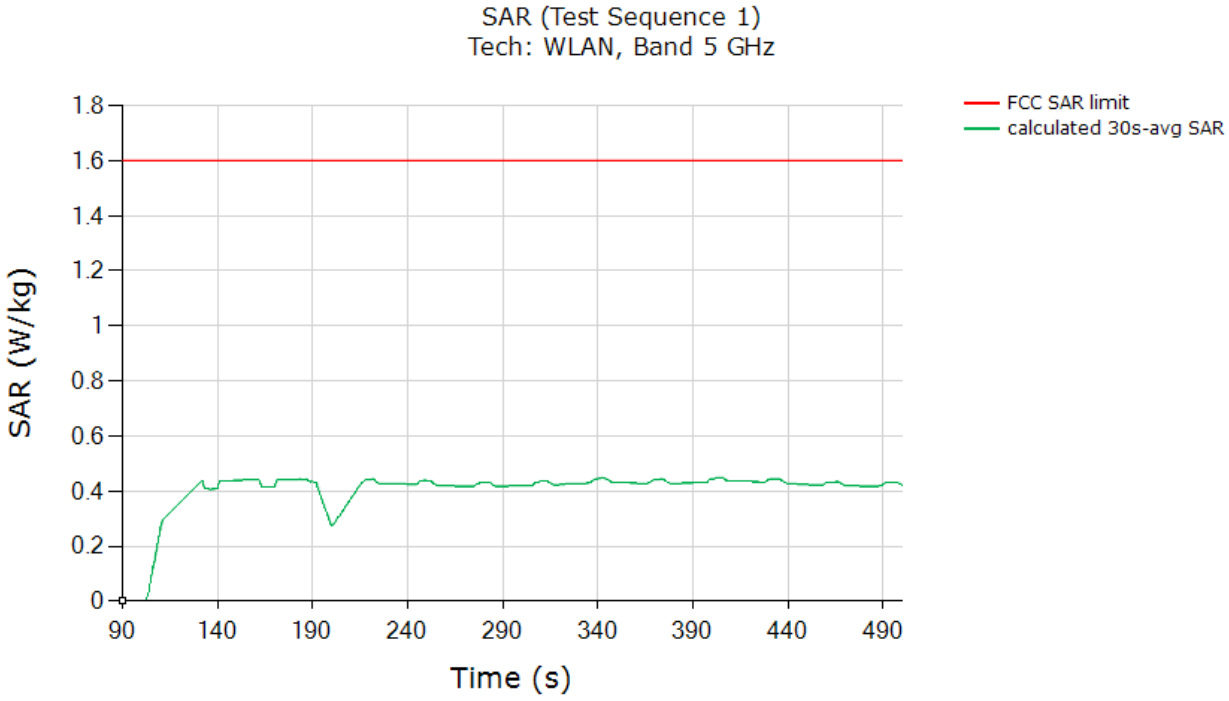
SAR test results for test sequence:



	(W/kg)
FCC 1gSAR limit	1.6
Max 30s-time averaged point 1gSAR (green curve)	0.566
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

11.4 WLAN 5 GHz, MIMO

SAR test results for test sequence:



	(W/kg)
FCC 1gSAR limit	1.6
Max 30s-time averaged point 1gSAR (green curve)	0.448
Validated: Max time averaged SAR (green curve) is within 1 dB device uncertainty of measured SAR at P_{limit} (worst case SAR column in Table 8-3).	

12 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8594A	(9kHz-2.9GHz) Spectrum Analyzer	N/A	N/A	N/A	3051A00187
Agilent	E4438C	ESG Vector Signal Generator	1/18/2023	Annual	1/18/2024	MY47270002
Agilent	N9020A	MXA Signal Analyzer	3/15/2023	Annual	3/15/2024	US46470561
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433974
Anritsu	MT8000A	Radio Communication Test Station	2/9/2023	Annual	2/9/2024	6272337408
Anritsu	MT8821C	Radio Communication Test Station	1/10/2023	Annual	1/10/2024	6201524637
Anritsu	MA24106A	USB Power Sensor	1/20/2023	Annual	1/20/2024	2018534
Anritsu	MA24106A	USB Power Sensor	2/9/2023	Annual	2/9/2024	1520505
Anritsu	ML2496A	Power Meter	8/16/2022	Annual	8/16/2023	1351001
Anritsu	MA2411B	Pulse Power Sensor	1/10/2023	Annual	1/10/2024	1315051
Anritsu	MA2411B	Pulse Power Sensor	10/21/2022	Annual	10/21/2023	1207364
COMTECH	AR85729-5/5759B	Solid State Amplifier	CBT	N/A	CBT	M3W1A00-1002
COMTech	AR85729-5	Solid State Amplifier	CBT	N/A	CBT	M1S5A00-009
Control Company	4352	Long Stem Thermometer	9/10/2022	Biennial	9/10/2023	210774678
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/17/2023	Annual	1/17/2024	160574418
Control Company	4352	Long Stem Thermometer	9/10/2022	Biennial	9/10/2023	210774685
K & L	11SH10-1300/U4000	High Pass Filter	CBT	N/A	CBT	11SH10-1300/U4000 - 2
Krytar	110067006	Directional Coupler, 10 - 67 GHz	CBT	N/A	CBT	200391
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Mini Circuits	ZA2PD2-63-S+	Power Splitter	CBT	N/A	CBT	SUU64901930
Mini Circuits	ZAPD-2-272-S+	Power Splitter	CBT	N/A	CBT	SF702001405
MIniCircuits	NLP-1200+	Low Pass Filter	CBT	N/A	CBT	VUU78201318
MiniCircuits	SLP-2400+	Low Pass Filter	CBT	N/A	CBT	R8979500903
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter DC to 1000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	CBT	N/A	CBT	01492
Narda	4216-10	Directional Coupler, 0.5 to 8.0 GHz, 10 dB	CBT	N/A	CBT	01493
Narda	4772-3	Attenuator	CBT	N/A	CBT	9406
Narda	BW-S3W2	Attenuator	CBT	N/A	CBT	120
Narda	BW-S10W2+	Attenuator	CBT	N/A	CBT	831
Narda	4014C-6	4 - 8 GHz SMA 6 dB Directional Coupler	CBT	N/A	CBT	N/A
Newmark System	NSC-G2	Motion Controller	CBT	N/A	CBT	1007-D
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	9/1/2022	Annual	9/1/2023	128636
Rohde & Schwarz	CMW500	Radio Communication Tester	8/25/2022	Annual	8/25/2023	140144
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	8/10/2022	Annual	8/10/2023	109322
Rohde & Schwarz	NRP8S	3-Path Dipole Power Sensor	8/10/2022	Annual	8/10/2023	109052
Rohde & Schwarz	NRP50S	3-Path Dipole Power Sensor	8/10/2022	Annual	8/10/2023	101339
SPEAG	D2450V2	2450 MHz SAR Dipole	11/25/2021	Biennial	11/25/2023	981
SPEAG	D5GHzV2	5 GHz SAR Dipole	1/18/2023	Annual	1/18/2024	1191
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/15/2023	Annual	2/15/2024	665
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/15/2022	Annual	8/15/2023	1681
SPEAG	EX3DV4	SAR Probe	2/8/2023	Annual	8/22/2023	7417
SPEAG	EX3DV4	SAR Probe	8/22/2022	Annual	8/22/2023	7670

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.

13 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	

14 CONCLUSION

14.3 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]

15 REFERENCES

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.

[2] ANSI/IEEE C95.1-2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.

[3] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.

[4] ANSI/IEEE C95.3-2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, December 2002.

[5] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528-3013, IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

[6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.

[7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.

[8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 1 -124.

[9] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.

[10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.

[11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.

[12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.

[13] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.

[14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.

[15] W. Gander, Computermathematick, Birkhaeuser, Basel, 1992.

[16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.

[17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.

[18] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.

[19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hoschschule Zürich, Dosimetric Evaluation of the Cellular Phone.

[20] IEC 62209-1, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz), July 2016.

[21] Innovation, Science, Economic Development Canada RSS-102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) Issue 5, March 2015.

[22] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2015

[23] FCC SAR Test Procedures for 2G-3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225, D01-D07

[24] SAR Measurement Guidance for IEEE 802.11 Transmitters, KDB Publication 248227 D01

[25] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474 D03-D04

[26] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04

[27] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01-D02

[28] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01-D02

[29] Anexo à Resolução No. 533, de 10 de Septembro de 2009.

[30] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), Mar. 2010.