verify No.907560856964

TEST REPORT

Eurofins KCTL Co.,Ltd. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-70-5008-1021 FAX: 82-505-299-8311 www.kctl.co.kr	Report No.: KR23-SPF0044-B Page (1) of (54)	eurofins KCTL

1. Client

- Name : Samsung Electronics Co., Ltd.
- Address : 129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
- Date of Receipt : 2023-09-05

2. Use of Report : Certification

3. Name of Product and Model : Tablet PC

- Model Name : SM-X308U
- Manufacturer and Country of Origin : Samsung Electronics Co., Ltd. / Vietnam

4. FCC ID : A3LSMX308U

5. Date of Test : 2023-10-04 ~ 2023-12-19

6. Location of Test : ■ Permanent Testing Lab □ On Site Testing
(Address: 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea)

7. Test Standards : FCC 47 CFR 2 § 2.1093

8. Test Results : Refer to the test result in the test report

Affirmation	Tested by Name : Jewon Choi (Signature)	Technical Manager Name : Jongwon Ma (Signature)

2023-12-20

Eurofins KCTL Co.,Ltd.

As a test result of the sample which was submitted from the client, this report does not guarantee the whole product quality. This test report should not be used and copied without a written agreement by Eurofins KCTL Co.,Ltd.

REPORT REVISION HISTORY

Date	Revision	Page No
2023-11-28	Originally issued	-
2023-12-12	Revised Tx Frequency Revised P_{max} and P_{limit}	6 23
2023-12-20	Added UL CA Test	Overall

General remarks for test reports

Statement concerning the uncertainty of the measurement systems used for the tests

(may be required by the product standard or client)

☐ **Internal procedure used for type testing through which traceability of the measuring uncertainty has been established:**

Procedure number, issue date and title:

Calculations leading to the reported values are on file with the testing laboratory that conducted the testing.

☒ **Statement not required by the standard or client used for type testing**

1. Identification when information is provided by the customer: Information marked " # " is provided by the customer. - Disclaimer: This information is provided by the customer and can affect the validity of results.

CONTENTS

1. General information

Client	:	Samsung Electronics Co., Ltd.
Address	:	129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
Manufacturer	:	Samsung Electronics Co., Ltd.
Address	:	129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
Factory	:	Samsung Electronics Vietnam Thai Nguyen Co., Ltd
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Laboratory	:	Eurofins KCTL Co.,Ltd.
Address	:	65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
Accreditations	:	FCC Site Designation No: KR0040, FCC Site Registration No: 687132
		VCCI Registration No. : R-3327, G-198, C-3706, T-1849
		CAB Identifier: KR0040, ISED Number: 8035A
		KOLAS No.: KT231

1.1 Report Overview

This report details the results of testing carried out on the samples listed in section 2, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this test report is used in any configuration other than that detailed in the test report, the manufacturer must ensure the new configuration complies with all relevant standards and certification requirements. Any mention of Eurofins KCTL Co.,Ltd. Wireless lab or testing done by Eurofins KCTL Co.,Ltd. Wireless lab made in connection with the distribution or use of the tested product must be approved in writing by Eurofins KCTL Co.,Ltd. Wireless lab.

2. Device information

2.1 Basic description

Product Name		Tablet
Product Model Number		SM-X308U
Product Manufacturer		Samsung Electronics Co., Ltd
Product Serial Number	Conduction	R32W90020SH
Mode of Operation		WCDMA II/ IV/ V, LTE Band 2/4/5/7/12/13/14/25/26/30/40/41/48/66/71 NR Band n2/n5/n12/n25/n30/n41/n48/n66/n71/n77/n78

The equipment under test (EUT) is SM-X308U (FCC ID : A3LSMX308U), it contains S.LSI chipset supporting 4G/5G NR Sub6 technologies. these chipsets are enabled with 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.

This document consists of TAS algorithm description, algorithm parameters, validation methodology, test cases, test procedures and test results. In order to demonstrate that TAS algorithm meets FCC requirements for SAR exposure..

This device has Samsung S.LSI TAS algorithm v2.5 applied.

The P_{limit} (For 3G/4G and 5G NR Sub-6) used in this report is determined in Part 0 and Part 1 reports.
Refer to Part0 report for product description and terminology used in this report.

Device Overview		
Band & Mode	**Operating Modes**	**Tx Frequency**
WCDMA Band II	Data	1 852.4 ~ 1 907.6
WCDMA Band IV	Data	1 712.4 ~ 1 752.6
WCDMA Band V	Data	826.4 ~ 846.6
LTE Band 2	Data	1 850.7 ~ 1 909.3
LTE Band 4	Data	1 710.7 ~ 1 754.3
LTE Band 5	Data	824.7 ~ 848.3
LTE Band 7	Data	2 502.5 ~ 2 567.5
LTE Band 12	Data	699.7 ~ 715.3
LTE Band 13	Data	779.5 ~ 784.5
LTE Band 14	Data	790.5 ~ 795.5
LTE Band 25	Data	1 850.7 ~ 1 914.3
LTE Band 26	Data	814.7 ~ 848.3
LTE Band 30	Data	2 307.5 ~ 2 312.5
LTE Band 40 (lower)	Data	2 307.5 ~ 2 312.5
LTE Band 40 (upper)	Data	2 352.5 ~ 2 357.5
LTE Band 41	Data	2 498.5 ~ 2 687.5
LTE Band 48	Data	3 552.5 ~ 3 697.5
LTE Band 66	Data	1 710.7 ~ 1 779.3
LTE Band 71	Data	665.5 ~ 695.5
NR Band n2	Data	1 852.5 ~ 1 907.5
NR Band n5	Data	826.5 ~ 846.5
NR Band n12	Data	701.5 ~ 713.5
NR Band n25	Data	1 852.5 ~ 1 912.5
NR Band n30	Data	2 307.5 ~ 2 312.5
NR Band n41	Data	2 501.01 ~ 2 685.00
NR Band n48	Data	3 555.00 ~ 3 694.98
NR Band n66	Data	1 712.5 ~ 1 777.5
NR Band n71	Data	665.5 ~ 695.5
NR Band n77 DoD	Data	3 455.01 ~ 3 544.98
NR Band n77	Data	3 705.00 ~ 3 975.00
NR Band n78	Data	3 455.01 ~ 3 544.98
2.4 ㎓ WLAN	Data	2 412.0 ~ 2 462.0
U-NII-1	Data	5 180.0 ~ 5 240.0
U-NII-2A	Data	5 260.0 ~ 5 320.0
U-NII-2C	Data	5 500.0 ~ 5 720.0
U-NII-3	Data	5 745.0 ~ 5 825.0
Bluetooth	Data	2 402.0 ~ 2 480.0
NFC	Data	13.56
Digitizer	Data	0.531 25 ~ 0.593 75

2.1.2 EN-DC Carrier Aggregation

EN-DC Carrier Aggregation Possible Combinations	The technical description includes all the possible carrier aggregation combinations
LTE Anchor Bands for NR Band n2 (Main1 ANT)	LTE Band 5/12/13/14/71 (Main1 ANT)
	LTE Band 48 (Main2 ANT)
LTE Anchor Bands for NR Band n5 (Main1 ANT)	LTE Band 2/66 (Main1 ANT)
	LTE Band 7/30/48 (Main2 ANT)
LTE Anchor Bands for NR Band n12 (Main1 ANT)	LTE Band 2/66 (Main1 ANT)
LTE Anchor Bands for NR Band n25 (Main1 ANT)	LTE Band 12 (Main1 ANT)
	LTE Band 48 (Main2 ANT)
LTE Anchor Bands for NR Band n30 (Main2 ANT)	LTE Band 5/12/14 (Main1 ANT)
	LTE Band 2/66 (Sub1 ANT)
LTE Anchor Bands for NR Band n41 (Main2 ANT)	LTE Band 12/25/71 (Main1 ANT)
	LTE Band 2/4/66 (Sub1 ANT)
LTE Anchor Bands for NR Band n48 (Main2 ANT)	LTE Band 2/66 (Main1 ANT)
LTE Anchor Bands for NR Band n66 (Main1 ANT)	LTE Band 5/12/13/14/71 (Main1 ANT)
	LTE Band 7 (Sub1 ANT)
	LTE Band 48 (Main2 ANT)
LTE Anchor Bands for NR Band n71 (Main1 ANT)	LTE Band 2/66 (Main1 ANT)
	LTE Band 7/48 (Main2 ANT)
LTE Anchor Bands for NR Band n77 (Main2 ANT)	LTE Band 1/2/3/5/12/13/14/66 (Main1 ANT)
	LTE Band 7/30 (Main2 ANT) (Main1 ANT)
LTE Anchor Bands for NR Band n78 (Main2 ANT)	LTE Band 1/2/3/4/5/12/13/66/71 (Main1 ANT)
	LTE Band 7 (Main2 ANT)

3. Test Under Dynamic Transmission Condition for RF Exposure Compliance

This device is enabled with Samsung S.LSI proprietary TAS (Time Average SAR) algorithm to control and manage transmitting power in real time and to ensure that the time-averaged RF exposure from 2G/3G/4G/5G NR WWAN is incompliance with FCC requirements.
This feature performs time averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements all the time.
The Smart Transmit algorithm maintains the time-averaged transmit power, in turn, time-averaged RF exposure of SAR_design_target for sub 6 radio, below the predefined time averaged power limit for each characterized technology and band.
Smart Transmit allows the device to transmit at higher power instantaneously, as high as P_{max}, when needed, but enforces power limiting to maintain time-averaged transmit power to P_{limit} for frequencies < 6 GHz and for frequencies > 6 GHz.
Note that the device uncertainty for sub 6GHz WWAN is 1.0dB for this DUT, and the reserve power margin is 3 dB.

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

3.1 RF Exposure Limits for Frequencies < 6 GHz

HUMAN EXPOSURE	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT Occupational (W/kg) or (mW/g)
SPATIAL PEAK SAR * (Partial Body)	1.6	8.0
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.4
SPATIAL PEAK SAR *** (Hands / Feet / Ankle / Wrist)	4.0	20.0

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

NOTES:

* The Spatial Peak value of the SAR averaged over any 1 g of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

** The Spatial Average value of the SAR averaged over the whole-body.

*** The Spatial Peak value of the SAR averaged over any 10 g of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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 mad 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.

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.

3.2 Interim Guidance for Time Averaging

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	Maximum Averaging Time
SAR	< 3	100
	3 – 6	60
MPE	6 – 10	30
	10 - 16	14
	16 - 24	8
	24 – 42	4
	42 - 95	2

4. Tx Varying Transmission Test Cases and Test Proposal

The following scenarios are covered in this report to demonstrate compliance with FCC RF exposure in Tx varying transmission conditions.

1. During a time-varying Tx power transmission – to prove that TAS feature accounts for Tx power variations in time accurately.

2. During a call disconnect and re-establish scenario – to prove that the TAS feature accounts for history of Tx power from past accurately.

3. During a technology/band handover – to prove that TAS feature accounts for history across transitions in band/technology.

4. During RSI (Radio SAR index) change – to prove that TAS feature functions correctly to meet compliance limits across RSI changes.

5. During time averaging window change – to prove that TAS feature properly handles the change from one time averaging window to another as specified by FCC, and meets the normalized FCC limit of 1.0 at all time.

6. During SAR exposure switch – to prove that TAS feature accounts for history across transitions in ENDC power sharing.

7. During TAS to non TAS Handover – to prove that TAS feature properly handles the change from TAS support band to non TAS support band.

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

As described in linearity analysis in SAR characterization report, the RF exposure is proportional to the Tx power for both FR1(2G/3G/LTE/NR Sub6). 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 (i.e., transmission scenarios 1, 2, 3, 4, 5, 6, and 7) for validating the test is summarized below:

1. Measure conducted power (FR1) over time , denoted as $TxPower(t)$
2. Convert measured powers to RF exposure values using linear relationship shown below. In below expression, $Plimit$, $FR1$ would be the measured power at which FR1 technology meets measured SAR level of SAR_design_target.

Mathematical expression:

$$SAR(t) = \frac{TxPower(t)}{P_{limit,FR1}} \times SAR\_design\_target \qquad \text{(equation : 2.1)}$$

3. Compute the average RF exposure over the most recent measurement duration which are denoted as $TSAR$ for FR1. These durations are as specified by FCC. This measurement duration interval is then given by $[t - TSAR\ ,\ t]$ 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 following to following equations which describe the calculation of TER and its target constraint. The expressions below is general considering a number of FR1 radio in general denoted by $LSAR$.

Mathematical expression (For FR1 transmissions only):

$$\sum_{l_{SAR}=0}^{L_{SAR}-1} \frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} SAR_{l_{SAR}}}{FCC\ SAR_{limit}} \leq 1 \qquad \text{(equation : 2.2)}$$

5. SAR Time Averaging Validation Test configuration selection

This section provides the test plan and test procedure for validating Samsung S.LSI TAS feature for FR1(2G/3G/LTE/NR Sub6) scenarios.

5.1 Test sequence determination for validation

Two sequences for time varying Tx power are pre-defined as given below for FR1 case.

1. Test Sequence A is generated with two power levels. One is maximum power level Pmax and the other is lower power level. The lower power level is defined as 3dB lower value than maximum power level. At first, maximum power level is applied for 100 seconds ($1.0 * TSAR$). After this, lower power level is used until this test is finished.

2. Test Sequence B is generated at multiple power levels that are specified in the Appendix as a function of Pmax and Plimit.

5.2 Test configuration selection criteria for validating TAS

This section provides general guidance for selecting test cases in TAS algorithm validation.

5.2.1 Test configuration selection for time-varying Tx power transmission

The Samsung S.LSI TAS algorithm is independent of band, modes or channel of any 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 Plimit and Pmax. Essentially, we need to pick this combination such that Plimit is less than Pmax so that the TAS algorithm will enforce power restriction. Two bands can be selected to different values of Plimit - one corresponding to lowest value and another being highest but still less than Pmax.

5.2.2 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 Plimit among all bands. The test is performed with DUT requested power at Pmax so that the Samsung S.LSI TAS feature enforces power restriction for 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.

5.2.3 Test configuration selection for change in technology/band

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 averaging for frequency below 3GHz to 60s averaging for frequency above 3GHz in FR1. The criteria for selecting test case to demonstrate compliance across time window change is to pick a technology/band corresponding to each time window such that Plimit is less than Pmax.

5.2.4 Test configuration for change in RSI (Radio SAR Index)

The criteria for selecting test case to demonstrate compliance across RSI change within a radio. The two RSI states are chosen by pick a technology/band such that Plimit is less than Pmax for both states.

5.2.5 Test configuration for SAR exposure switching

The criteria for selecting test case is to pick an LTE band and a NR band with Plimit lower than Pmax 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, DUT is requested to transmit at maximum power for both NR and LTE. In the final portion of the test, DUT is requested to transmit at minimum power for NR and maximum power for LTE.

5.2.6 Test configuration for TAS to non TAS Handover

This test scenario is similar section 5.2.3. The difference is that one tech support TAS feature and the other tech does not support TAS feature. This test is conducted according to the test procedures provided in Samsung S.LSI.

5.2.7 Test configuration for LTE Uplink CA

This test shows that the TAS algorithm compliance is independent on the Transmission scenarios (single CC or CA). This test is conducted according to the test procedures provided in Samsung S.LSI.

6 Test procedures description

6.1 Test procedures for conducted power measurements

This section provides general conducted power measurement procedures to perform compliance test under dynamic transmission scenarios described in Section 4.

6.1.1 Time-varying Tx power transmission scenario

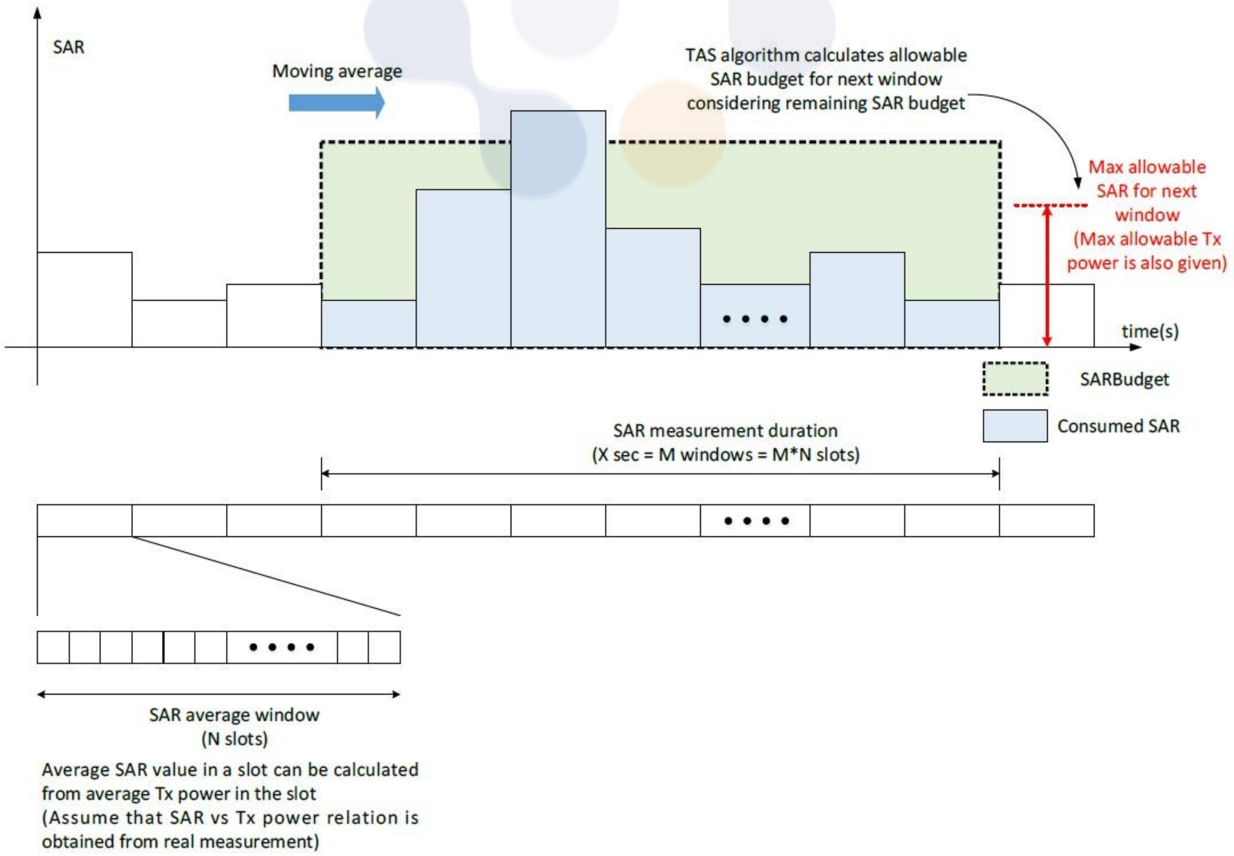
This test is performed with the two pre-defined test sequences described in Section 5.1 for all the technologies and bands selected in Section 5.2.1. The purpose of the test is to demonstrate the effectiveness of power limiting enforcement and that the time-averaged SAR (corresponding time-averaged Tx power) does not exceed the FCC limit at all times.

Test procedure

1. Using the Pmax and Plimit, 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 in the sequence. This is illustrated in the figure below.

Figure 5-1 100s running average illustration



3. Release connection

4. After the 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.

5. Make a second plot containing the following information:

   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 any time in the plot in Step 4

6.1.2 Change in call scenario

This test is to demonstrate that Samsung S.LSI TAS feature correctly accounts for 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 DUT with call box e.g. using LTE technology.

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 of Pmax is achieved.

4. After 60s of transmission at Pmax power level, release the call from call box.

5. After 10s, re-establish the LTE connection from call box to 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 400s.

7. Release LTE connection.

8. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Requested Tx power versus time (c) Time-averaged power over 100s using instantaneous values and (d) Power level Plimit which is determined as meeting SAR target

9. Make a second plot containing the following information (a) Computed time-averaged 1gSAR versus time and (b) FCC 1gSAR limit of 1.6W/kg

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.

6.1.3. Change in technology/band and 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 6.2.1 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 first band is chosen below 3GHz, we would have $T1,SAR$ = 100s, and by choosing second band to be above 3GHz, we would use $T2,SAR$ = 60s. On the other hand, when first band is chosen above 3GHz and second band below 3GHz, we would use $T1,SAR$ = 60s and $T1,SAR$ = 100s.

Test procedure for switching from 100s to 60s and vice-versa

1. Establish radio connection of DUT with call box e.g. using LTE technology in band A (e.g B2) which has 100s averaging duration.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 160s.
3. Configure call box to send "ALL UP" power control commands and continue LTE transmission From DUT so that maximum power of Pmax is achieved. Continue transmission at the maximum power for at least 140s.
4. Change band from band A (B2) to another LTE band B (e.g. B48), 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 200s.
5. Change band from band B(B48) back to the first band A(B2) and continue call at maximum power for at least 120s.
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 Eqn (3.3.3.1) and (3.3.3.2), and (c) FCC 1gSAR limit of 1.6W/kg.

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.

Test procedure for switching from 60s to 100s and vice-versa :

1. Establish radio connection of DUT with call box e.g. using LTE technology in band B (B48) which has 60s averaging duration.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 160s.
3. Configure call box to send "ALL UP" power control commands and continue LTE transmission from DUT so that maximum power of Pmax is achieved. Continue transmission at the maximum power for at least 140s.
4. Change band from band B (B48) to another LTE band A (B2), 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 120s
5. Change band from band A(B2) back to the first band B(B48) and continue call at maximum power for at least 180s.
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 Eqn (3.3.3.1) and (3.3.3.2), and (c) FCC 1gSAR limit of 1.6W/kg.

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.

6.1.4 Change in RSI (Radio SAR Index)

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle change of RSI resulting from different SAR index state detected by host platform software. It involves changing the Plimit value during the test for the same technology to emulate RSI change, while the SAR_design_target remains the same. Note that the DUT has a proximity sensor to manage extremity exposure, which is represented using RSI (number = related proximity senor scenario) ; the head exposure can be distinguished through audio receiver mode, represented as RSI (number = related head exposure scenario); similarly, the body worn with 15mm distance exposure is represented as RSI (number = related head exposure scenario); the other exposure would be updated and defined as other RSI numbers.

Test procedure :

1. Establish radio connection of DUT with call box.
2. Configure DUT to send at low Tx power of 0dBm for 110s and set the RSI index corresponding to Plimit.
3. Configure call box to send "ALL UP" power control commands and continue transmission from DUT so that maximum power of Pmax is achieved. Continue the transmission for 200s.
4. Change the RSI index corresponding to lower value of (Plimit - 3dB) and continue the transmission for another 300s
5. Release the connection.

Pass condition is to demonstrate time-averaged 1gSAR value versus time does not exceed the FCC limit 1.6 W/kg throughout the test duration. It is required to check if power limiting enforcement is operated as expected when RSI index is changed during the test.

6.1.5 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 both call boxes, e.g. LTE band and NR band.
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 220s.
3. In the second part of test, configure the LTE call box to sent "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 110s.
4. In the third part of 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.

The validation criteria is, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed the regulatory *1gSARlimit* of 1.6W/kg or *10gSARlimit* of 4.0W/kg

6.1.6 LTE Uplink CA

The test is to demonstrate that Samsung S.LSI TAS feature can properly handle the SAR exposure for LTE with the addition and/or removal of another intra-band LTE CC.

Test procedure for uplink CA

1. Establish LTE connection of DUT with call box over Cell 1 E.g. one cell of the band Combo CA_3C.
2. Configure the call box to send "ALL down" power control commands and continue this stage for about 100s.
3. Configure Call box to send "ALL UP" command for transmission on cell 1 and continue transmission for 540s
4. Establish LTE connection of DUT with call box over Cell 2 E.g. other cell of the band Combo CA_3C.
5. Configure Call box to send "ALL UP" command for transmission on cell 2and continue transmission for 540s
6. Release LTE connection for both cells

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

6.1.7 Change in TAS to non TAS Handover

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle change of TAS to non TAS handover scenarios. Since Both Plimits can change across bands, we have to use below 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 supported TAS band meets measured SAR level of SAR_design_target1 as described in Table 6.2.1 with time-averaging duration of T1,SAR Similarly, the quantities $Plimit$,2,FR1 , SAR_design_target2 , T2,SAR are defined for the second Non-TAS band.

Test procedure for switching from TAS to Non TAS Handover :

1. Establish radio connection of DUT with call box e.g. using TAS technology in band A which has 100s averaging duration.
2. Configure call box to set DUT Tx power to a low value of -10dBm for 110s.
3. Configure call box to send "ALL UP" power control commands and continue TAS technology transmission From DUT so that maximum power of Pmax is achieved. Continue transmission at the maximum power for at least 110s.
4. Change band from TAS technology band A to Non TAS technology band B. Continue call in Non TAS technology band B with call box requesting maximum power for at least 390s.
5. Release WCDMA connection.
6. 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.
7. 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 Eqn (3.3.3.1) and (3.3.3.2), and (c) FCC 1gSAR limit of 1.6W/kg.

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.

6.2 Time-Averaging Algorithm for RF Exposure Compliance

This Device is enabled with the Samsung S.LSI TAS feature.

This feature performs time averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements all the time.

Note that WLAN operations are not enabled with Smart Transmit.

The Smart Transmit algorithm maintains the time-averaged transmit power, in turn, time-averaged RF exposure of SAR_design_target, below the predefined time-averaged power limit (i.e., P_{limit} for sub-6 radio), for each characterized technology and band.

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

Below table shows P_{limit} EFS settings and maximum tune up output power P_{max} configured for this EUT for various transmit conditions (Radio SAR Index RSI).

Note that the device uncertainty for sub-6GHz WWAN is +1.0dB/-1.5dB for this EUT.

7. Test Configurations

7.1 WWAN (sub-6) transmission

The P_{limit} values, corresponding to 1.0 W/kg (1gSAR) of SAR_design_target, for technologies and bands supported by EUT are derived in Part 0 report and summarized in Table 7-1.

P_{limit} values in blue indicate $P_{limit} < P_{max}$		Plim values in grey indicate $P_{limit} > P_{max}$		
				P_{max}
SAR Exposure Position		Body Max Power	Body Grip sensor On Back-off Power	Maximum Tune-up Output power (Frame Averaged Power) [dBm]
Averaging Volume		1g	1g	
Separation Distance		19, 18, 14, 7 mm	0 mm	
Mode	Band	RSI = 0	RSI = 1	
WCDMA	2	28.6	14.0	24.5
WCDMA	4	27.6	14.0	24.5
WCDMA	5	27.0	17.0	23.5
LTE FDD (Sub)	2	29.2	14.0	24.0
LTE FDD	5	28.0	17.0	24.5
LTE FDD (Main)	7	25.4	10.0	22.5
LTE FDD (Sub)	7	27.8	10.0	22.5
LTE FDD	12	30.9	17.0	24.5
LTE FDD	13	29.1	17.0	24.5
LTE FDD	14	29.5	17.0	24.5
LTE FDD	25(2)	30.5	14.0	24.5
LTE FDD	26	28.2	17.0	24.0
LTE FDD	30	26.6	14.0	22.3
LTE TDD	40	29.7	14.0	22.5
LTE TDD (PC2)	41	27.9	13.0	26.5
LTE TDD (PC3)	41	26.3	13.0	24.0
LTE TDD	48	26.3	12.5	22.5
LTE FDD (Main)	66(4)	27.3	14.0	24.5
LTE FDD (Sub)	66(4)	30.0	14.0	24.5
LTE FDD	71	31.5	19.0	23.5
NR FDD	n5	27.6	17.0	24.5
NR FDD	n12	29.9	17.0	24.5
NR FDD	n25(n2)	29.5	14.0	24.5
NR FDD	n30	27.7	13.0	22.5
NR TDD (PC2)	n41	20.0	11.0	27.0
NR TDD	n48	16.5	8.0	22.5
NR TDD (SRS1)	n48	6.0	-	12.0
NR TDD (SRS2)	n48	6.0	-	12.0
NR TDD (SRS3)	n48	10.0	-	16.0
NR FDD	n66	26.6	14.0	24.5
NR FDD	n71	31.7	19.0	23.5
NR TDD (PC2)	NR n77	21.0	11.0	27.0
NR TDD (PC2, SRS1)	NR n77	6.0	-	13.5
NR TDD (PC2, SRS2)	NR n77	6.0	-	13.5
NR TDD (PC2, SRS3)	NR n77	10.0	-	17.5
NR TDD (PC3)	NR n77	18.0	11.0	24.5
NR TDD (PC3, SRS1)	NR n77	6.0	-	12.0
NR TDD (PC3, SRS2)	NR n77	6.0	-	12.0
NR TDD (PC3, SRS3)	NR n77	10.0	-	16.0
NR TDD (PC3)	NR n78	18.0	8.0	24.5
NR TDD (PC3, SRS1)	NR n78	6.0	-	12.0
NR TDD (PC3, SRS2)	NR n78	6.0	-	12.0
NR TDD (PC3, SRS3)	NR n78	10.0	-	16.0

Table 7-1 P_{limit} for supported technologies and bands

Note:

1. In the cases of LTE band 2 (Main), LTE Band 4 (Main, Sub), NR n2 are marked as N/A, which are frequency overlapping band.
2. For NR FR1 TDD Band and SRS Modes, P_{limit} listed averaged power level, and P_{max} listed burst power level.

7.2 Test Radio Configurations

The measured P_{limit} for all the selected radio configurations given in Table 1-3 are listed in below Table 7-2.

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.

TC #	Test Scenario	Tech	Band	Ant.	RSI	Frequency [MHz]	Bandwidth / RB / RB Offset	Mode	SAR Exposure Scenario	Part 1 Worst Case Measured SAR at P_{limit} (W/kg)
1	Time varying Tx power case (Test Sequence.A)	LTE	B7	Main.2	1	2 510.0	20 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.487
			B30	Main.2	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
2		FR1	n5	Main.1	1	836.5	20 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.351
			n12	Main.1	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.503
3	Time varying Tx power case (Test Sequence.B)	LTE	B7	Main.2	1	2 510.0	20 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.487
			B30	Main.2	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
4		FR1	n5	Main.1	1	836.5	20 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.351
			n12	Main.1	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.503
5	Change in call (Disconnect-Re-establishment)	LTE	B30	Main.2	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
6	FR1 to LTE IRAT Re-selection	FR1	n12	Main.1	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.503
		LTE	B30	Main.2	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
7	Window change case 1	LTE	B30	Main.1	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
			B48	Main.2	1	3 690.0	20 / 1 / 49	QPSK	1g/0mm/Grip ON_Rear	0.470
8	Window change case 2	LTE	B48	Main.2	1	3 690.0	20 / 1 / 49	QPSK	1g/0mm/Grip ON_Rear	0.470
			B30	Main.2	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.612
9	Switch in SAR exposure (FR1 dominant power change)	NSA FR1	n30	Main.2	1	2 310.0	10 / 25 / 14	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.558
			B5	Main.2	1	836.5	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.359
10	LTE UL CA	LTE	B48	Main2	1	3 690.0	20 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.432
			B48	Main2	1	3 670.2	20 / 1 / 99	QPSK		
13	Change in RSI	FR1	n12	Main.1	0	707.5	15 / 36 / 22	DFT-S-OFDM_QPSK	1g/0mm/Grip OFF_Rear	0.309
			n12	Main.1	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/Grip ON_Rear	0.503
14	TAS to Non TAS	LTE	B5	Main.2	1	836.5	10 / 1 / 0	QPSK	1g/0mm/Grip ON_Rear	0.359
		WCDMA	B2	Main.1	1	1 880.0	-	RMC	1g/0mm/Grip ON_Rear	0.512

Table 7-2 Measured P_{limit} and P_{max} of selected radio configurations

Notes:
Reported SAR values in Part 1 SAR report are tested at P_{limit} + tolerance. Therefore, 100s(or 60s) average SAR is shown to be ± 1.0 dB from SAR design target.
Some of Test Case (RSI Change) was omitted due to RSI configuration issues.

Exposure Scenario (RSI = No.)		Description	KDB guide for SAR test
Body Max power	Standalone exposure Without triggering sensor (RSI = 0)	■ Grip sensor is not triggered even if Device was touched to user's body. ■ Grip sensor is not triggered due to triggering distance.	KDB 616217 D04
Body Grip On Back-off Power	Standalone exposure With triggering sensor (RSI = 1)	■ Grip sensor is triggered, when Device was touched to user's body.	KDB 616217 D04

Table 7-3 RSI and Corresponding Exposure Scenarios

Note: that the EUT has a proximity sensor to manage extremity exposure, which is represented using RSI = 1; Grip sensor is triggered, when Device was touched to user's body or hands. and is managed as the same exposure condition as extremity exposure at 0 mm; RSI = 0 represents all other exposures which cannot be distinguished, thus, in this case, the maximum 1gSAR among all remaining exposure scenarios or the minimum P_{limit} among all remaining exposure scenarios (i.e., body worn 1gSAR evaluation at 0mm spacing, body worn 1gSAR extremity evaluation at 0mm spacing, body worn 1gSAR extremity evaluation at 0mm spacing for rear surfaces) is used in Smart Transmit feature for time averaging operation.
Reported SAR values in Part 1 SAR report are tested at P_{limit} + tolerance. Therefore, 100s(or 60s) average SAR is shown to be ± 1.0 dB from SAR design target.

8. Time-varying Tx power measurement for below 6GHz frequency

8.1 Conducted Measurement Test setup

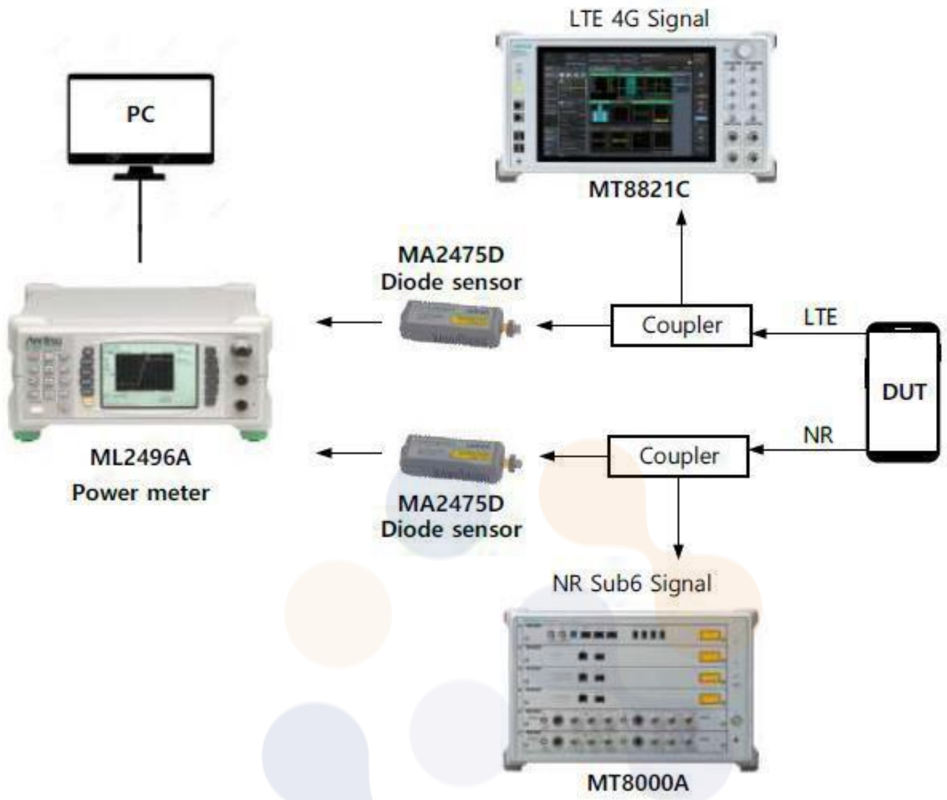


Figure 8-2

Conducted power measurement setup

The MT8000A callbox was used in this test. The test setup schematic is the same as the Legacy Test Setup shown in Figure 6-1a (Appendix B – Test Setup Photo 4). One port of the callbox is connected to the RF port of the DUT using a directional coupler. In the setup, the power meter is used to tap the directional coupler for measuring the conducted output power of the DUT.

LTE+Sub6 NR test setup:

If LTE conducted port and Sub6 NR conducted port are same on this EUT (i.e., they share the same antenna), then low-/high-pass filter is used to separate LTE and Sub6 NR signals for power meter measurement via directional couplers, as shown in below Figures 8 (see Appendix B- Test setup photo).

The test setup for TAS validation with sub-6GHz RATs only is shown in Figure 5.1-1. Normally, a power sensor would measure total power in the entire frequency of its specification e.g. 10MHz to 18GHz for the MA2472D unit. However, when two radios are active, we need to measure their powers separately for using the corresponding SAR mapping table. Therefore, this test setup considers scenarios where two radios would be transmitting from different ports of the DUT so that separate power sensors measure them individually. A common power meter is able to display and record the readings for each sensor at the same time for postprocessing at a PC. The signaling call boxes MT8000A and MT8821C are used to establish the call and data connection to the DUT on those same ports for NR and LTE, respectively.

The couplers are able to provide the transmit signal from DUT to power sensors while uplink and downlink signaling messages exchanged with the call boxes on the same paths. We can build scripts to program a certain sequence of power control commands from the call boxes to the DUT which can essentially instruct the DUT to change its transmit power. Thus, if we want DUT to transmit at maximum power in LTE, then continuous power up commands are sent by MT8821C. Similarly, continuous power up commands from MT8000A will try to increase NR power up to its maximum limit. Other power control scenarios which mimic real field behavior such as sequence of power up followed by power down are also possible as described in Section 4.1 and Section 5.1. All the path losses from RF port of DUT to the callbox and the power meters are calibrated and automatically entered as offsets in the callbox and power meter, which are also connected to the control PC used in the test setup. We use an Anritsu AMS tool, which is capable of executing the entire test sequence including requested power variation over time and call setup/disconnect scenarios based on pre-configured test case definition.

Power readings for each active technology are recorded every 100ms and dumped in an excel file. A post-processing tool is used to extract data from the excel file and plot the required metrics such as time-averaged power, SAR and TER values versus time as described in Section 3.3. In summary, the tests have to be executed as following procedure.

1. Measure conduction sub 6GHz Tx power corresponds to SAR regulation.

2. Set sub 6GHz power level with some margin. And start the test

3. Execute time-varying test scenarios. And record sub 6GHz power using sub 6GHz power meter equipment.

4. Plot the recorded results over measurement time. And evaluate the results for validation.

Note that Plimit is different according to the used OEM, so it is necessary to set the Plimit suitable for each terminal.

8.2 P_{limit} and P_{max} measurement results

The measured P_{limit} for all the selected radio configurations given in Table 1-3 are listed in below Table 1-4. P_{max} was also measured for radio configurations selected for testing time-varying Tx power transmission scenarios in order to generate test sequences following the test procedures. Note that Table 5.2.1 is not actual Plimit corresponding to 1 W/kg SAR, but our measured averaged power when forcing Plimit in our SW.

Table 8-1 : Measured P_{limit} and P_{max} of selected radio configurations
Note: the device uncertainty of P_{max} is +1.0dB/-1.5dB as provided by manufacturer.

TC #	Test Scenarios	Tech	Band	RSI	Frequency (MHz)	Bandwidth /RB /RB offset	Mode	Detail	Plimit setting (dBm)	Pmax setting (dBm)	Measured Plimit (dBm)	Measured Pmax (dBm)
1	Time varying Tx power case (Test Sequence.A)	LTE	B7	1	2 510.0	20 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	10.0	22.5	9.25	23.48
			B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
2		FR1	n5	1	836.5	20 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.57	24.65
			n12	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.78	24.73
3	Time varying Tx power case (Test Sequence.B)	LTE	B7	1	2 510.0	20 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	10.0	22.5	9.25	23.48
			B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
4		FR1	n5	1	836.5	20 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.57	24.65
			n12	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.78	24.73
5	Change in call (Disconnect-Re-establishment)	LTE	B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
6	FR1 to LTE IRAT Re-selection	FR1	n12	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.78	24.73
		LTE	B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
7	Window change case 1	LTE	B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
			B48	1	3 690.0	20 / 1 / 49	QPSK	1g/0mm/ Grip ON_Rear	12.5	22.5	13.44	23.41
8	Window change case 2	LTE	B48	1	3 690.0	20 / 1 / 49	QPSK	1g/0mm/ Grip ON_Rear	12.5	22.5	13.44	23.41
			B30	1	2 310.0	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	14.0	22.3	13.72	22.86
9	Switch in SAR exposure (FR1 dominant power change)	NSA FR1	n30	1	2 310.0	10 / 25 / 14	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	13.0	22.5	12.73	23.46
			B5	1	836.5	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.39	23.85
10	LTE UL CA	LTE	B48	1	3 690.0	20 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	12.5	22.5	13.21	23.41
			B48	1	3 670.2	20 / 1 / 99	QPSK					
13	Change in RSI	FR1	n12	0	707.5	15 / 36 / 22	DFT-S-OFDM_QPSK	1g/0mm/ Grip OFF_Rear	17.0	24.5	16.78	24.73
			n12	1	707.5	15 / 1 / 1	DFT-S-OFDM_QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.78	24.73
14	TAS to Non TAS	LTE	B5	1	836.5	10 / 1 / 0	QPSK	1g/0mm/ Grip ON_Rear	17.0	24.5	16.39	23.85
		WCDMA	B2	1	1 880.0	-	Rel 99	1g/0mm/ Grip ON_Rear	14.0	24.5	14.27	24.74

Notes:

. Validation is proceed with restricted EFS File and SAR values provided by OEMs.

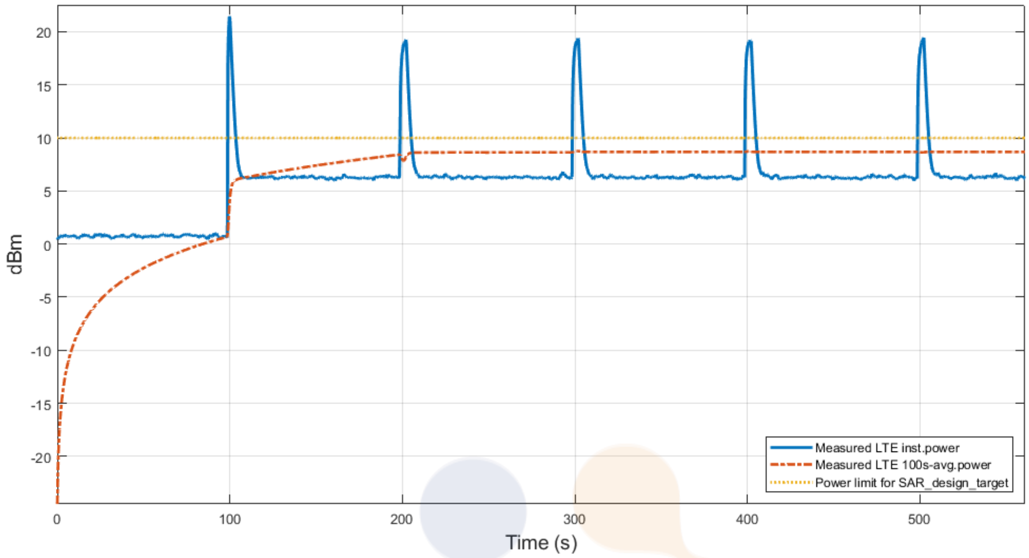
. The device uncertainty of P_{max} is +/- 1 dB as provided by manufacturer

8.3 TC01-04: Time-varying Tx power measurement results

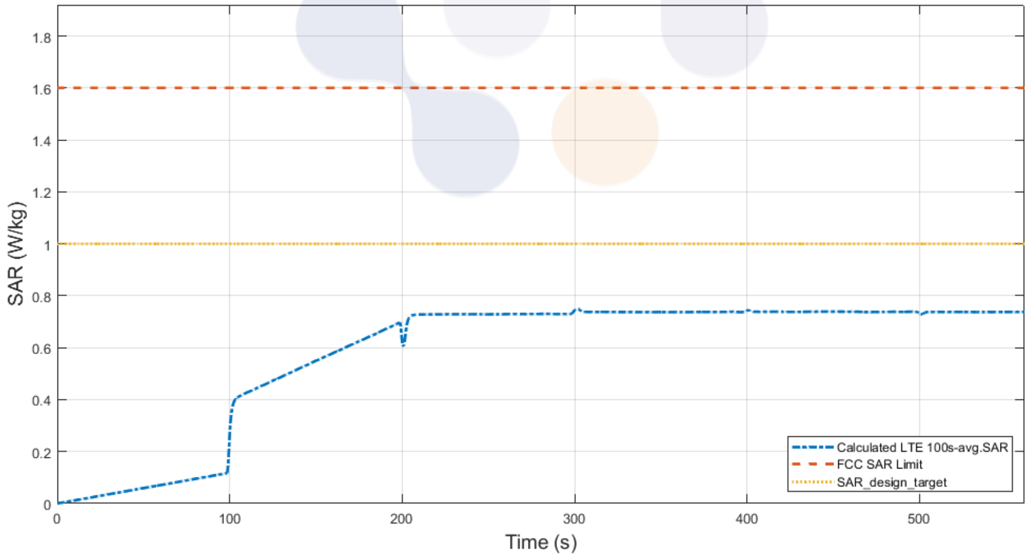
Following the test procedure in Section 5, the conducted Tx power measurement results for all selected test cases are listed in this section. In all conducted Tx power plots, the blue line shows the measured instantaneous power using the power meter, the red line shows the time-averaged Tx power and yellow line shows the Plimit value corresponding to 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 1.6W/Kg. Time-varying Tx power measurements were conducted for TC #01-04 in Table 8-1 by generating the test sequence A or B given in Section A.

8.3.1 LTE B7 (test case 1, 3 in Table 7-2)

Test result for test sequence A:



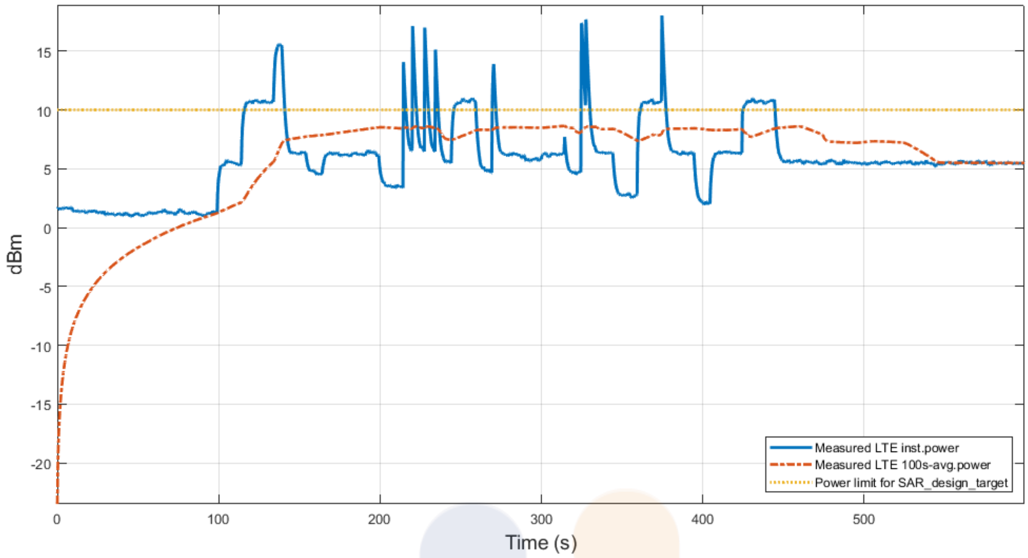
Plot.1 shows the conducted Tx power plot with calculated time-averaged power based on the measured instantaneous Tx power with 1gSAR FCC Limit value. As shown in Plot.1, it is confirmed for time average Tx power that the FCC limit was not exceeded, and that the averaged Tx power is smaller than the target power, and it will saturate to target power with little margin.



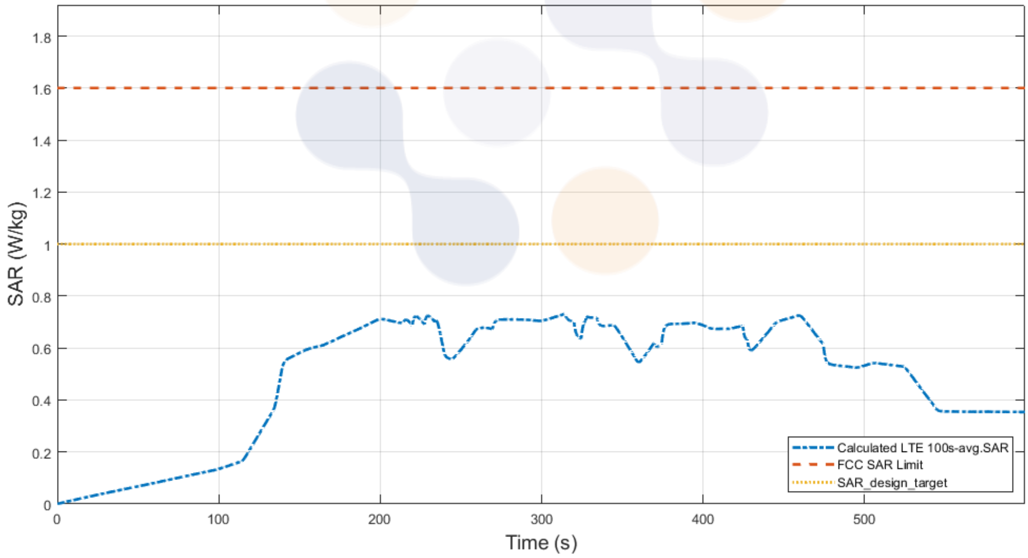
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC 1g SAR Limit [W/kg]	**1.6** W/kg
Max 100s-time averaged 1g SAR (red curve)	**0.752** W/kg
Device uncertainty	**1.0** dB

Test result for test sequence B:



Plot.1 shows the instantaneous and time-averaged Tx power with test sequence B.

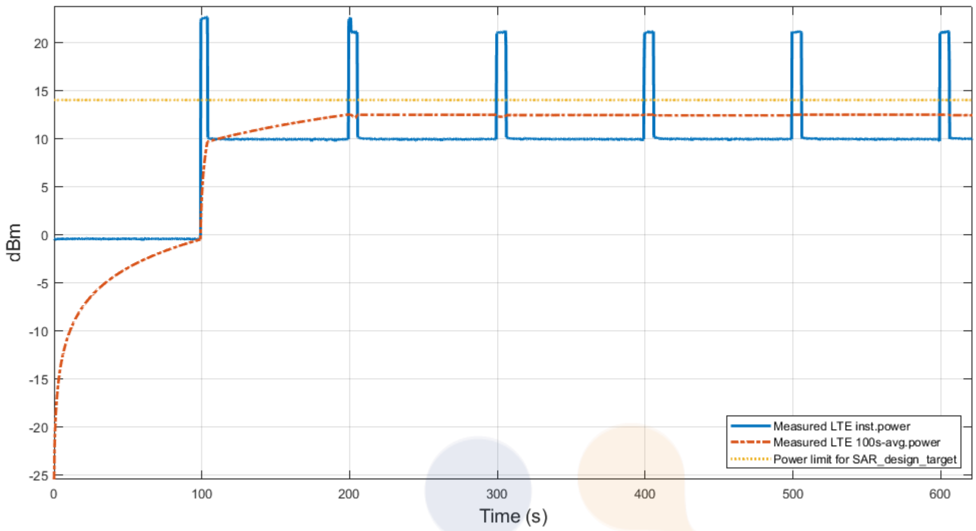


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

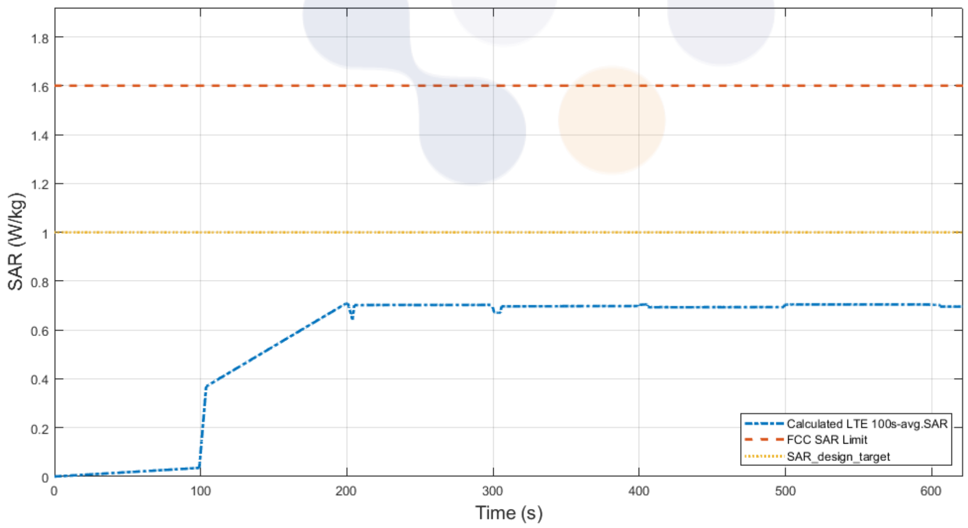
FCC 1g SAR Limit [W/kg]	**1.6**	W/kg
Max 100s-time averaged 1g SAR (red curve)	**0.732**	W/kg
Device uncertainty	**1.0**	dB

8.3.2 LTE Band 30 (test case 1, 3 in Table 7-2)

Test result for test sequence A:



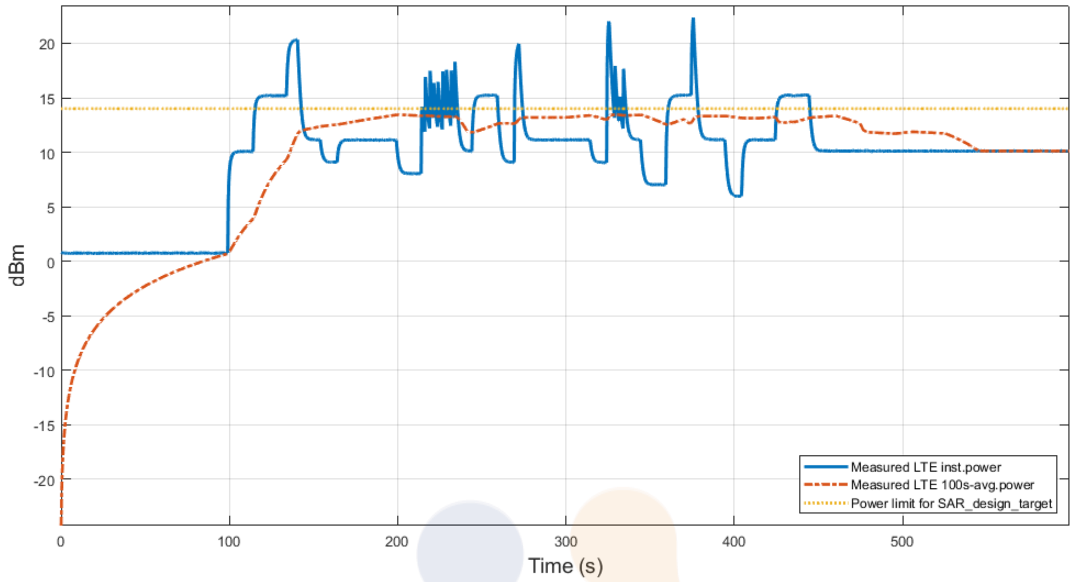
Plot.1 shows the conducted Tx power plot with calculated time-averaged power based on the measured instantaneous Tx power with 1gSAR FCC Limit value. As shown in Plot.1, it is confirmed for time average Tx power that the FCC limit was not exceeded, and that the averaged Tx power is smaller than the target power, and it will saturate to target power with little margin.



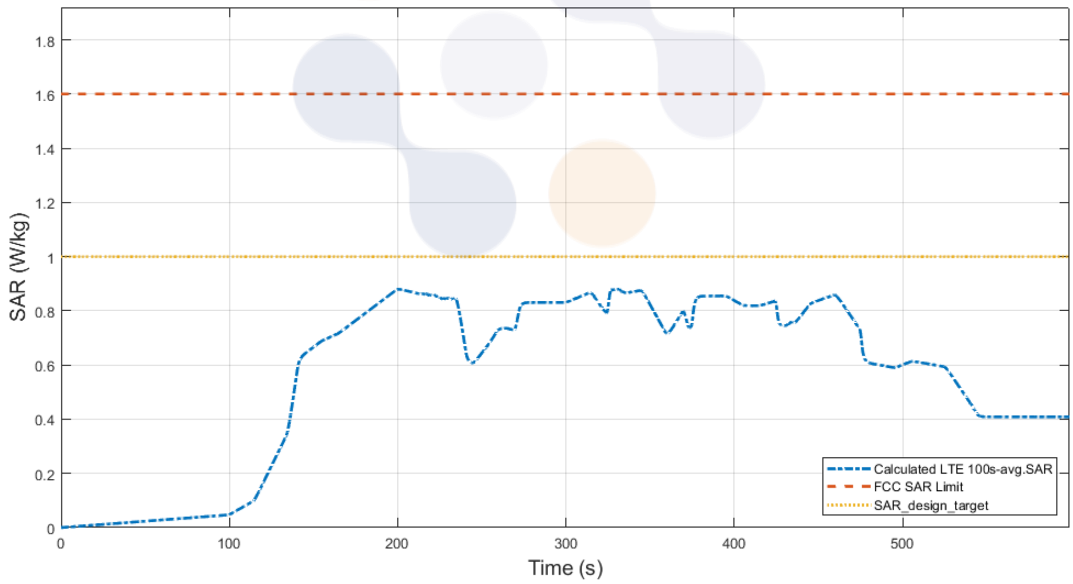
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC 1g SAR Limit [W/kg]	**1.6**	W/kg
Max 100s-time averaged 1g SAR (red curve)	**0.708**	W/kg
Device uncertainty	**1.0**	dB

Test result for test sequence 2:



Plot.1 shows the instantaneous and time-averaged Tx power with test sequence B.

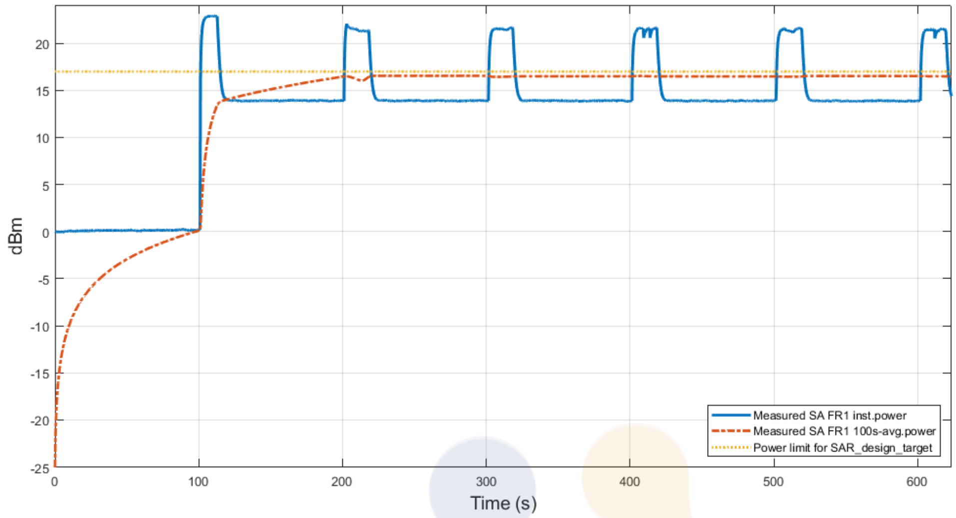


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

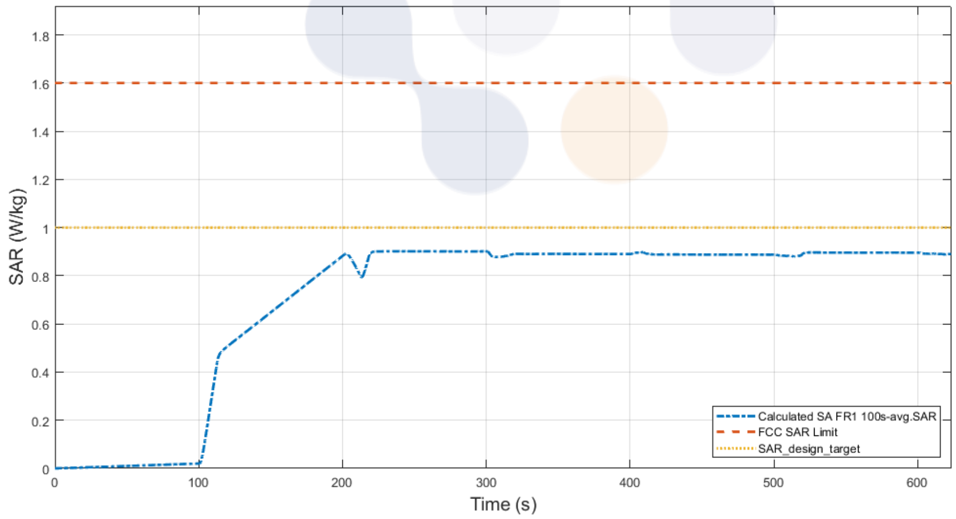
FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.880 W/kg
Device uncertainty	**1.0** dB

8.3.3 NR n5 (test case 2, 4 in Table 7-2)

Test result for test sequence 1:



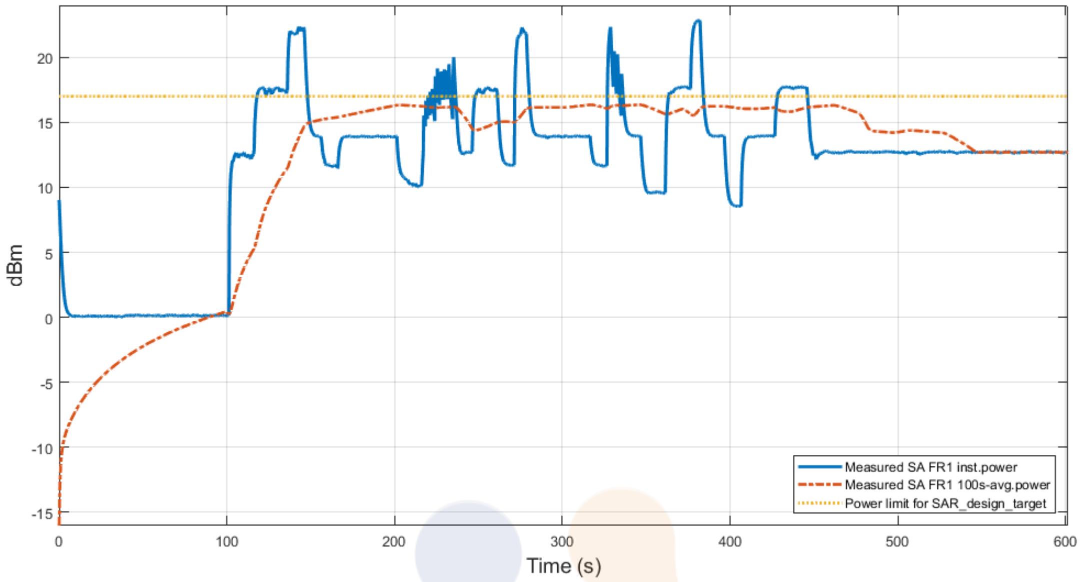
Plot.1 shows the conducted Tx power plot with calculated time-averaged power based on the measured instantaneous Tx power with 1gSAR FCC Limit value. As shown in Plot.1, it is confirmed for time average Tx power that the FCC limit was not exceeded, and that the averaged Tx power is smaller than the target power, and it will saturate to target power with little margin.



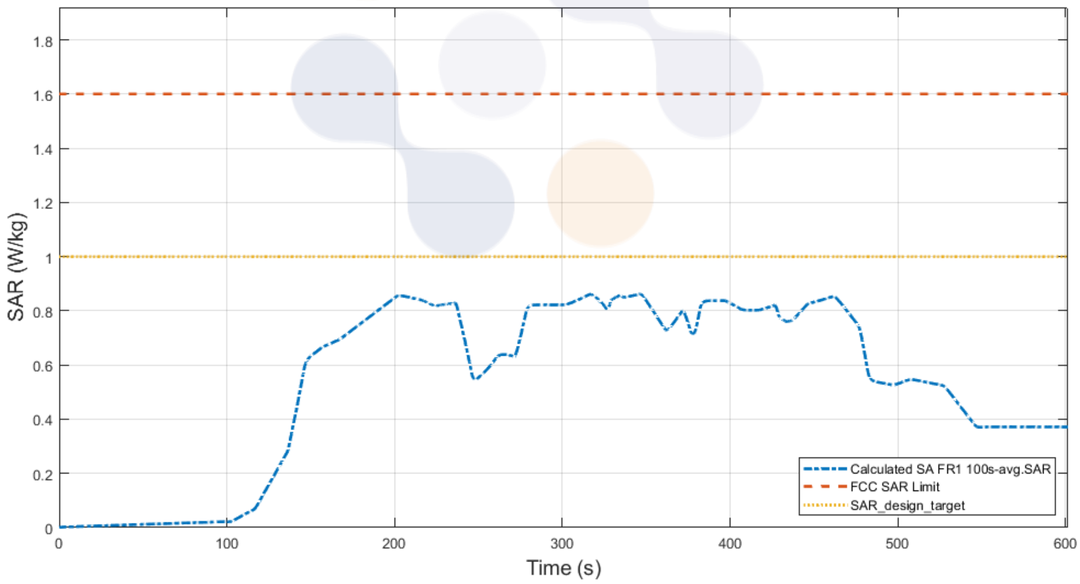
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.902 W/kg
Device uncertainty	**1.0** dB

Test result for test sequence 2:



Plot.1 shows the instantaneous and time-averaged Tx power with test sequence B.

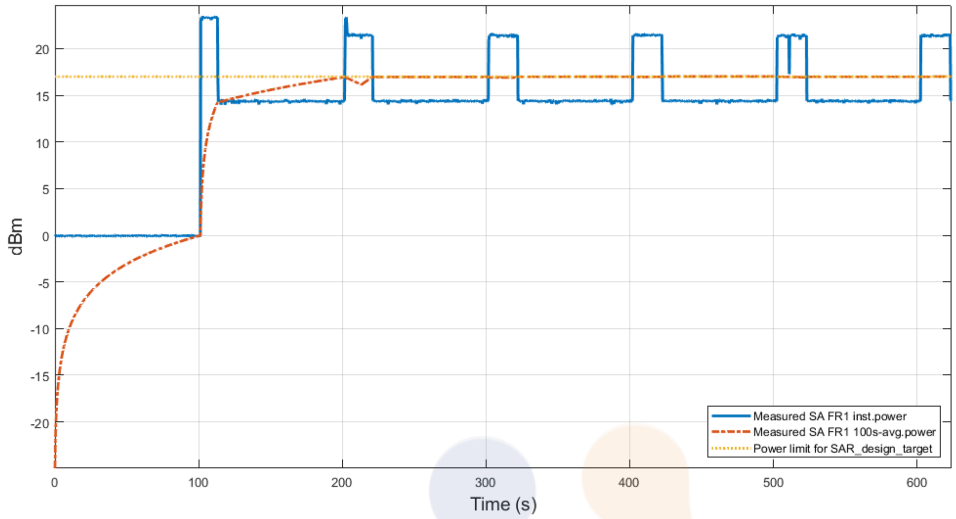


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

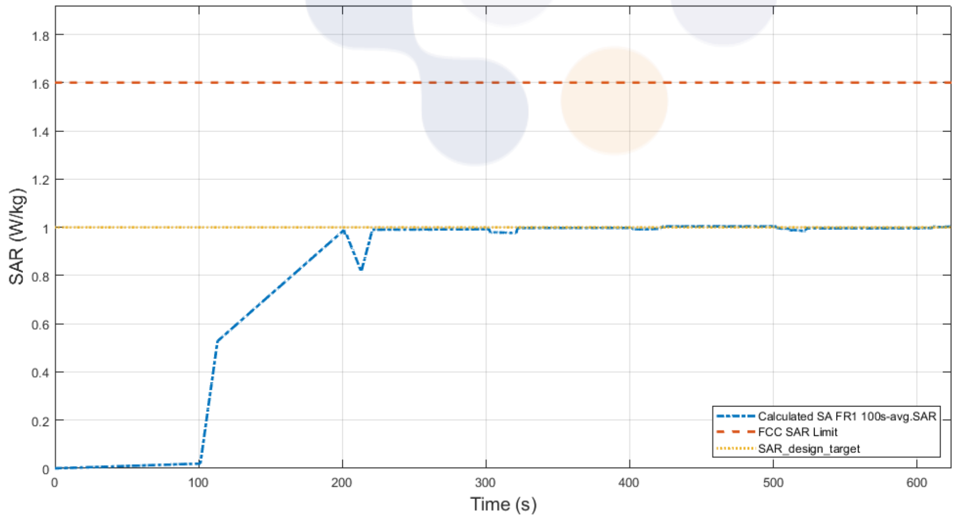
FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.862 W/kg
Device uncertainty	**1.0** dB

8.3.4 Sub6 NR n12 (test case 2, 4 in Table 7-2)

Test result for test sequence 1:



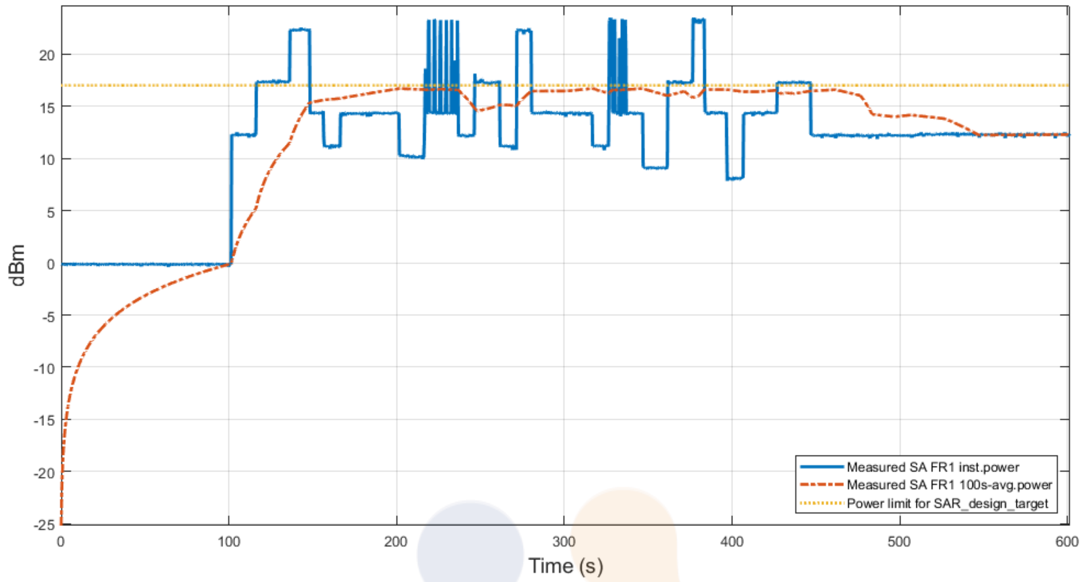
Plot.1 shows the conducted Tx power plot with calculated time-averaged power based on the measured instantaneous Tx power with 1gSAR FCC Limit value. As shown in Plot.1, it is confirmed for time average Tx power that the FCC limit was not exceeded, and that the averaged Tx power is smaller than the target power, and it will saturate to target power with little margin.



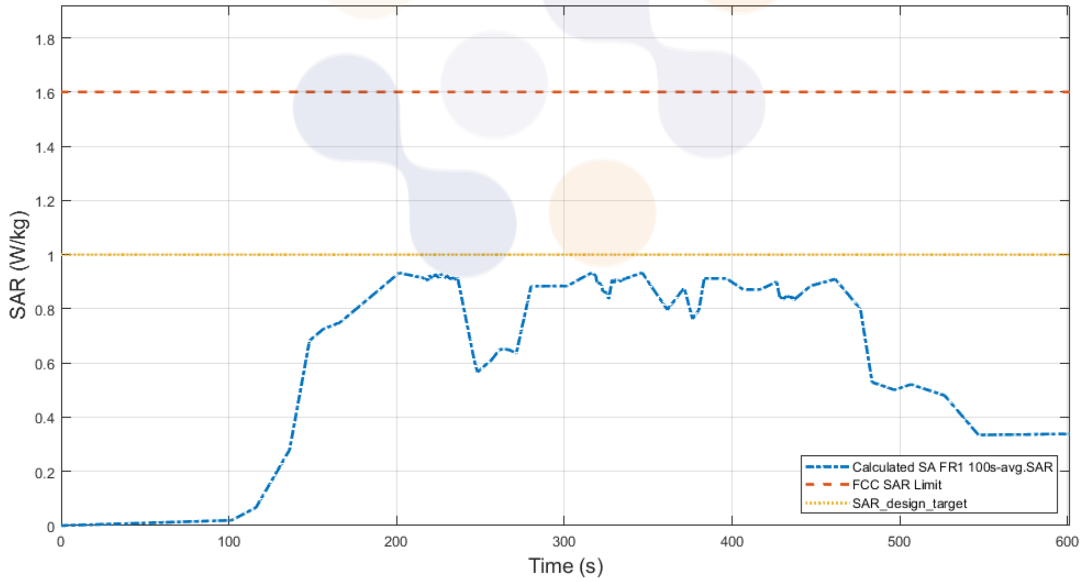
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.1004 W/kg
Device uncertainty	**1.0** dB

Test result for test sequence 2:



Plot.1 shows the instantaneous and time-averaged Tx power with test sequence B.



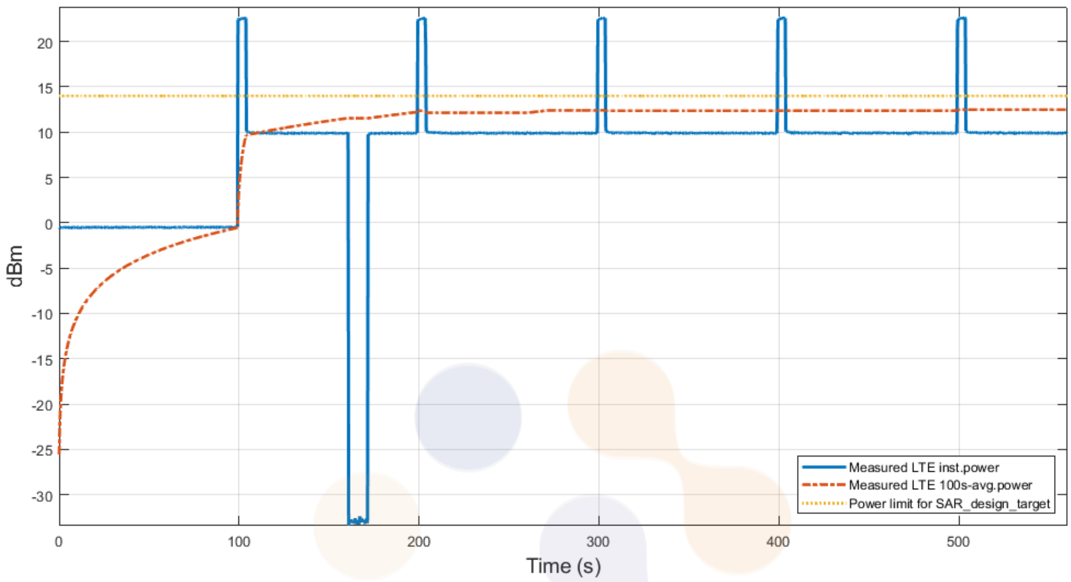
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.936 W/kg
Device uncertainty	**1.0** dB

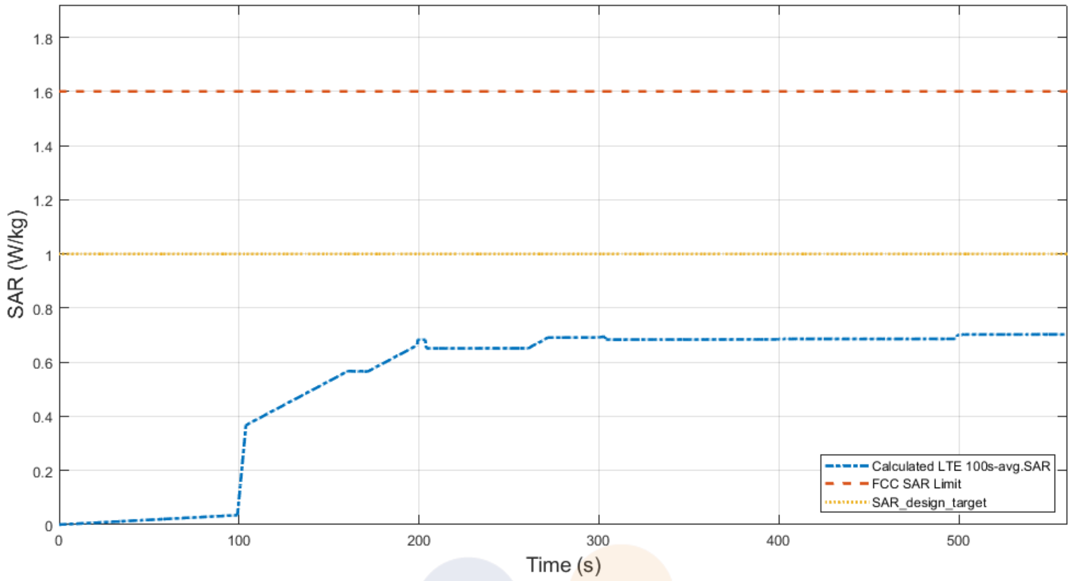
8.4 Change in Call Test results (test case 5 in Table 7-2)

This test was measured with LTE Band 30, RSI=1, the test results in this section are obtained following the procedure in Section 5. The test case corresponds to TC05 in Table 8-1.

Call drop test result:



Plot.1 shows the instantaneous and time-averaged Tx power for this test. The call disconnected around 160s and resumed after 10s. It is confirmed for time-average Tx power that the FCC limit was not exceeded, and that the averaged Tx power is lower than the value of Plimit.



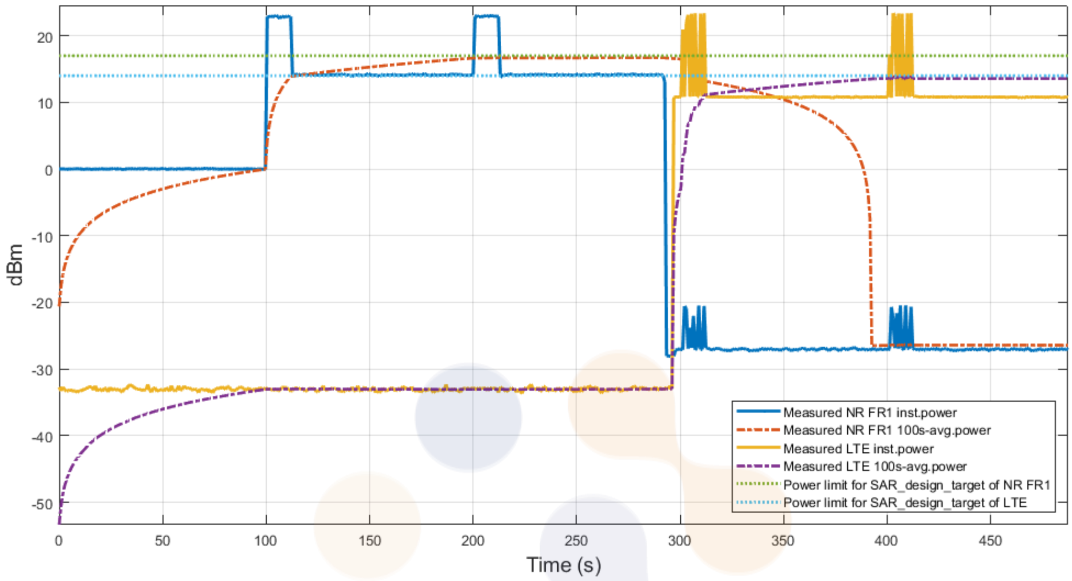
Plot.2 shows calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg. Looking at the results, it can be seen that even if transmission is stopped due to a call drop, the SAR value measured for a period of time window is stored in the window section and is continuously checked.

FCC 1g SAR Limit [W/kg]	1.6 W/kg
Max 100s-time averaged 1g SAR (green curve)	0.703 W/kg
Device uncertainty	**1.0** dB

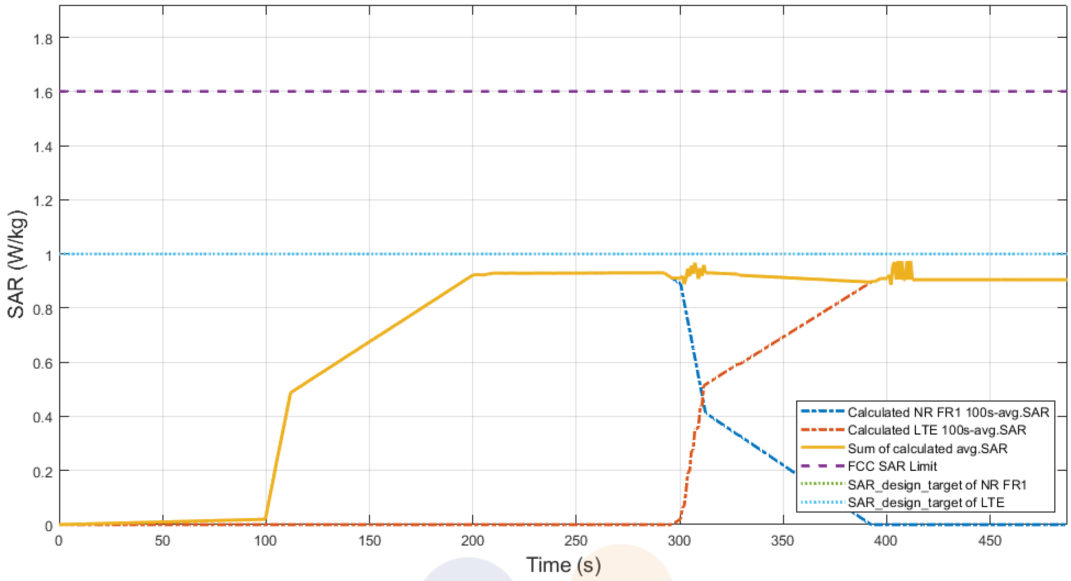
8.5 Re-selection in call (test case 6 in Table 7-2)

The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC06 in Table 8-1.

Test result for IRAT Re-selection in Call



Plot.1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band and NR FR1 Band for the duration of the test. Around time stamp of ~510s, a RAT re-selection from LTE Band to NR FR1 Band was executed, resulting in reduction of time-averaged power of LTE Band and simultaneous increase in time-averaged power of NR FR1 Band.



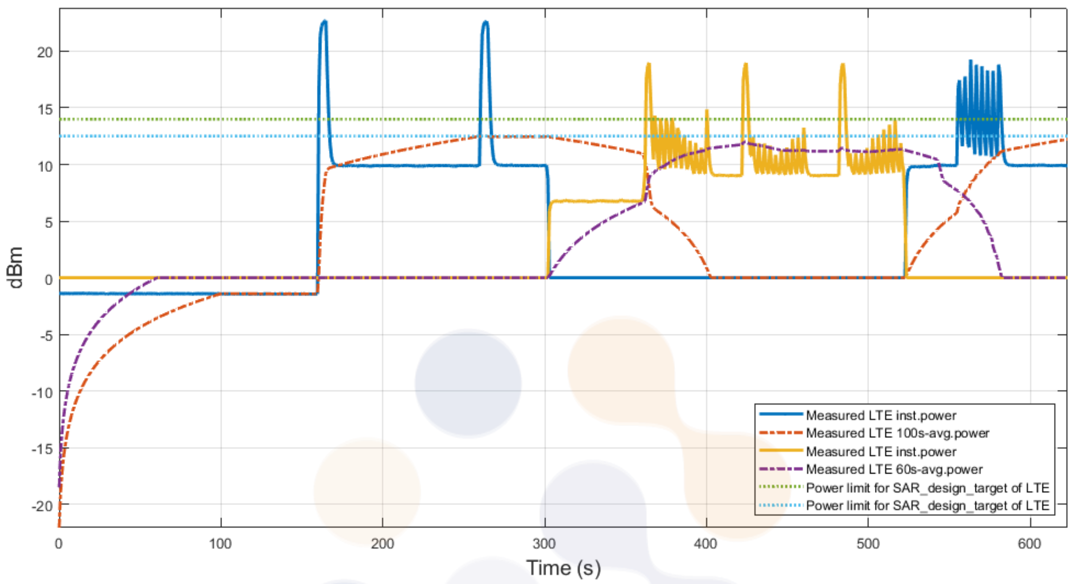
Plot.2 shows the time-averaged 1gSAR value for each of LTE Band and NR FR1 Band, as well as the total SAR value. We can see that the total 1gSAR exposure is well below the SAR Design Target of 1.0W/Kg, also always under the total FCC limit of 1.6W/Kg.

FCC normalized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.975 W/kg
Device uncertainty	**1.0** dB

8.6 Change in band/time-window (100s-60s-100s) test results (test case 7 in Table 7-2)

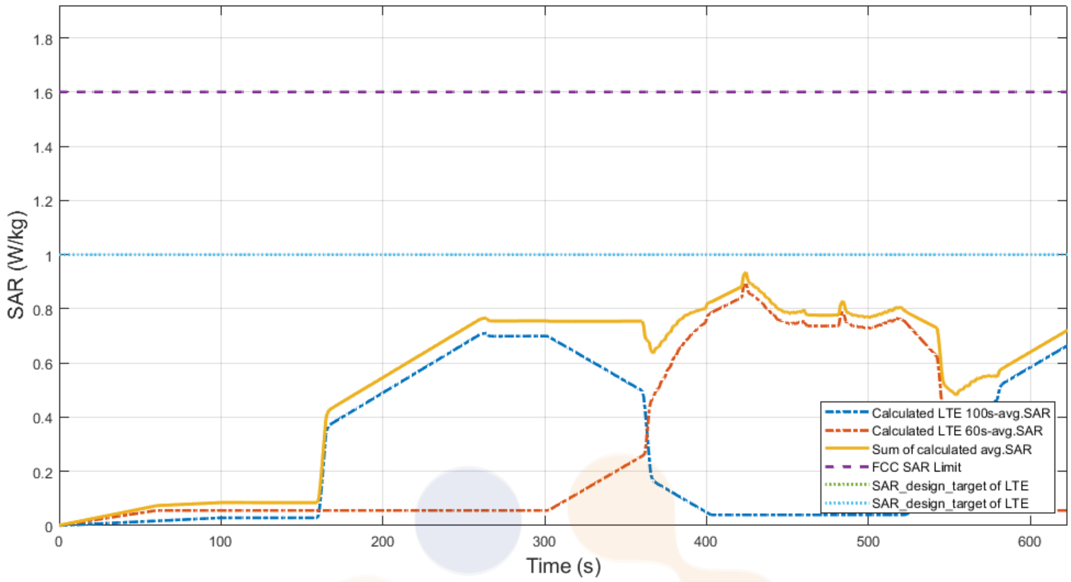
The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC07 in Table 8-1.

Test result for change in technology/band:



Plot.1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band 30 and Band 48 for the duration of the test. Around time stamp of ~300s, a handover from Band 30 to Band 48 was executed, resulting in reduction of time-averaged power of Band 66 and simultaneous increase in time-averaged power of Band 48. Around time stamp of ~500s, handover back to Band 30 was executed, resulting in reduction of time-averaged power of Band 48 and increase of time-averaged power of Band 30. It can be seen that transition time of time-averaged values for Band 66 is longer than Band 48, which is the consequence of 100s time averaging for Band 30 versus shorter 60s averaging for Band 48. Plot.2 shows the time-averaged 1gSAR value for each of Band 30 and Band 48, as well as the total SAR value. We can see that the total 1gSAR is higher during the band transitions, but is always under the total FCC limit of 1.6W/Kg.

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



FCC nomarlized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.935 W/kg
Device uncertainty	**1.0** dB

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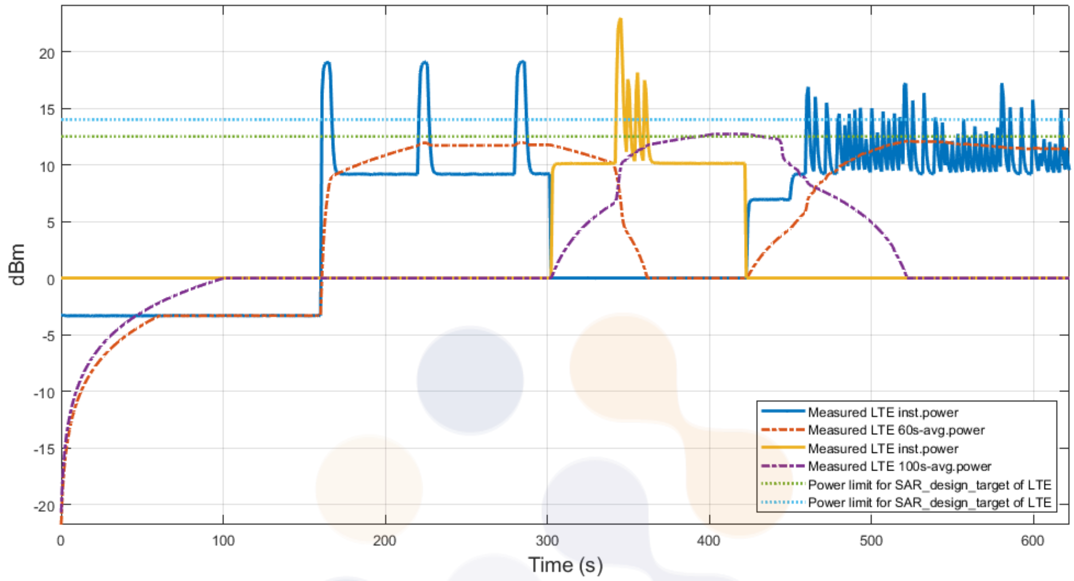
8.7 Change in band/time-window (60s-100s-60s) test results (test case 8 in Table 7-2)

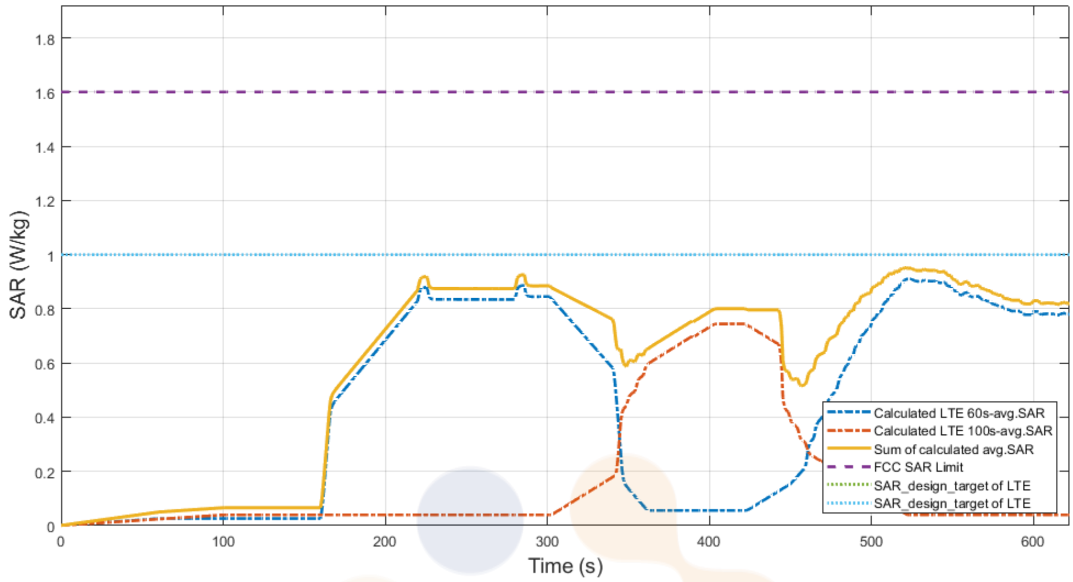
The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC08 in Table 8-1.

Test result for change in technology/band:



Plot.1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band 30 and Band 48 for the duration of the test. Around time stamp of ~300s, a handover from Band 48 to Band 30 was executed, resulting in reduction of time-averaged power of Band 48 and simultaneous increase in time-averaged power of Band 30. Around time stamp of ~420s, handover back to Band 48 was executed, resulting in reduction of time-averaged power of Band 30 and increase of time-averaged power of Band 48. It can be seen that transition time of time-averaged values for Band 30 is longer than Band 48, which is the consequence of 100s time averaging for Band 30 versus shorter 60s averaging for Band 48.

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



Plot.2 shows the time-averaged 1gSAR value for each of Band 66 and Band 48, as well as the total SAR value. We can see that the total 1gSAR is higher during the band transitions, but is always under the total FCC limit of 1.6W/Kg.

FCC nomarlized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.954 W/kg
Device uncertainty	**1.0** dB

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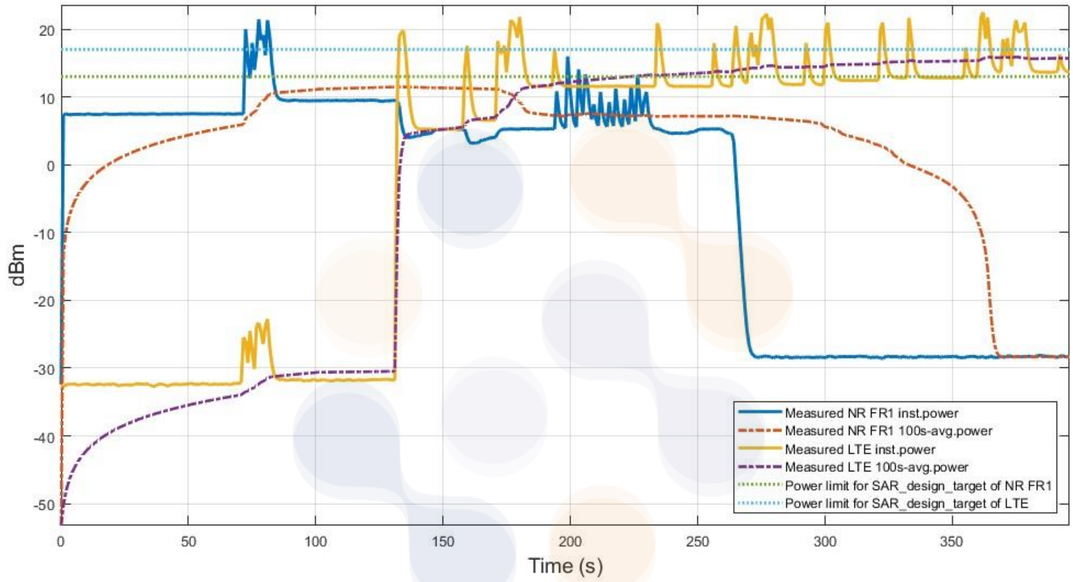
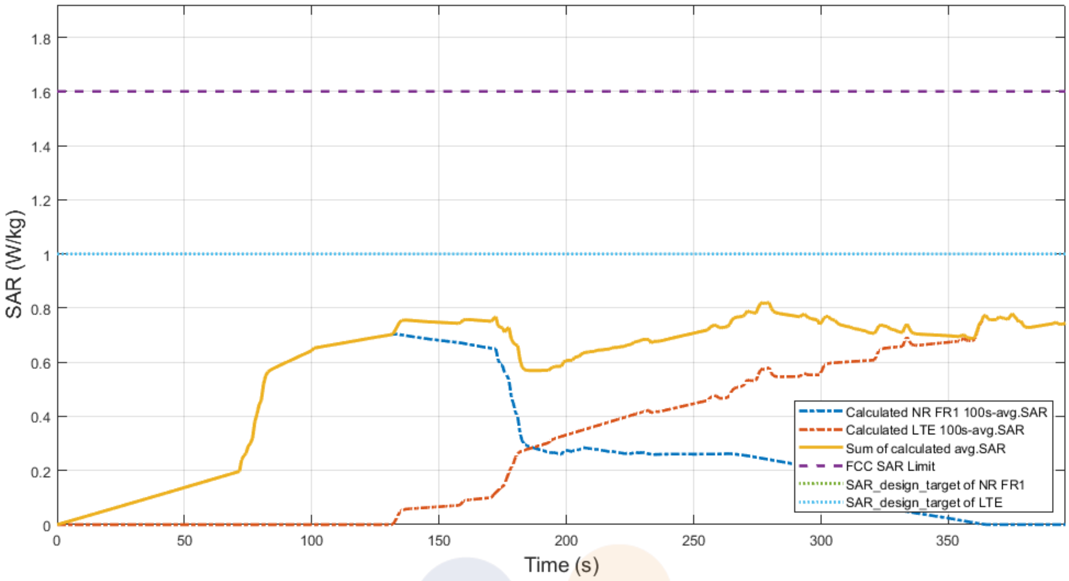
8.8 Switch in SAR exposure test results (test case 9 in Table 7-2)

The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC09 in Table 8-1.

In this LTE+FR1 NSA scenario, we first establish LTE and NR call. In the first part of test, LTE is sent to lowest transmit power using "ALL DOWN" power control commands from call box while NR is sent to maximum power using "ALL UP" power control commands from call box. This would correspond to FR1 dominant SAR scenario and lasts about 220s. In the second part of test, LTE is sent "ALL UP" commands and transmissions are continued, resulting in LTE+FR1 SAR scenario lasting another 110s. In the third part of test, NR is sent "ALL DOWN" power control commands so that it becomes an FR1 dominant SAR scenario for 110s. Finally, both LTE and NR connections are released.



Plot.1 shows the instantaneous and time-averaged Tx power for both LTE band and NR FR1 band versus time. When both LTE and FR1 operate, the SAR value was the highest instantaneously, but it can be seen that sum of average power in LTE and FR1 decreases again as soon as it is turned off. Plot.2 shows the computed time-averaged SAR value for LTE and FR1 as well as the sum. It was confirmed that algorithm operated under the total SAR design target limit of 1.2W/Kg, while also being under the FCC limit of 1.6W/Kg at all times. After the operation of FR1 is turned off, it can also be seen that the average power of LTE increases.



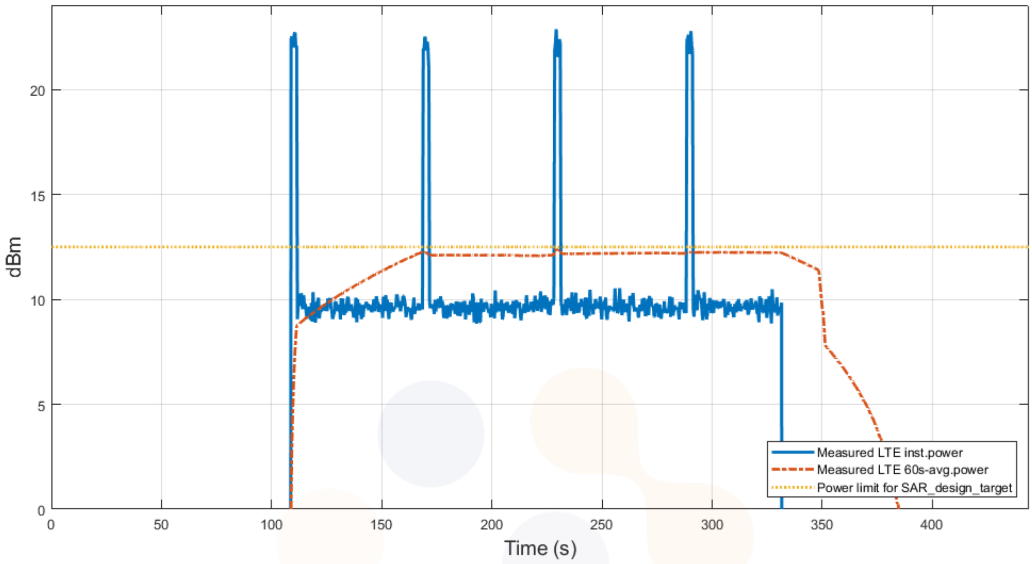
Plot.2 shows the computed time-averaged SAR value for LTE and FR1 as well as the sum. It was confirmed that algorithm operated under the total SAR design target limit of 1.2W/Kg, while also being under the FCC limit of 1.6W/Kg at all times. After the operation of FR1 is turned off, it can also be seen that the average power of LTE increases.

FCC normalized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.821 W/kg
Device uncertainty	**1.0** dB

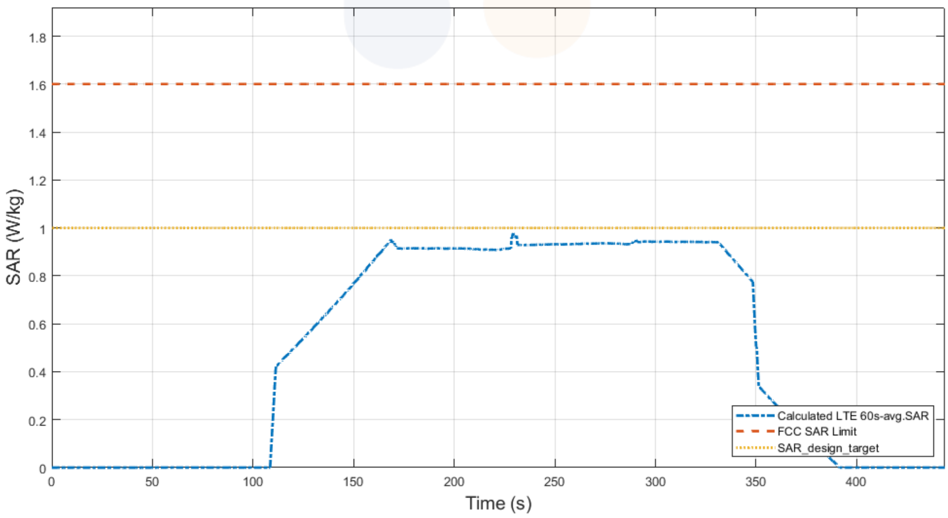
8.9 LTE UL CA test results (test case 10 in Table 7-2)

The test results in this section are obtained following the procedure in Section 6. The test cases correspond to TC10 in Table 8-1.

Test result for LTE UL CA :



Plot.1 shows the instantaneous and time-averaged conducted Tx power for LTE Band 48 for the duration of the test. Around time stamp of ~100s, start a single CC is transmitted, and after 540s, an intra-band CA is configured and transmitted. As shown in Figure, the total power of the two CC is kept almost the same as in the single CC transmission. Average power in Figure assures the compliance of the average power of the transmitted signal which is below 12.5 dBm and consequently the average SAR in Figure is below 1W/kg which is below the FCC limit of 1.6W/kg.

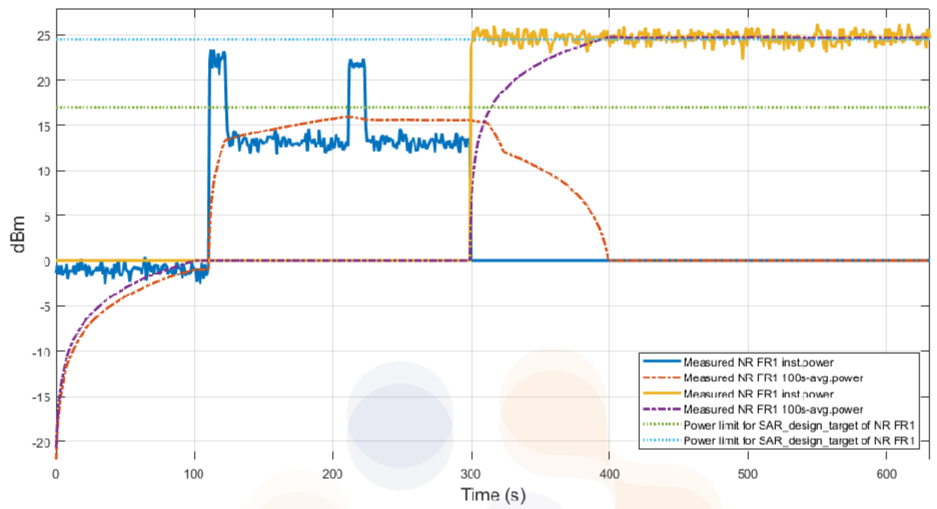


Plot.2 shows the time-averaged 1gSAR value for LTE Band 48 UL CA, as well as the total SAR value. We can see that the total 1gSAR exposure is well below the SAR Design Target of 1.0W/Kg, also always under the total FCC limit of 1.6W/Kg.

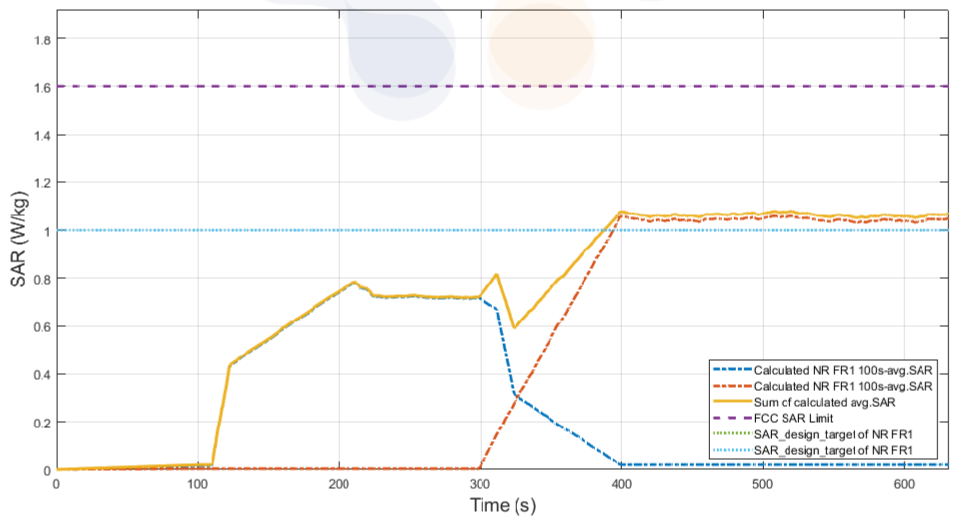
FCC normalized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.978 W/kg
Device uncertainty	**1.0** dB

8.10 Change in RSI (test case 13 in Table 7-2)

The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC13 in Table 8-1.



Plot.1 shows the instantaneous and time-averaged Tx power for both SA NR FR1 band n12 for the duration of the test. Around time stamp of ~310s, the RSI value is changed from RSI=0 to RSI=1, resulting in reduction of target time-averaged power of SAR FR1 Band n12. It can be seen that Plimit value of RSI=0 is lower than that of RSI=1, so in RSI=1 region, more Tx power is limited compared to RSI=1 region. Shows the time-averaged 1g SAR value for each of RSI value, as well as the total SAR value. We can see that the total 1g SAR is higher during the band transitions but is always under the total FCC limit of 1.6 W/kg.



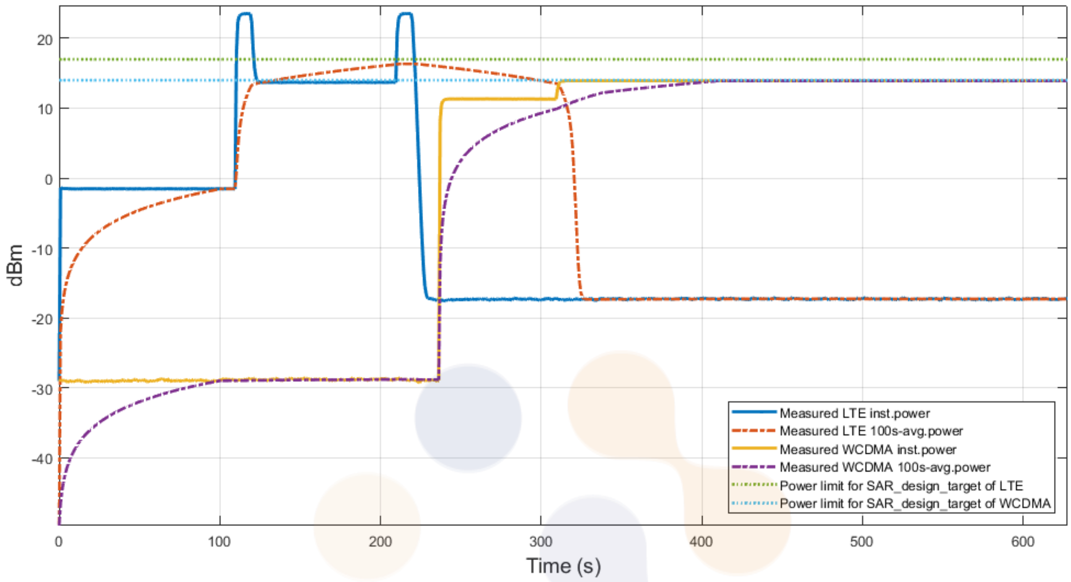
Plot.2 shows the computed time-averaged SAR value fir each of RSI values, as well as the total SAR value. We can see that the total 1g SAR is higher during the band transitions, but is always under the total FCC limit of 1.6 W.kg

FCC normalized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	1.080 W/kg
Device uncertainty	**1.0** dB

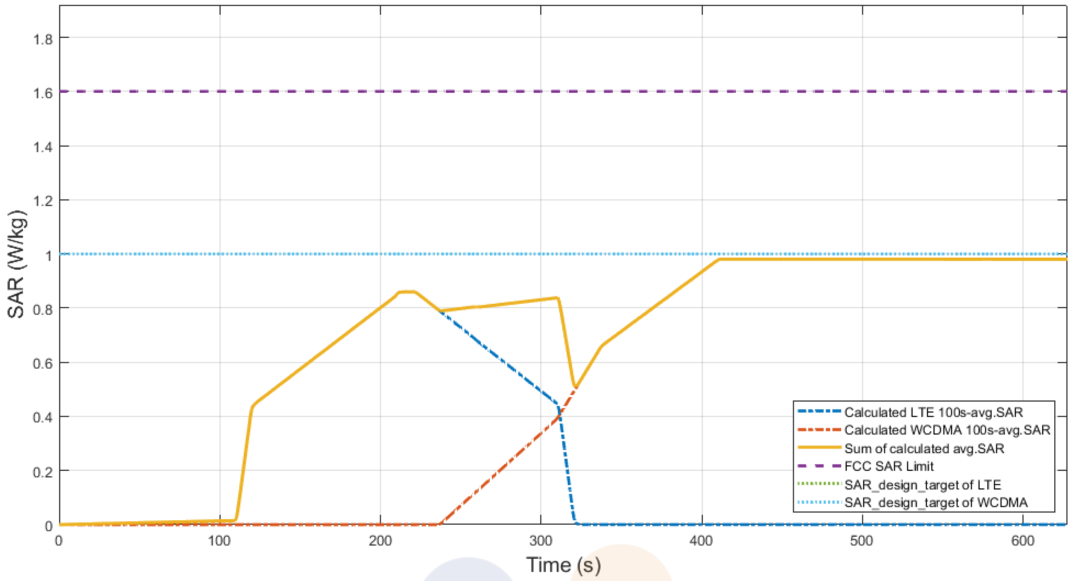
8.11 Non-TAS Handover (test case 14 in Table 7-2)

The test results in this section are obtained following the procedure in Section 5. The test cases correspond to TC13 in Table 8-1.

Test result for TAS to Non-TAS:



Plot.1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band and WCDMA Band for the duration of the test. Around time stamp of ~220s, a handover from LTE Band to WCDMA Band was executed, resulting in reduction of time-averaged power of LTE Band and simultaneous increase in time averaged power of WCDMA Band. Because WCDMA is non-TAS RAT, it always transmits maximum power. But when remaining SAR value is low after handover, non-TAS would limit the Tx power for a second to satisfy SAR Compliance.



Plot.2 shows the time-averaged 1gSAR value for each of LTE Band and WCDMA Band, as well as the total SAR value. We can see that the total 1gSAR is higher during the band transitions, but is always under the total FCC limit of 1.6W/Kg.

FCC normalized SAR Limit [W/kg]	1.0 W/kg
Max Norm. Total time-avg. 1g SAR (green curve)	0.981 W/kg
Device uncertainty	**1.0** dB

9. Equipment list

Equipment	Model	Serial Number	Calibration Date	Calibration Due
Power Meter	ML2438A	2323004	2023-07-04	2024-07-04
Power Sensor	MA2472D	2014492	2023-07-04	2024-07-04
Power Sensor	MA2472D	2014493	2023-07-04	2024-07-04
Low Pass Filter	NLP-1000+	VUU79701846	2023-04-26	2024-04-26
High Pass Filter	WHKX3.0/18G-12SS	44	2023-01-19	2024-01-19
High Pass Filter	WHKX1.0/15G-10SS	14	2023-01-19	2024-01-19
Dual Directional Coupler	CS10-19-436/19	2243-1	2022-12-14	2023-12-14
Dual Directional Coupler	CS10-19-436/19	2243-2	2022-12-14	2023-12-14
Radio Communication Analyzer	MT8821C	6262170371	2023-11-01	2024-11-01
Radio Communication Test Station	MT8000A	6261987911	2023-08-07	2024-08-07

Notes:
1. Each equipment item is used solely within its respective calibration period.

10. Conclusion

Samsung Time-Averaging SAR (TAS) feature employed in A has been validated through conducted power measurement as well as SAR measurement.
As demonstrated in this report, TAS feature limit the transmit power effectively and shows that SAR value does not exceed 1.6 W/Kg for all the transmission scenarios.

10.1 Measurement Conclusion

The SAR evaluation indicates that the DUT complies with the RF radiation exposure limits of the FCC and Innovation, Science, and Economic Development Canada, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

Appendix A. Test Sequences

1. Test sequence is generated based on below parameters of the EUT:

   a. Measured maximum power (P_{max})
   b. Measured Tx_power (P_{limit}) to satisfy SAR Compliance
   c. Setup time to make SAR Remaining be full
   d. Do test according to test sequence

2. Test Sequence A Waveform:

   Based on the parameters above, the Test Sequence A is generated with two power levels. One is maximum power level and the other is lower power level. The lower power level is defined as 3dB lower value than maximum power level. At first, maximum power level is applied for 120 seconds (SAR_time_window x 1.2). After then, lower power level is used until this test is finished.

3. Test Sequence B Waveform:
   Based on the parameters above, the Test Type B is generated with pre-defined power levels, which is described in Table A.3.1

Time duration (second)	Power level (dB)
15	P_{limit} - 5
20	P_{limit}
20	P_{limit}+ 5
10	P_{limit}- 6
20	P_{max}
15	P_{limit}
15	P_{limit} -7
20	P_{max}
10	P_{limit} - 5
15	P_{limit}
10	P_{limit} – 6
20	P_{limit} + 5
10	P_{limit} - 4
15	P_{limit}
10	P_{limit} - 6
20	P_{max}
15	P_{limit} - 8
15	P_{limit}
20	P_{max}
10	P_{limit} - 9
20	P_{limit} + 5
20	P_{limit}
15	P_{limit} - 5

Table A.3.1 - Test Sequence B Waveform

End of test report