FCC 47 CFR § 2.1093
RF EXPOSURE EVALUATION REPORT
(TAS validation Report)

FOR

GSM/WCDMA/LTE/5G NR Tablet + BT/BLE, DTS/UNII a/b/g/n/ac/ax and Digitizer

MODEL NUMBER: SM-X626B

FCC ID: A3LSMX626B

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TL-637

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V1	2025-02-10	Initial Issue	-

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Attestation of Test Results

Applicant Name	SAMSUNG ELECTRONICS CO.,LTD.
FCC ID	A3LSMX626B
Model Number	SM-X626B
Applicable Standards	FCC 47 CFR § 2.1093
Date Tested	2025-01-13 to 2025-02-10
Test Results	Pass

UL Korea, Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Korea, Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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Approved & Released By:	Prepared By:
	
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1. Introduction

The equipment under test (EUT) is SM-X626B(FCC ID : A3LSMX626B), It contains S.LSI chipset supporting 2G/3G/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. The TAS algorithm validated through S.LSI document Version 3.3. The document's information, please refer to Section.B in this report.

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

6. During Spatial TAS operation – to prove that TAS feature functions correctly to meet compliance limit during Spatial TAS operation.

As described in linearity analysis in SAR characterization report, the RF exposure is proportional to the Tx power for both FR1(2G/3G/4G/5G 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 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.

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

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 $LSAR$.

- For FR1 transmissions only:

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

3. SAR Time Averaging Validation Test Procedures

In this section, we cover the test plan and test procedure for validating Samsung S.LSI TAS feature for FR1(2G/3G/4G/5G NR Sub6) scenarios.

3.1. 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 which is generated with one or two levels where one of the level is maximum power level (Pmax) which is applied at least for 100s. Based on the second level this test sequence is sub-categorized into four different sequence used.

    a. Test Sequence A.i where after Pmax, a second level of Plimit is requested till the end of the test
    b. Test Sequence A.ii where after Pmax, a second level of Pmax-3dB is requested till the end of the test
    c. Test Sequence A.iii where after Pmax, a second level of Plimit-3dB is requested till the end of the test
    d. Test Sequence A.iv where only Pmax is requested till the end of the test

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

3.2. Test configuration selection criteria for validating TAS

This section provides general guidance for selecting test cases in TAS feature validation. Modifications of the test cases are possible to study other specific scenarios.

3.2.1 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.

3.2.2 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. 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.

3.2.3 Test configuration 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 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.

3.2.4 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.

3.2.5 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.

3.2.6 Test configuration for TAS to non TAS Handover

This test scenario is similar section 3.2.3. 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.

3.2.7 Test configuration for Uplink CA

The criteria for selecting this test case is to demonstrate the compliance of the TAS algorithm when an LTE transmission is done over multiple CC. This test shows that the TAS algorithm compliance is independent on the Transmission scenarios (single CC or CA).

3.2.8 Test configuration for Spatial TAS

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.

3.3 Test procedures for conducted power measurements

This section provides general conducted power measurement procedures to perform compliance test under dynamic scenarios described in Section 2.

3.3.1 Time-varying Tx power transmission scenario

This test is performed with two pre-defined test sequences as described in Section 3.1 for all technologies operating on sub-6GHz applying to FR1 as selected in Section 3.2.1. The purpose of the test is to demonstrate the maximum power limiting enforcement and that the time-averaged SAR 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.

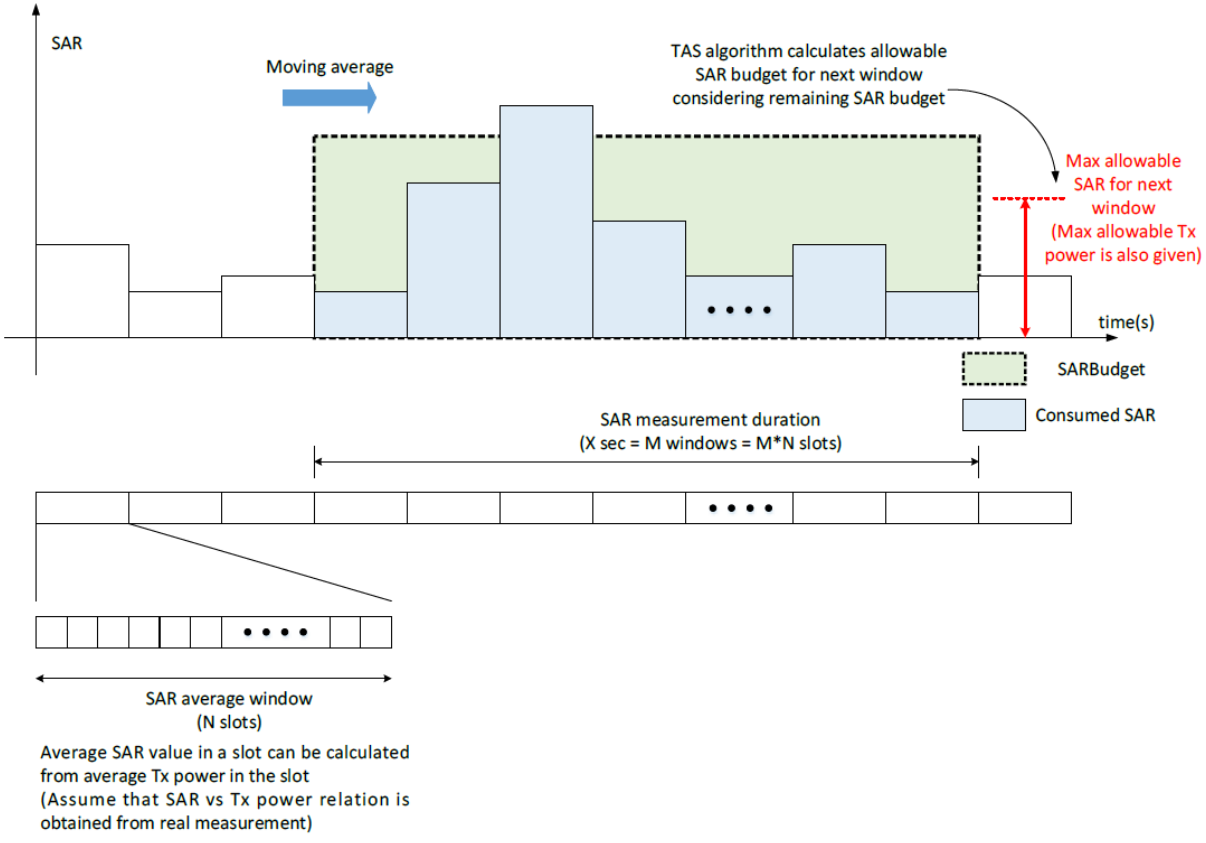


Figure 3.3-1 SAR measurement from Tx power using block-wise processing

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.

3.3.2 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.

3.3.3 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.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1 \quad \text{(equation : 3.3.3.1)}$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2 \quad \text{(equation : 3.3.3.2)}$$

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 handover between two TAS RATs :

1. Establish radio connection of DUT with call box e.g.using 5G FR1 NR technology
2. Configure call box to set DUT Tx power to a low value of 0dBm for 100s.
3. Configure call box to send “ALL UP” power control commands and continue NR transmission from DUT so that maximum power of Pmax is achieved. Continue transmission at the maximum power for at least 210s.
4. Change RAT from NR to LTE, and configure call box to send “ALL UP” power control commands in LTE.
5. Continue call in LTE at maximum power for 200s.
6. Release LTE connection
7. After the completion of the test, prepare one plot with the following information for each RAT (a) Instantaneous Tx power versus time (b) Time-averaged power for each RAT according to their averaging duration and (c) Plimit corresponding to each RAT
8. Make a second plot containing the following information (a) Computed time-averaged 1gSAR versus time for each RAT (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 RAT change occurs in-between.

3.3.4 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.

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 1st 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 2nd Plimit 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.

3.3.5 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 220s.
5. Finally, both LTE and NR connections are released.

3.3.6 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.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1 \quad \text{(equation : 3.3.3.1)}$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2 \quad \text{(equation : 3.3.3.2)}$$

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 120s.
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 400s.
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.

3.3.7 LTE Uplink CA

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

Test procedure for uplink CA :

1. Establish LTE connection of DUT with call box over Cell1 e.g. one cell of intra band-contiguous LTE CC.
2. Configure call box to send “ALL down” power control commands and continue this stage for about 110s.
3. Configure call box to send “ALL UP” command for transmission on cell 1 and continue transmission for 110s.
4. Establish LTE connection of DUT with call box over Cell 2 E.g. other cell of intra band-contiguous LTE CC.
5. Configure Call box to send “ALL UP” command for transmission on cell 2 and continue transmission for 110s.
6. Release LTE connection for both cells.

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 LTE uplink CA is operated during the test.

3.3.8 Spatial TAS

For the test cases with spatial TAS, we will consider all antennas with antenna groups where each antenna group consist of one antenna and one antenna and one/multiple bands.

Test procedure for LTE Antenna switching with spatial TAS :

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 for 240s.
4. Change the band from LTE Band A to LTE Band B so that the transmitting antenna changes and continue transmission for 140s (below 3Ghz) / 90s (above 3GHz).
5. Change the band from LTE Band B to LTE Band A so that the transmitting antenna changes and continue transmission till the end of the test.
6. Release LTE connection.

Test procedure for SA FR1 Antenna switching with spatial TAS :

1. Establish radio connection of DUT with call box e.g. using NR technology
2. Configure call box to set DUT Tx power to a low value of -10dBm for 140s.
3. Configure call box to send “ALL UP” power control commands and continue NR transmission from DUT so that maximum power of Pmax is achieved for 140s.
4. Change the band from NR Band A to NR Band B so that the transmitting antenna changes and continue transmission for 140s.
5. Change the band from NR Band B to NR Band A so that the transmitting antenna changes and continue transmission till the end of the test.
6. Release NR connection.

Test procedure for NSA with spatial TAS :

1. Establish LTE and NR radio connection in NSA case with both call boxes.
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 160s.
3. Configure 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 140s.
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 140s.
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.

Test procedure for NSA antenna switching with spatial TAS :

1. Establish LTE and NR radio connection in NSA case with both call boxes.
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 LTE call box to send “ALL UP” power control commands for LTE and configure the NR call box to send “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 NR Band to other band so that NR transmitting antenna is switched to other antenna and continue transmission 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 till the end of the test.
7. Finally, both LTE and NR connections are released.

4. Test Configurations

4.1 Test case list for sub-6GHz transmissions

To validate TAS algorithm in various sub-6GHz conditions, the chosen TC (Test Case) list is defined as in Table 4.1.1.

Table 4.1.1 Sub-6GHz TAS validation test case list

No.	Test Scenarios	Test cases	Test configurations	TAS Test (Y/N)
F_TC 01	Time-varying Tx Power transmission	LTE_Time_Varying_Tx_Power_Case_1	Selected LTE Band, Test Seq.A.i	**Y**
F_TC 02		SA_FR1_Time_Varying_Tx_Power_Case_1	Selected NR Band, Test Seq.A.ii	**Y**
F_TC 03		LTE_Time_Varying_Tx_Power_Case_2	Selected LTE Band, Test Seq.B	**Y**
F_TC 04		SA_FR1_Time_Varying_Tx_Power_Case_2	Selected NR Band, Test Seq.B	**Y**
F_TC 05	Change in call	LTE_Call_Disconnect_Reestablishment	Selected LTE Band	**Y**
F_TC 06	Re-selection in call	SA_FR1_to_LTE_RAT_Re-selection	Selected LTE Band and NR Band	N
F_TC 07	Change in band / time window	LTE_Averaging_Time_Window_Change	Switched LTE Band A(100s) to LTE Band B (60s)	N
F_TC 08		LTE_Averaging_Time_Window_Change 2	Switched LTE Band B(60s) to LTE Band A(100s)	N
F_TC 09	SAR exposure switch	NSA_FR1_Dominant_Power_Switching	Selected LTE Band and NR Band	N
F_TC 13	Change in RSI	LTE_RF_SAR_Index_Change	Selected NR Band	**Y**
F_TC 14	TAS to nonTAS H.O.	LTE_to_WCDMA_Hand Over	Selected LTE Band and WCDMA Band	N
F_TC 15	LTE UL CA	LTE_UL_CA	LTE UL CA Band	N
F_TC 16	FR1 UL MIMO	SA_FR1_UL_MIMO	Selected UL MIMO NR Band in same antenna group	N
F_TC 19	WCDMA Time-varying Tx Power transmission	WCDMA_Time_Varying_Tx_Power_Case_1	Selected WCDMA Band, Test Seq.A.iii	N
F_TC 20		WCDMA_Time_Varying_Tx_Power_Case_2	Selected WCDMA Band, Test Seq.B	N
F_TC 21	2G(GSM) Time-varying Tx Power transmission	GSM_Time_Varying_Tx_Power_Case_1	Selected GSM Band, Test Seq.A.iv	N
F_TC 22		GSM_Time_Varying_Tx_Power_Case_2	Selected GSM Band, Test Seq.B	N
F_TC 23	Antenna Switching with Spatial TAS	LTE_Ant_switching_Spatial_TAS	Selected LTE Band	N
F_TC 24		NR_Ant_switching_Spatial_TAS	Selected NR Band	**Y**
F_TC 25	NSA with Spatial TAS	NSA_Spatial_TAS	Selected NSA configuration	N
F_TC 26	NSA antenna switching with Spatial TAS	NSA_Ant_switching_Spatial_TAS	Selected NSA configuration (same LTE anchor)	**Y**
F_TC 27	FR1 UL MIMO with Spatial TAS	SA_FR1_UL_MIMO_Spatial_TAS	Selected UL MIMO NR Band in different antenna group	N
F_TC 28	FR1 inter-band ULCA with spatial TAS disabled	SA_FR1_ULCA_Spatial TAS disabled	Selected ULCA NR Band with Spatial TAS diabled	N
F_TC 29	FR1 inter-band ULCA with spatial TAS	SA_FR1_ULCA_Spatial TAS	Selected ULCA NR Band with Spatial TAS	N
F_TC 30	Re-selection in call (60s averaging for all bands)	SA_FR1_to_LTE_RAT_Re-selection	Selected LTE Band and NR Band	**Y**
F_TC 31	SAR exposure switch (60s averaging for all bands)	NSA_FR1_Dominant_Power_Switching	Selected LTE Band and NR Band	**Y**
F_TC 32	Time varying Tx power (60s averaging for all bands)	WCDMA_Time_Varying_Tx_Power_Case_1	Selected WCDMA Band, Test Seq.A.iii	**Y**
F_TC 33		GSM_Time_Varying_Tx_Power_Case_1	Selected GSM Band, Test Seq.A.iv	**Y**
F_TC 34	NSA with Spatial TAS (60s averaging for all bands)	NSA_Spatial_TAS	Selected NSA configuration	**Y**

Note(s):

1. TAS validation test cases were determined based on provide techs by the DUT.

2. Since all technologies are implemented with the TAS algorithm that performs 60-second time averaging regardless of the frequency range, TAS validation TC are replaced from TC_6, 9, 19, 20, 21, 22, 25 to TC_30, 31, 32, 33, 34 due to 60-second time averaging.
3. If TAS algorithm operates 60s averaging for all bands, then WCDMA and GSM time-varying test are performed for only Seq.A according to TAS validation guide.
4. All techs were implemented by the manufacturer with TAS algorithm that perform 60s time-averaging regardless of frequency ranges. Therefore, Time averaging window change test is not required due to this device has a time window of 60s across all bands.

5. Conducted Power Test Results for Sub-6 TAS validation

5.1. Measurement set-up

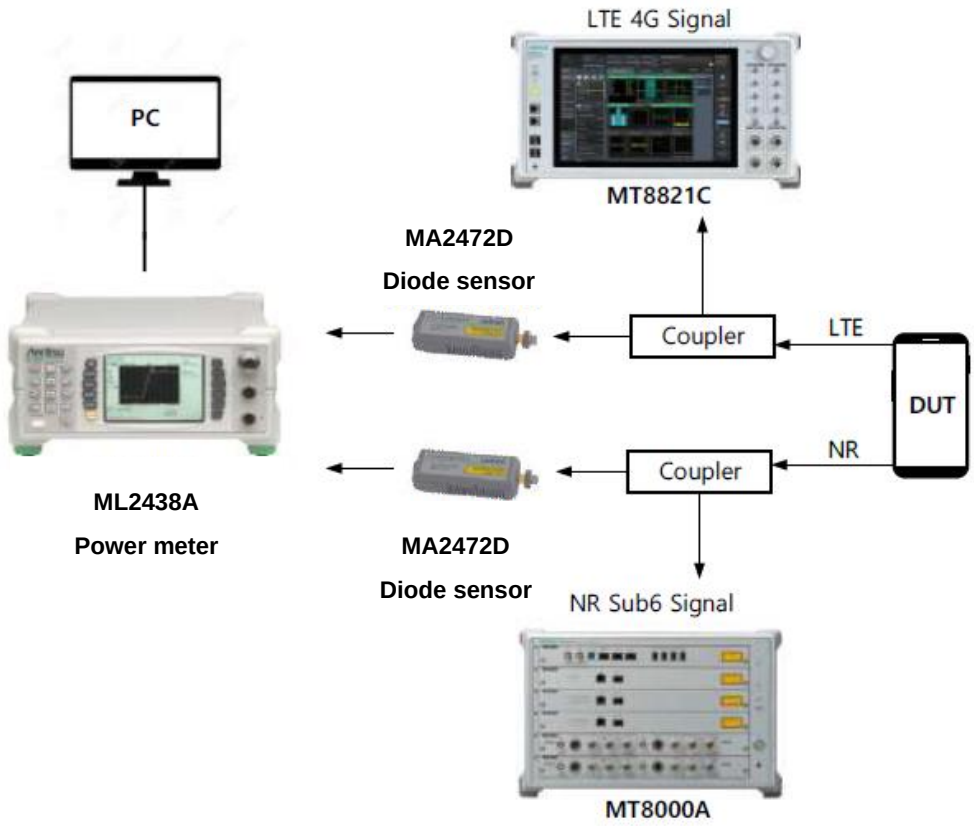


Figure 5.1-1 Test set-up for legacy and sub 6GHz

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 postprocessing 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.

5.2. P_{limit} and P_{max} measurement results

The measured $Plimit$ for all the selected radio configurations are listed in Table 5.2.1. $Pmax$ was also measured for radio configurations selected for testing time-varying Tx power transmission scenario in order to generate test sequences following the test procedures. Note that Table 5.2.1 is not actual Plimit corresponding to 1.0W/kg (1g SAR), but our measured averaged power when forcing Plimit in our SW.

Table 5.2.1 Measured P_{limit} and P_{max} of selected radio configurations

TC #	Test Scenarios	Tech	Band	Ant.	RSI	RB/offset	Mode	Detail	Plimit setting (dBm)	Pmax setting (dBm)	Measured Plimit (dBm)	Measured Pmax (dBm)
F_TC_ 01	Time varying (Seq.A i)	LTE	B12	Main.1	Grip	1/0/10 MHz	QPSK	1g/0mm/Standalone_Back	19.0	19.04	24.0	24.58
F_TC_ 03	Time varying (Seq.B)			Main.1	Grip	1/0/10 MHz	QPSK	1g/0mm/Standalone_Back	19.0	19.04	24.0	24.58
F_TC_ 01	Time varying (Seq.A i)		B41	Main.1	Grip	1/0/20 MHz	QPSK	1g/0mm/Standalone_Back	13.0	12.60	23.0	22.78
F_TC_ 03	Time varying (Seq.B)			Main.1	Grip	1/0/20 MHz	QPSK	1g/0mm/Standalone_Back	13.0	12.60	23.0	22.78
F_TC_ 02	Time varying (Seq.A ii)	NR	Bn77 PC3	Main.2	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22
F_TC_ 04	Time varying (Seq.B)			Main.2	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22
F_TC_ 02	Time varying (Seq.A ii)		Bn5	Main.1	Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	14.0	14.80	24.0	24.61
F_TC_ 04	Time varying (Seq.B)			Main.1	Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	14.0	14.80	24.0	24.61
F_TC_ 05	Change in call (Disconnect-Re-establishment)	NR	Bn77	Main.1	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22
F_TC_ 13	Change in RSI	NR	Bn5	Main.1	RSI0	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/20mm/Standalone_Back	24.0	24.60	24.0	24.61
					Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	14.0	14.80	24.0	24.61
F_TC_ 24	Antenna swtiching with Spatial TAS	NR	Bn41	Main.1	Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Top	10.0	9.11	24.0	24.32
		NR	Bn77	Main.2	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22
F_TC_ 26	NSA antenna switching with Spatial TAS	LTE	B66	Main.1	Grip	1/0/20 MHz	QPSK	1g/0mm/Standalone_Top	16.0	15.77	25.0	23.85
		NR	Bn5	Main.1	Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	14.0	15.06	24.0	24.61
		NR	Bn77	Main.2	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22
F_TC_ 30	Re-selection in call (60s averaging for all bands)	LTE	B12	Main.1	Grip	1/49/10 MHz	QPSK	1g/0mm/Standalone_Back	19.0	19.04	24.0	24.58
		NR	Bn5	Main.1	Grip	1/1/20 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	14.0	14.80	24.0	24.61
F_TC_ 31	SAR exposure switch (60s averaging for all bands)	LTE	B5	Main.1	Grip	1/1/10 MHz	QPSK	1g/0mm/Standalone_Back	17.0	16.44	24.0	24.44
		NR	Bn66	Main.1	Grip	1/1/40 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Top	13.0	12.94	24.0	24.22
F_TC_ 32	Time varying Tx power (60s averaging for all bands)(Seq.A iii)	WCDMA	2	Main.1	Grip	-	Rel 99	1g/0mm/Standalone_Top	14.0	14.46	24.0	23.64
		WCDMA	5	Main.1	Grip	-	Rel 99	1g/0mm/Standalone_Back	14.0	14.51	24.0	23.90
F_TC_ 33	Time varying Tx power (60s averaging for all bands)(Seq.A iv)	GSM	850	Main.1	Grip	-	4 Tx slots	1g/0mm/Standalone_Back	13.8	13.52	23.3	23.33
		GSM	1900	Main.1	Grip	-	4 Tx slots	1g/0mm/Standalone_Back	11.8	11.81	20.3	20.63
F_TC_ 34	NSA with Spatial TAS (60s averaging for all bands)	LTE	B66	Main.1	Grip	1/99/20 MHz	QPSK	1g/0mm/Standalone_Top	16.0	15.77	25.0	23.85
		NR	Bn77	Main.2	Grip	1/1/100 MHz	DFT-s OFDM π/2 BPSK	1g/0mm/Standalone_Back	9.0	8.36	24.5	24.22

Note(s):

1. Test cases/techs(bands) determined according to table 4.1.1 in Sec.4.1.

Even if the same SAR_design_target is set, the Plimit will be changed according to the used OEM.

**Plimit and Pmax for LTE TDD Band in the table above were written with Frame average power.

**Plimit and Pmax for NR FR1 TDD Bands in the table above were written with Frame average power at 88.5% duty cycle using Call box.

***Following S.LSI chipset manufacturer's guide, S.LSI TAS algorithm has the following operation added during Dynamic TAS operations.

1. For All FDD Bands, If Plimit is below 18.0 dBm, Peak power is limited Plimit+6dB even if Pmax is more higher.
2. For All TDD Bands, NR TDD Band is the same as NR FDD band operation (note.1), with an additional power back-off for duty cycle : Peak power = (Plimit + 6dB) + 10*Log10(100%/duty cycle)
3. Despite the descriptions in 1 and 2, NR FDD and TDD bands can operate at full Pmax power only for EN-DC (NSA) operation. Detail of explain refer to operational description.

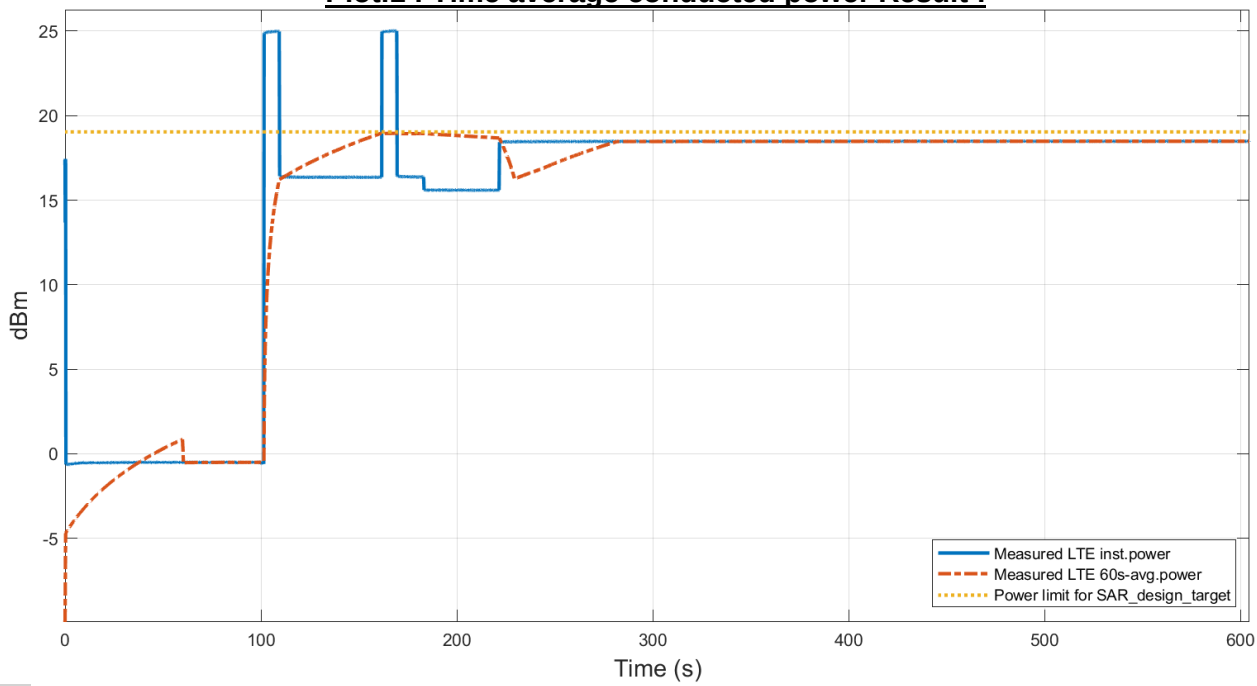
5.3. TC01-04, TC32-33: Time-varying Tx power measurement results

Following the test procedure in Section 3.3.1, 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 design target. In all SAR plots, the dotted blue line shows the time-averaged 1gSAR 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 5.2.1 by generating the test sequence A and B given in Section A. And Time-varying Tx power measurements were conducted for TC #32-33 in Table 5.2.1 by generating the test sequence A given in Section A.

5.3.1. LTE Band 12 (Main.1)

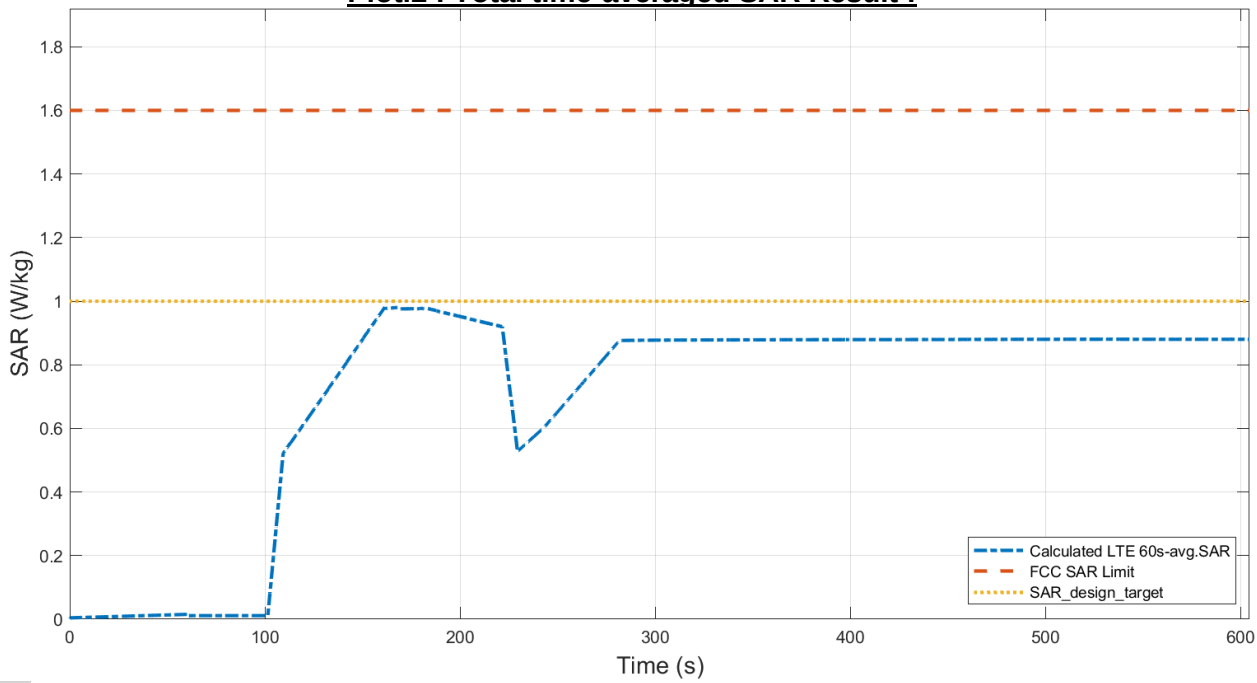
(TC01: LTE Band_Time_Varying_Tx_Power_Case_1)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :

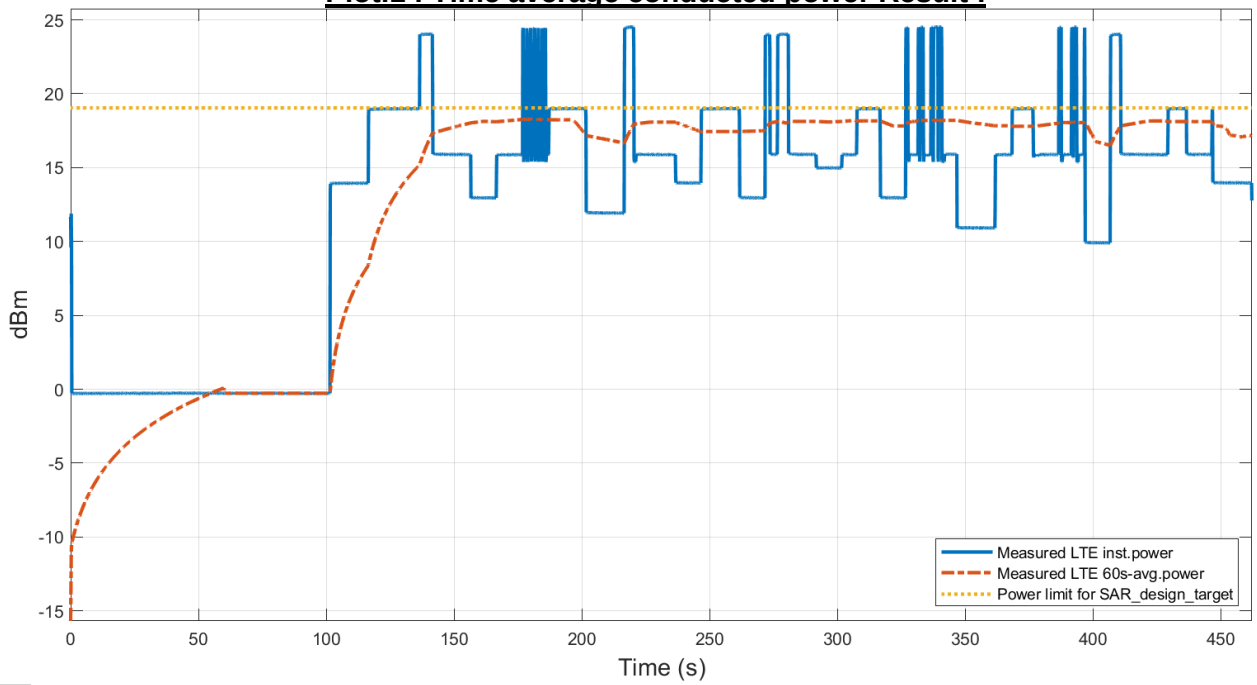


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.981**	W/kg
Device uncertainty	**1.0**	dB

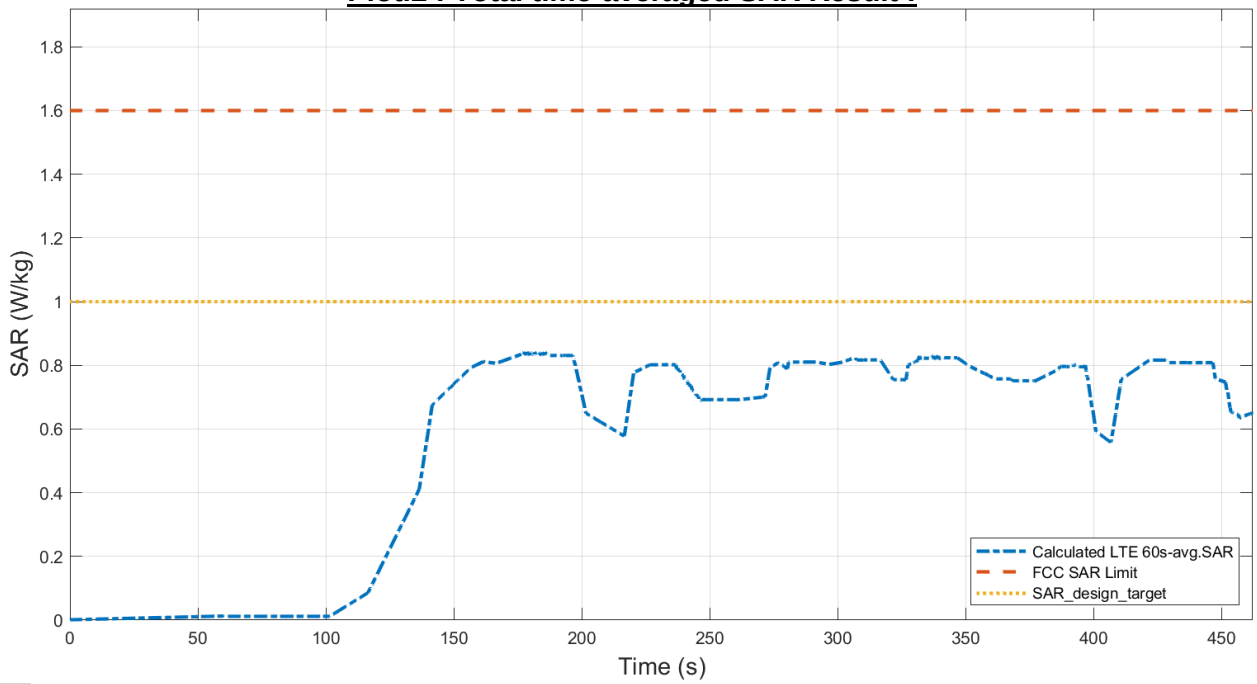
(TC03: LTE Band_Time_Varying_Tx_Power_Case_2)

Plot.1 : Time average conducted power Result :



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

Plot.2 : Total time-averaged SAR Result :



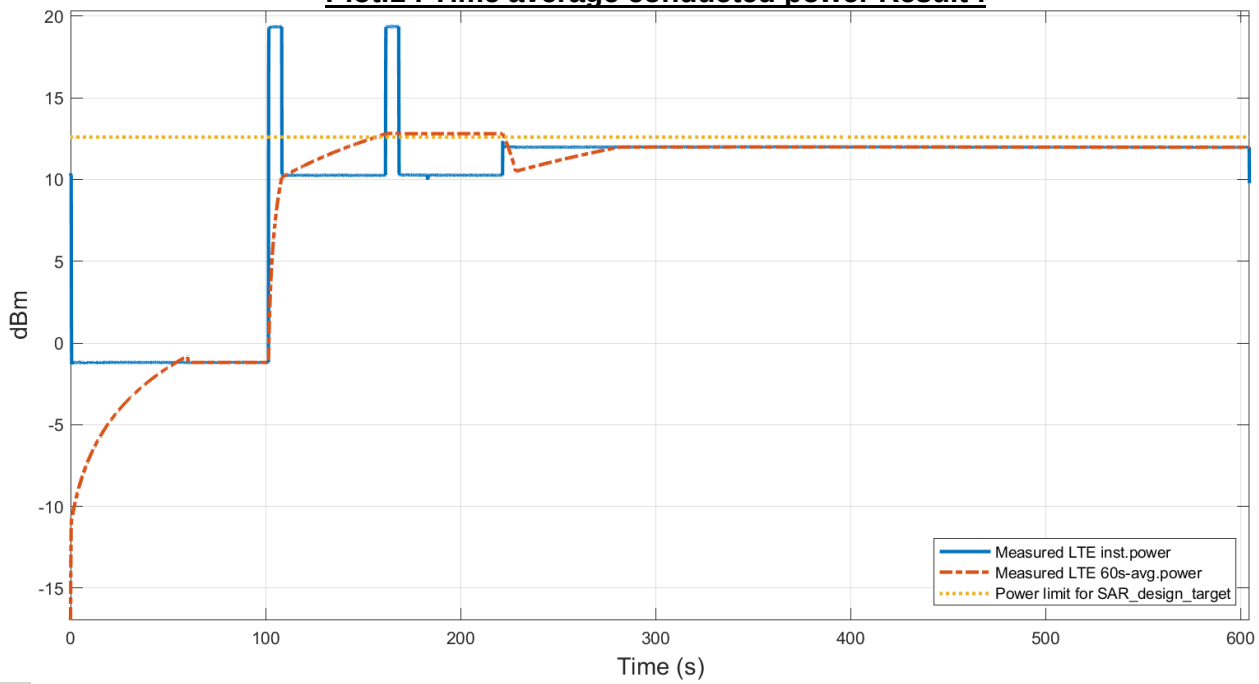
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.842**	W/kg
Device uncertainty	**1.0**	dB

5.3.2. LTE Band 41 (Main.1)

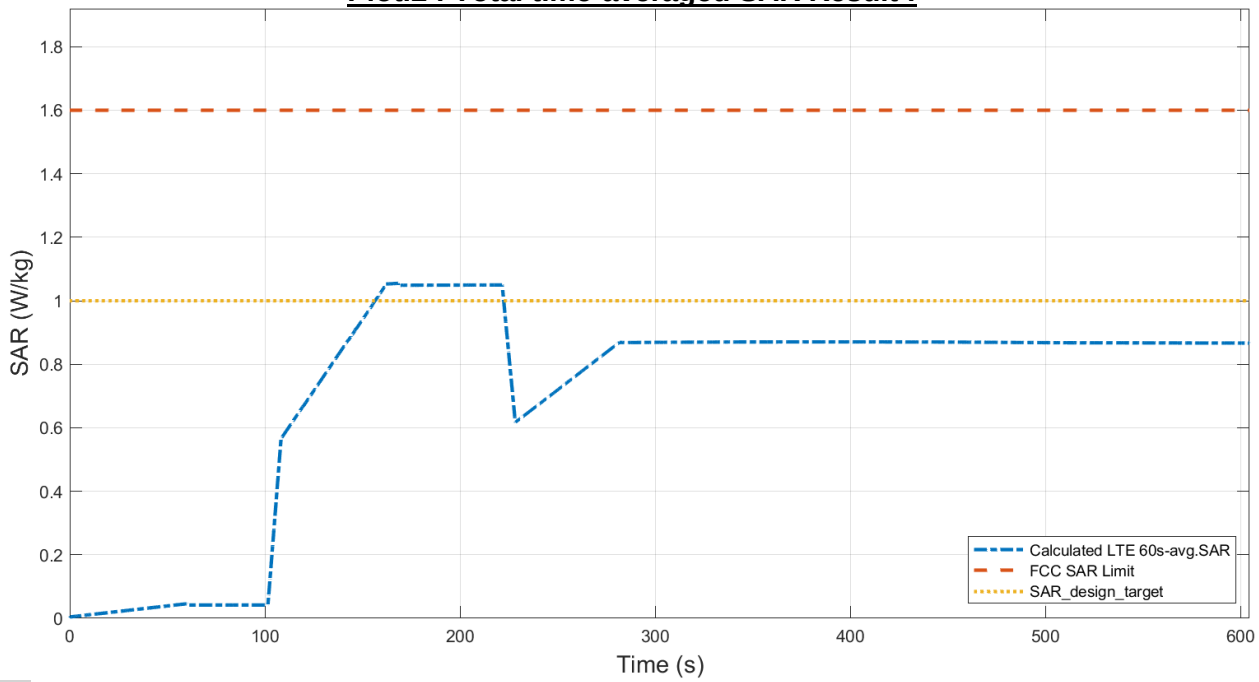
(TC01: LTE Band_Time_Varying_Tx_Power_Case_1)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :

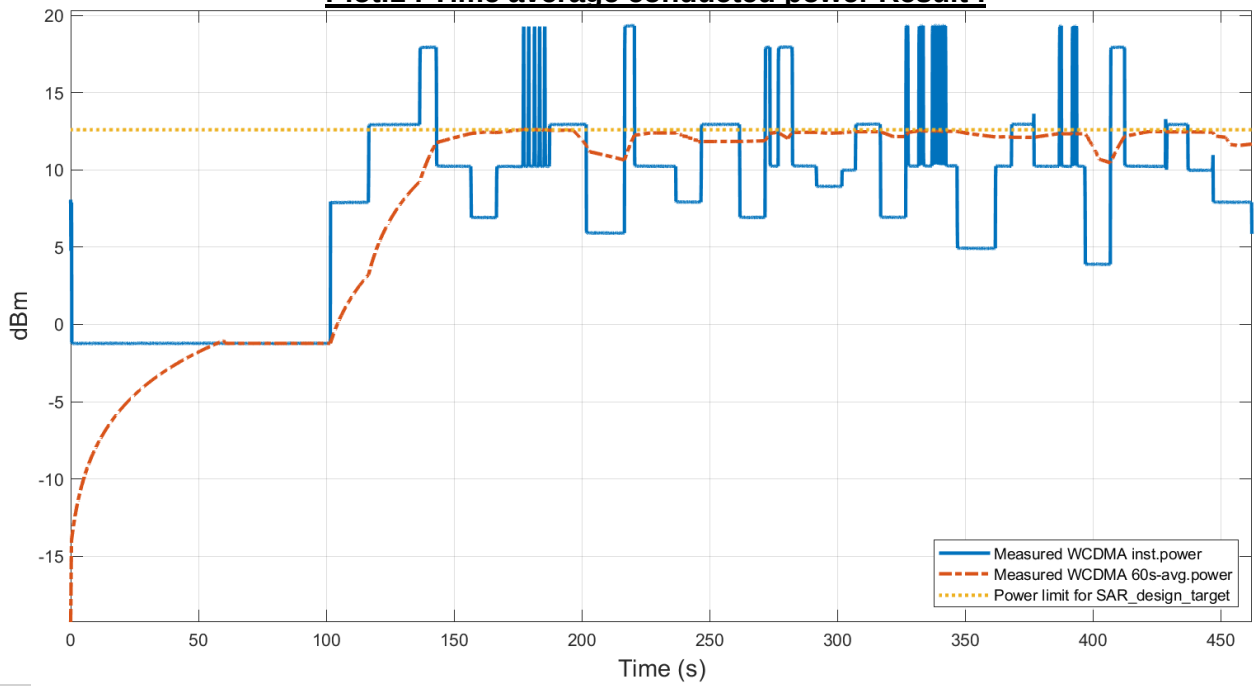


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.058**	W/kg
Device uncertainty	**1.0**	dB

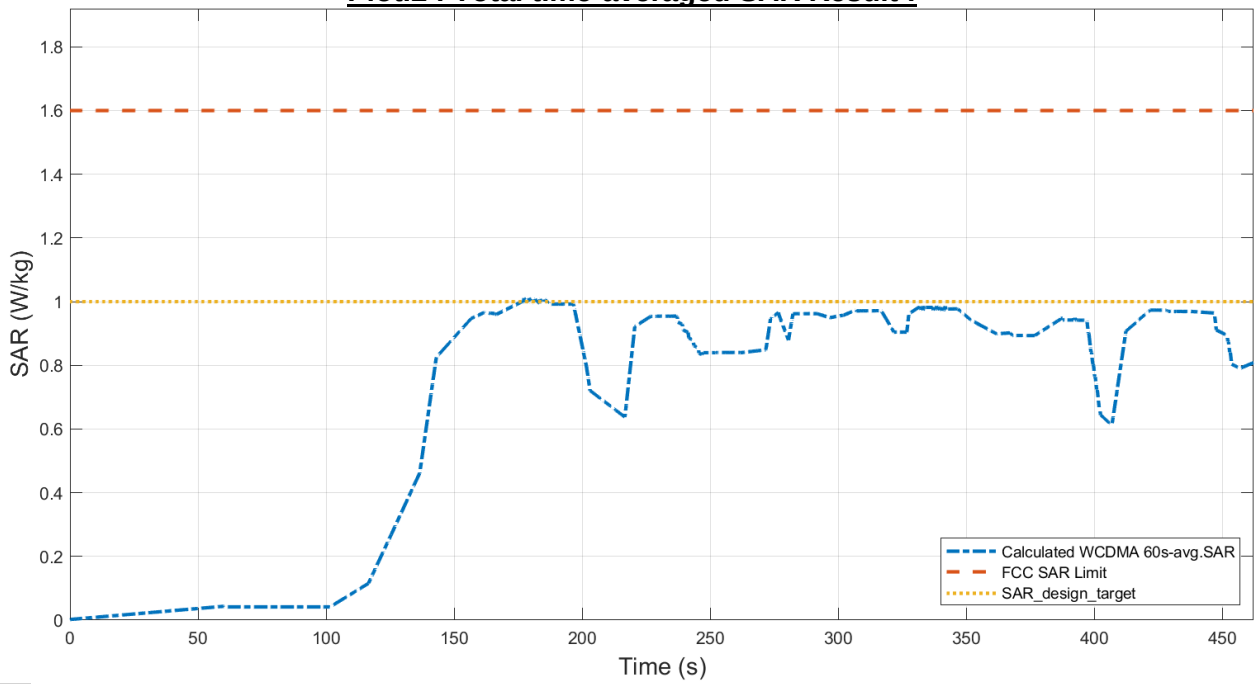
(TC03: LTE Band_Time_Varying_Tx_Power_Case_2)

Plot.1 : Time average conducted power Result :



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

Plot.2 : Total time-averaged SAR Result :



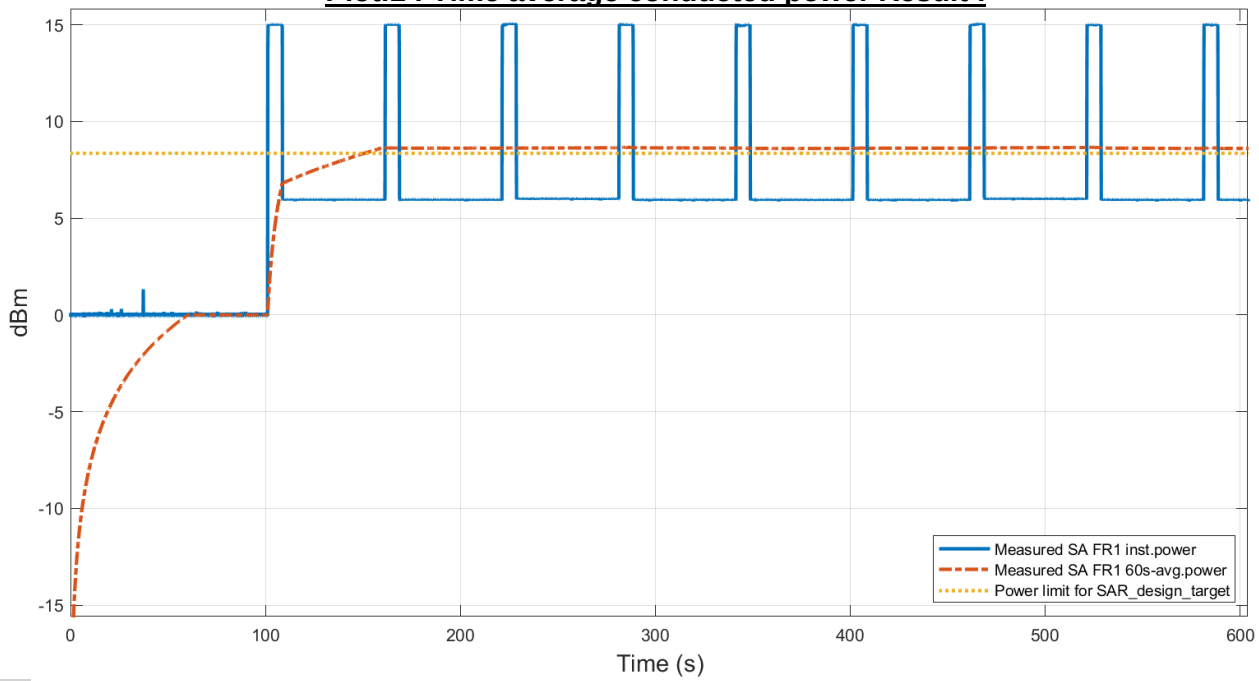
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.011**	W/kg
Device uncertainty	**1.0**	dB

5.3.3. NR Band n77 (Main.2)

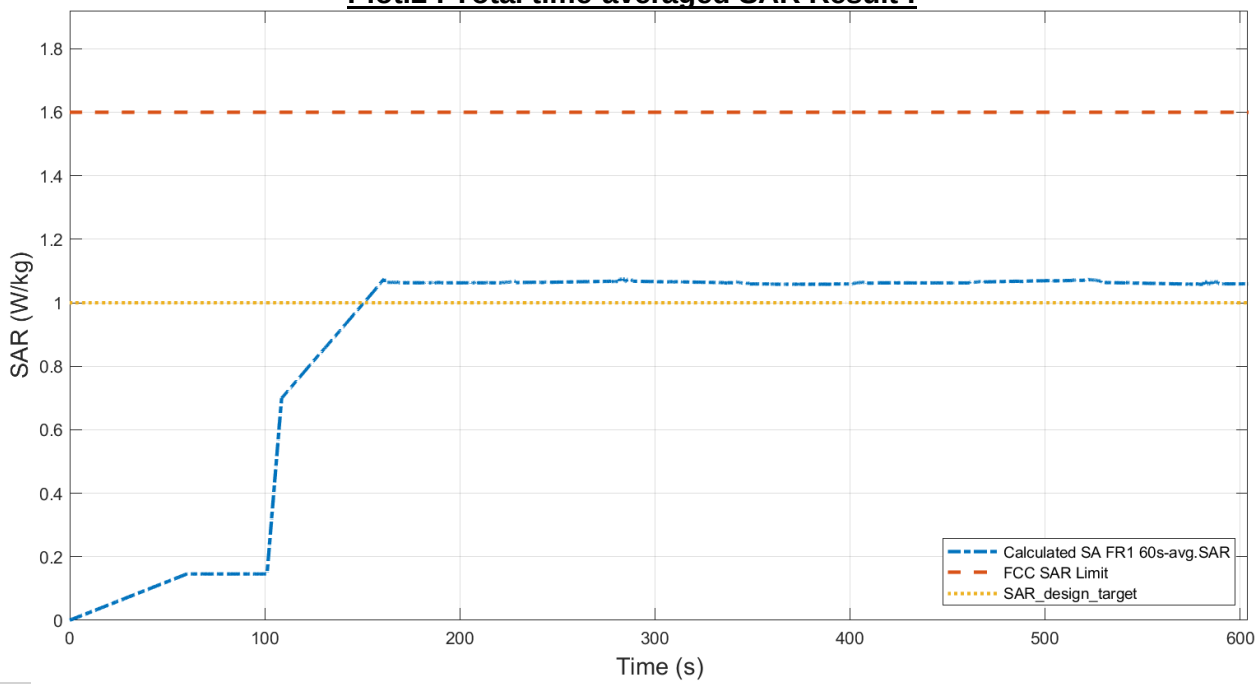
(TC02: SA_FR1_NR Band_Time_Varying_Tx_Power_Case_1)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :



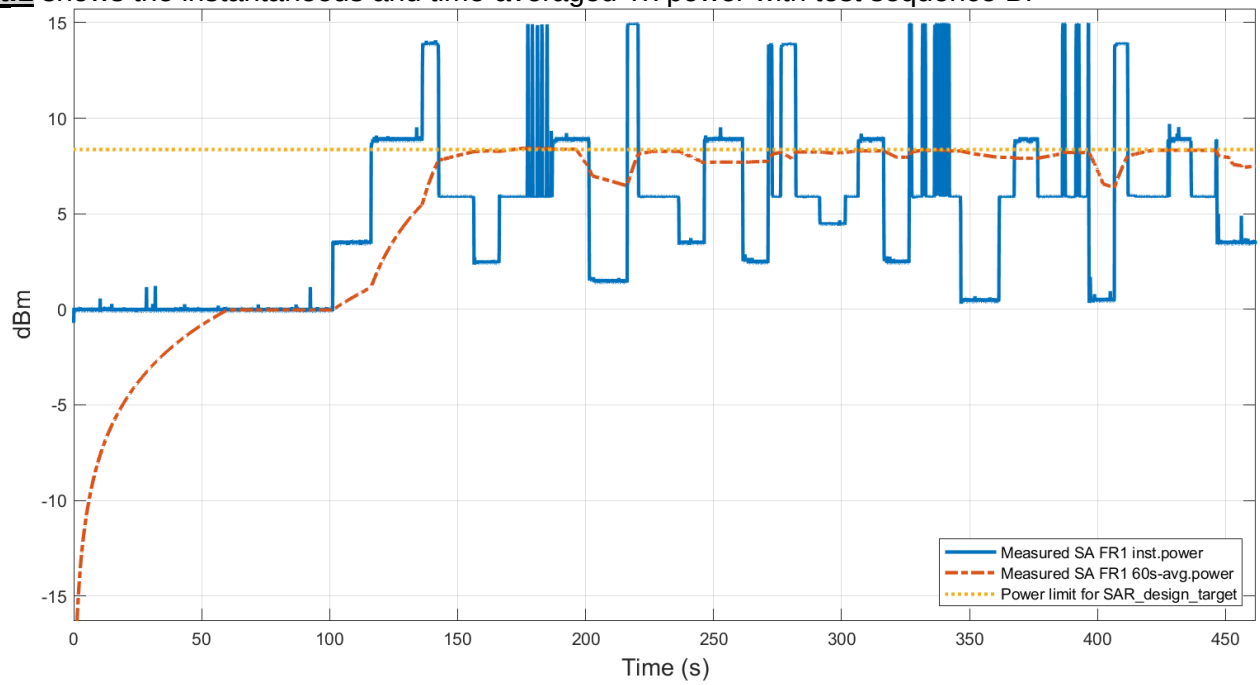
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.076**	W/kg
Device uncertainty	**1.0**	dB

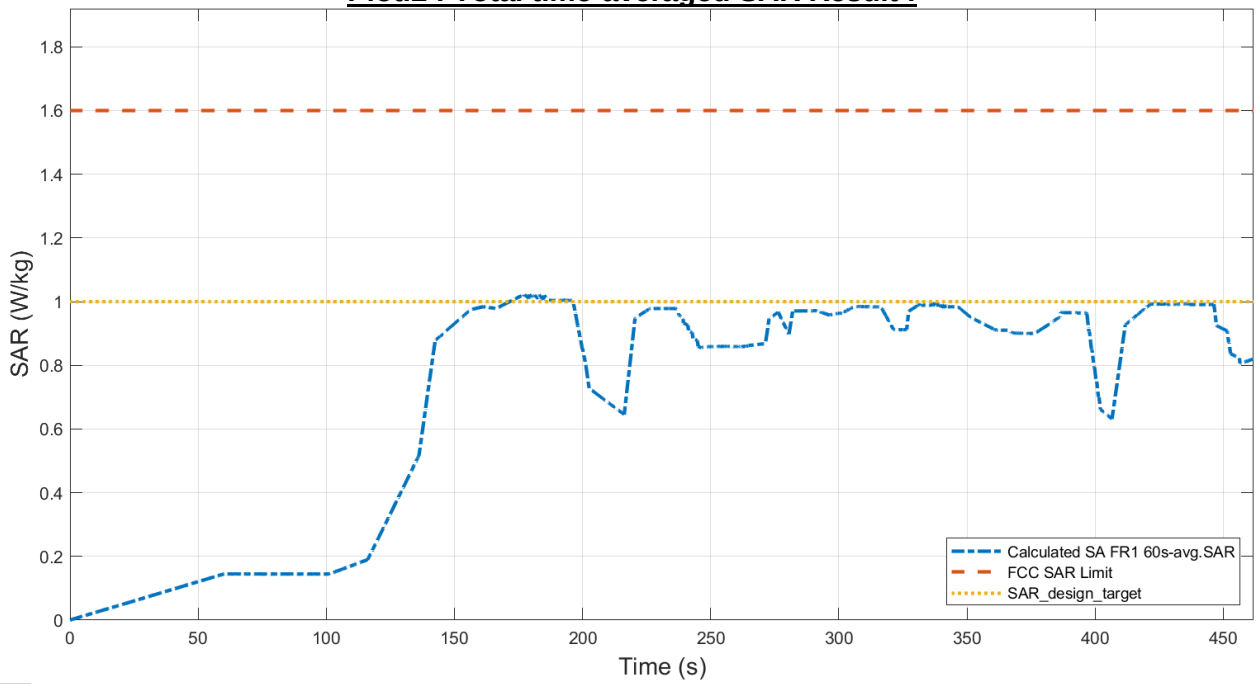
(TC04: SA_FR1_NR Band_Time_Varying_Tx_Power_Case_2)

Plot.1 : Time average conducted power Result :

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



Plot.2 : Total time-averaged SAR Result :



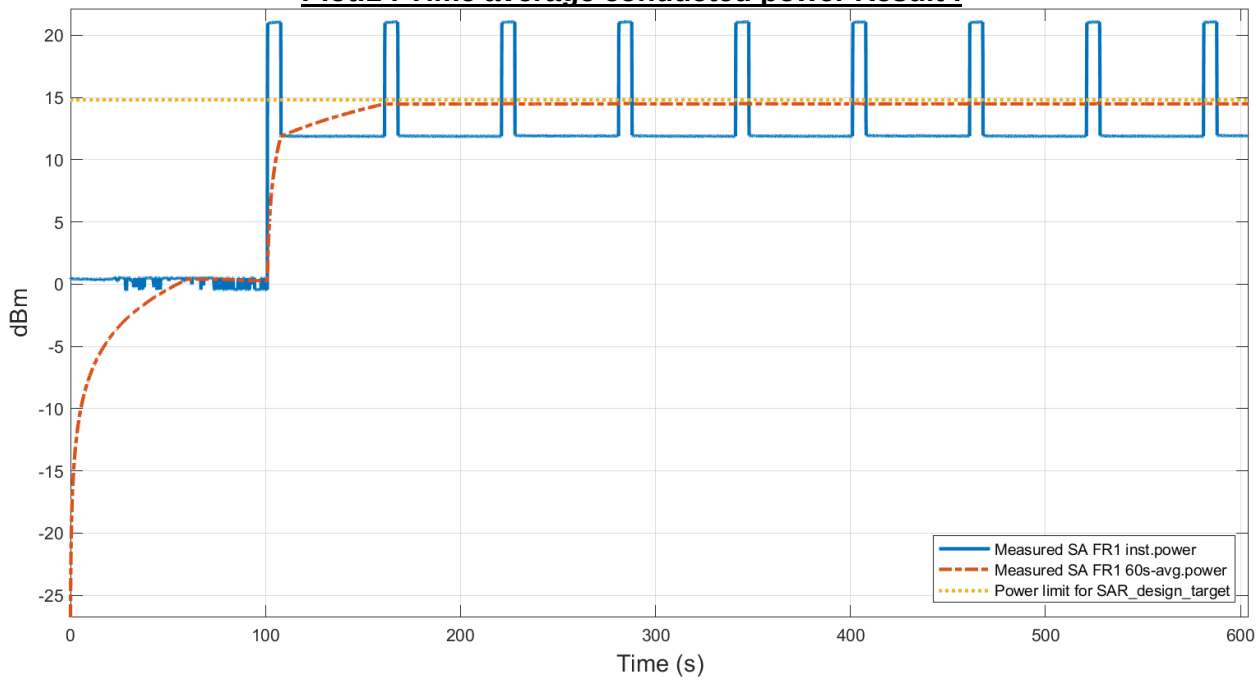
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.023**	W/kg
Device uncertainty	**1.0**	dB

5.3.4. NR Band n5 (Main.1)

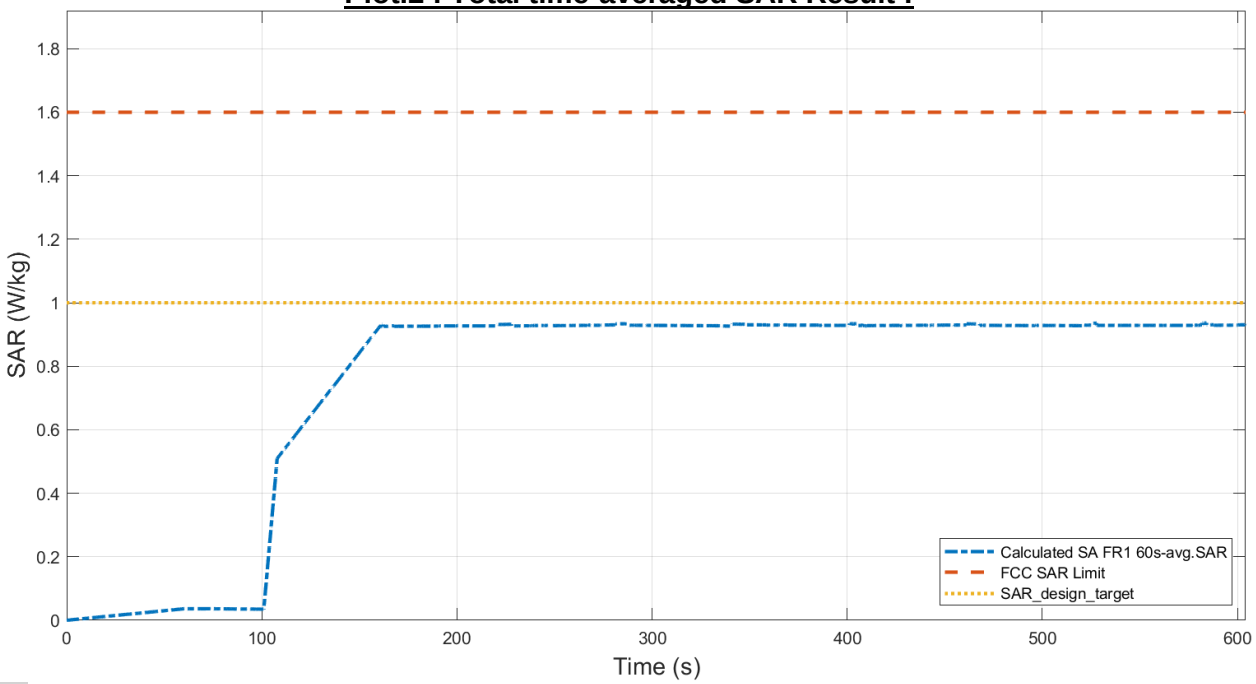
(TC02: SA_FR1_NR Band_Time_Varying_Tx_Power_Case_1)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :

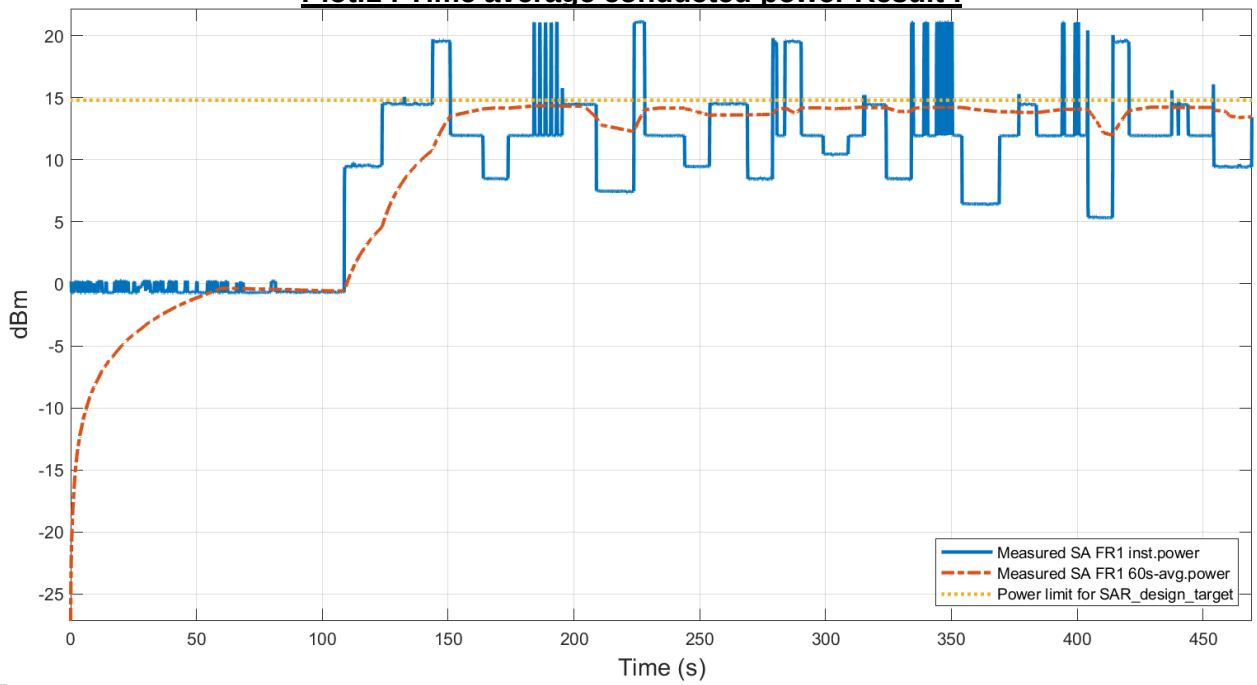


Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.937**	W/kg
Device uncertainty	**1.0**	dB

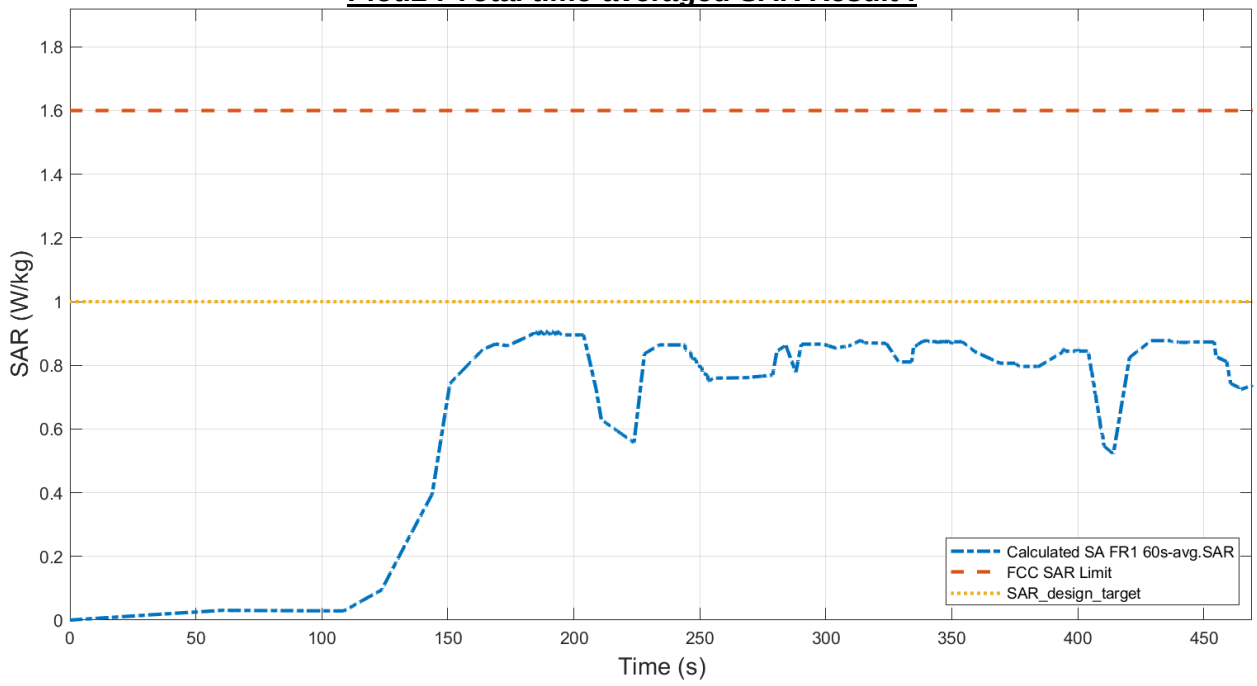
(TC04: SA_FR1_NR Band_Time_Varying_Tx_Power_Case_2)

Plot.1 : Time average conducted power Result :



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

Plot.2 : Total time-averaged SAR Result :



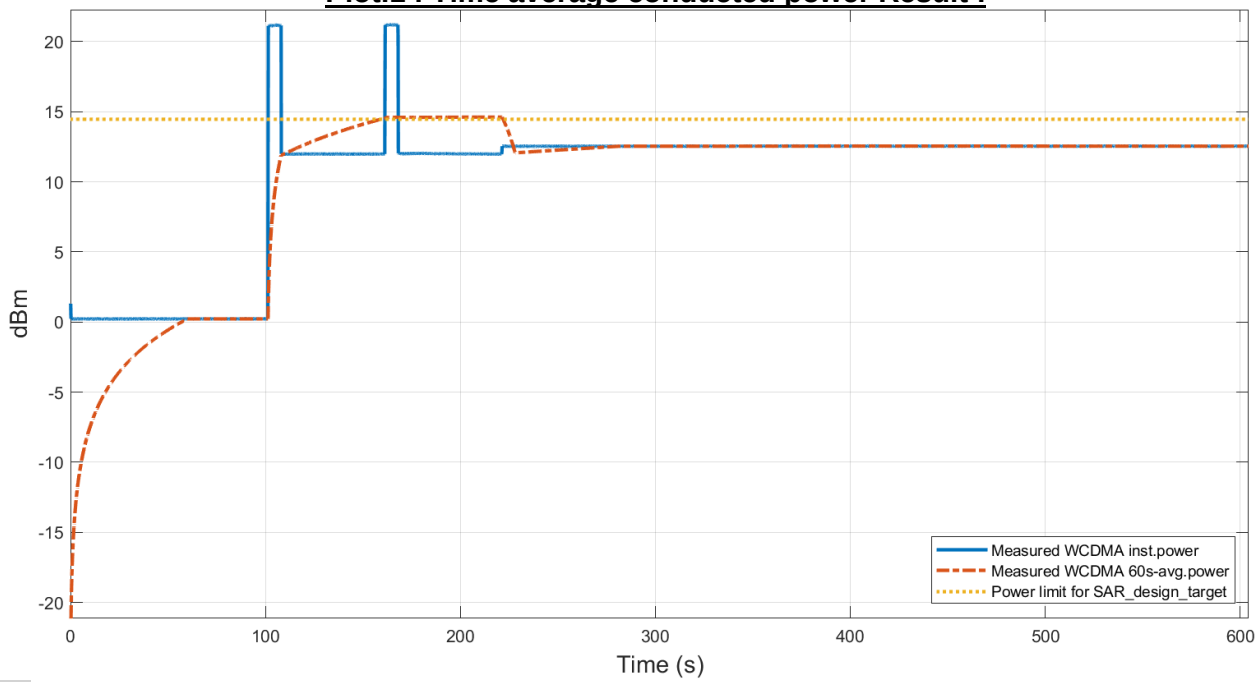
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.909**	W/kg
Device uncertainty	**1.0**	dB

5.3.5. WCDMA Band 2 (Main.1)

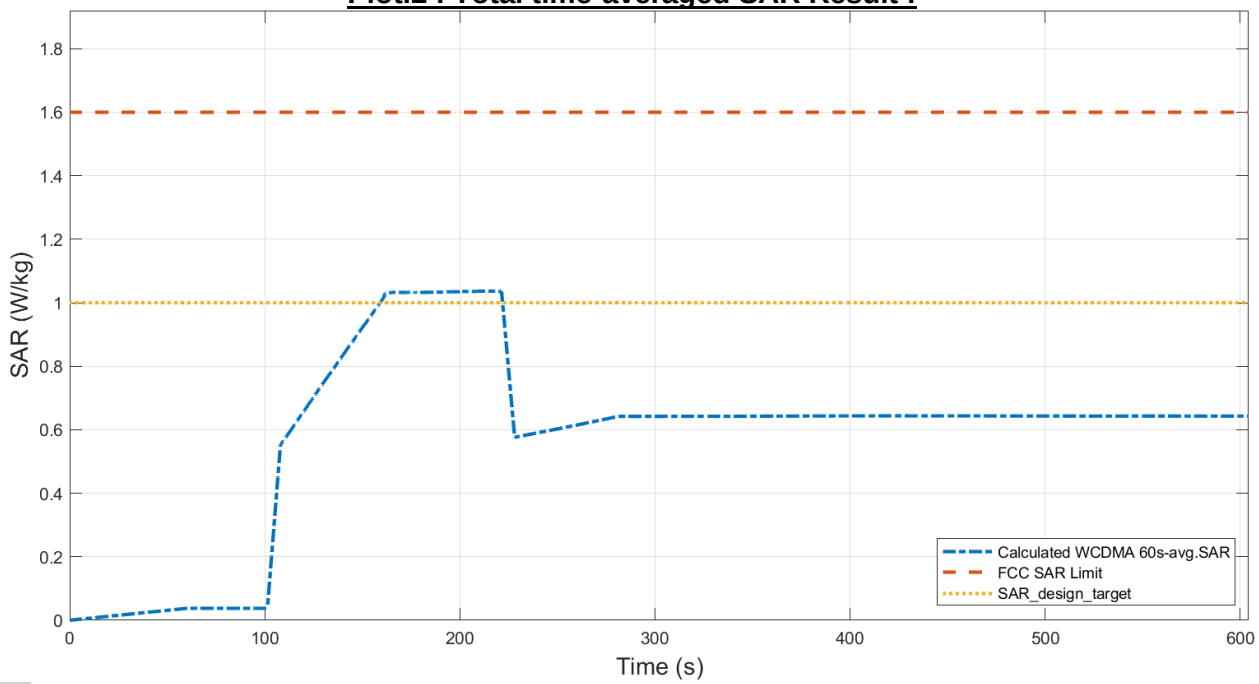
(TC32: WCDMA Band_Time_Varying_Tx_Power)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :



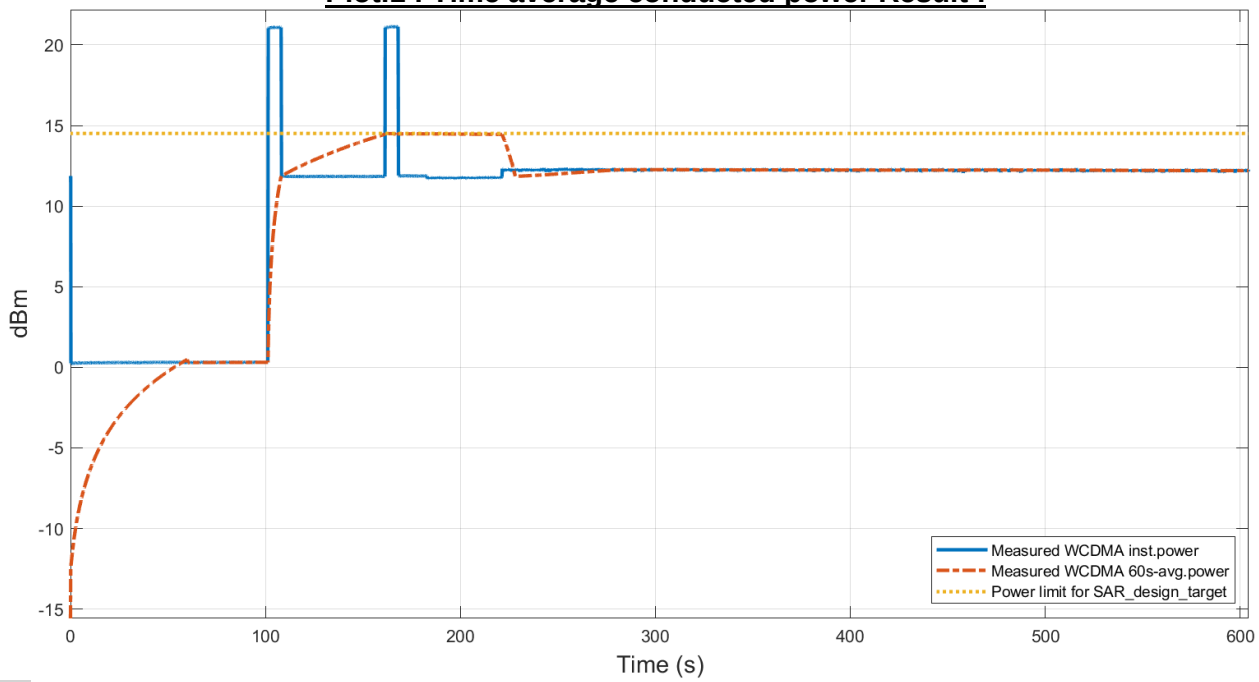
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.037**	W/kg
Device uncertainty	**1.0**	dB

5.3.6. WCDMA Band 5 (Main.1)

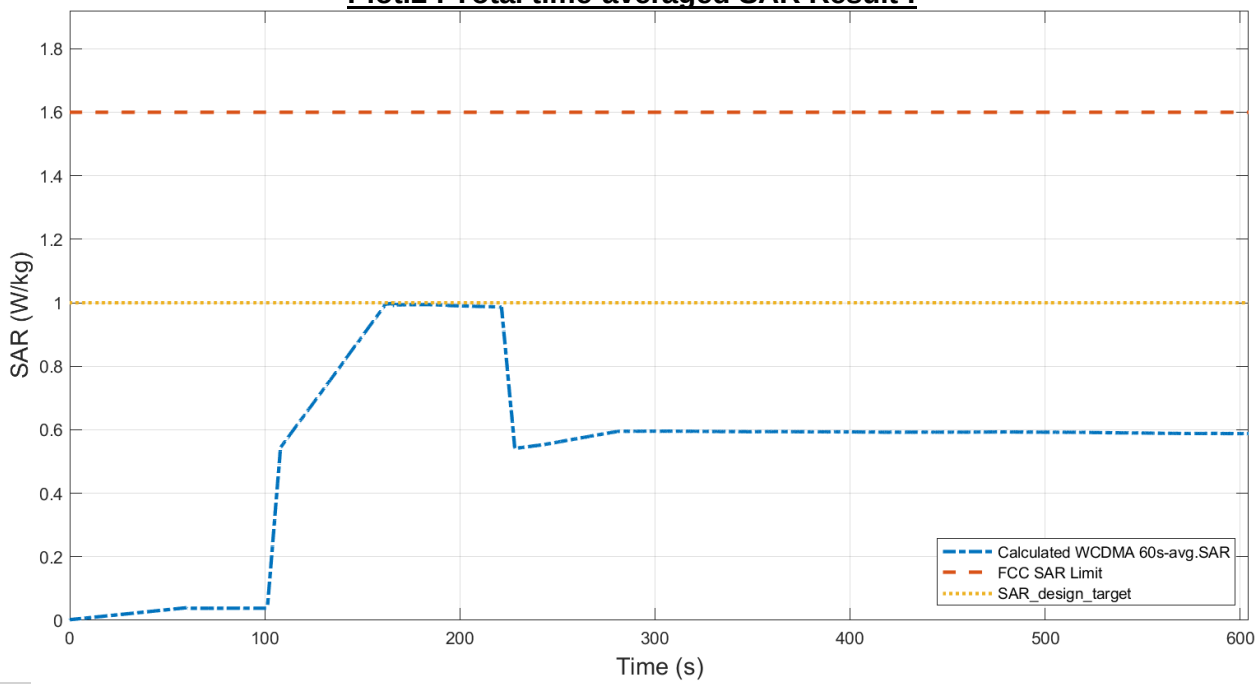
(TC32: WCDMA Band_Time_Varying_Tx_Power)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :



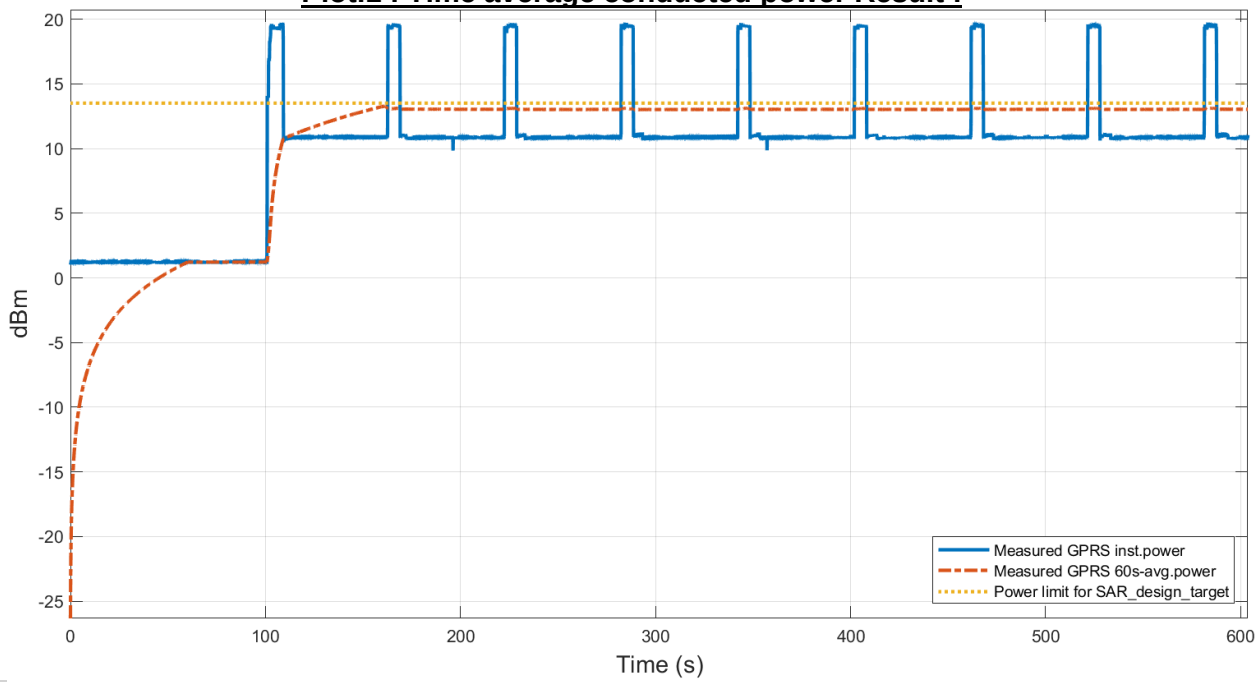
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.000**	W/kg
Device uncertainty	**1.0**	dB

5.3.7. GSM 850 (Main.1)

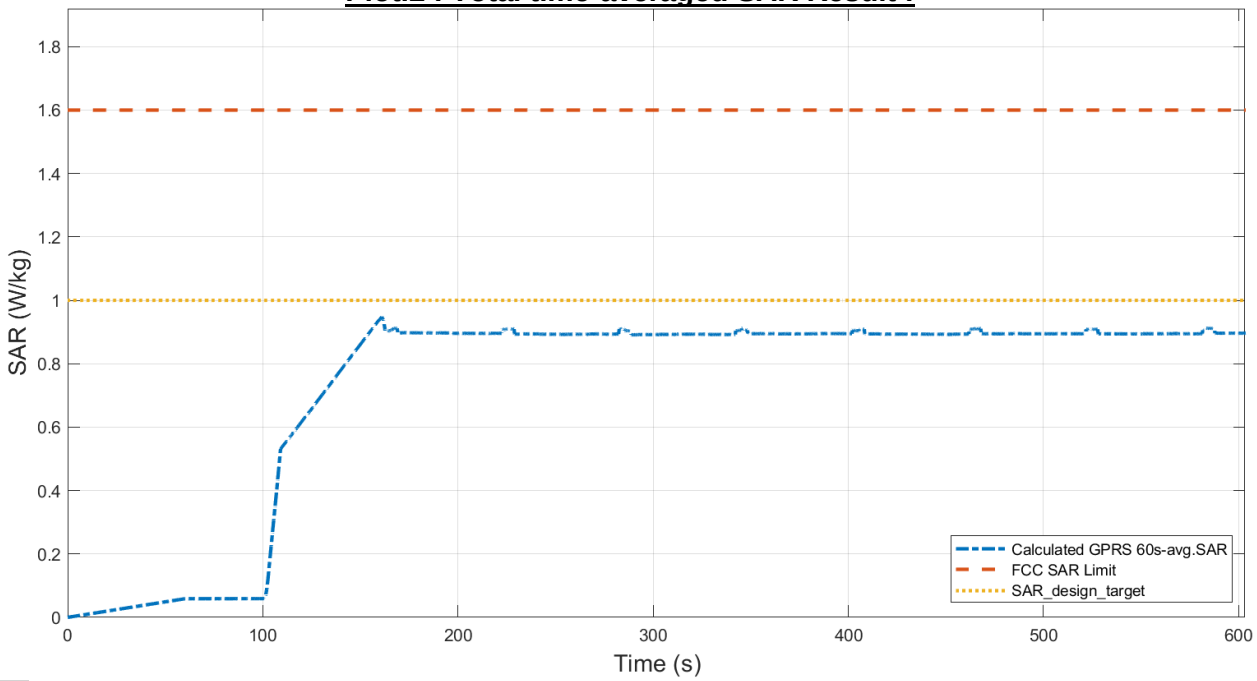
(TC33: GSM Band_Time_Varying_Tx_Power)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :



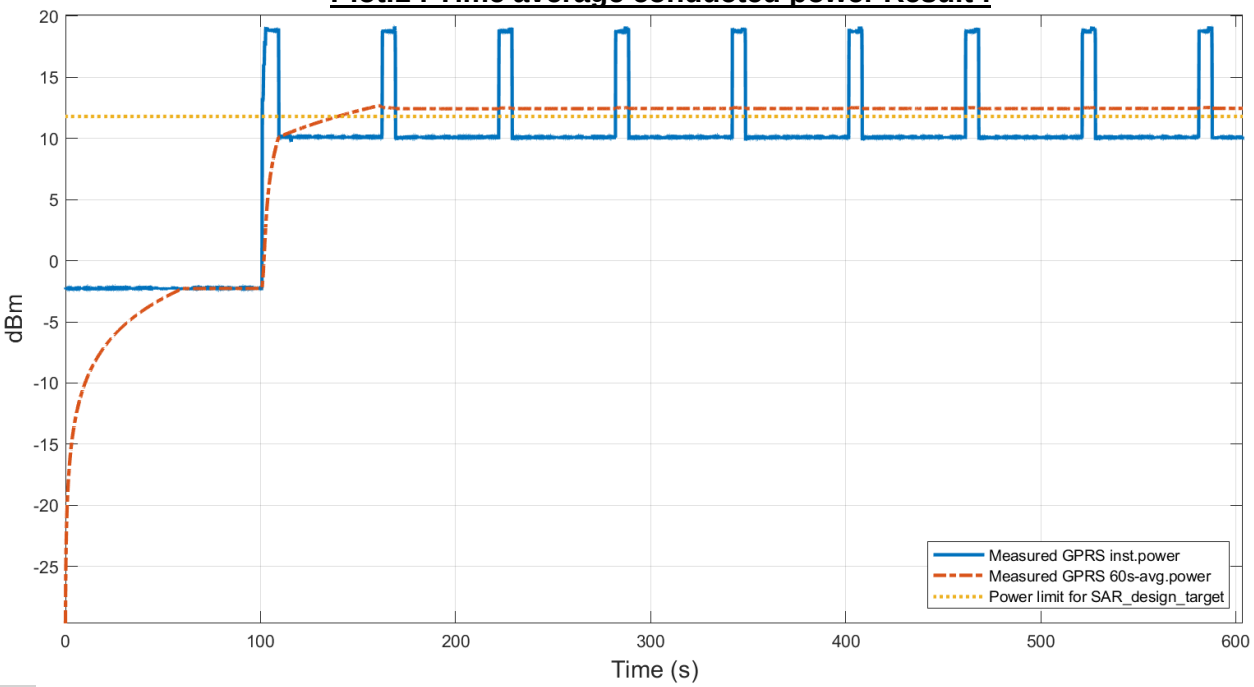
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.948**	W/kg
Device uncertainty	**1.0**	dB

5.3.8. GSM 1900 (Main.1)

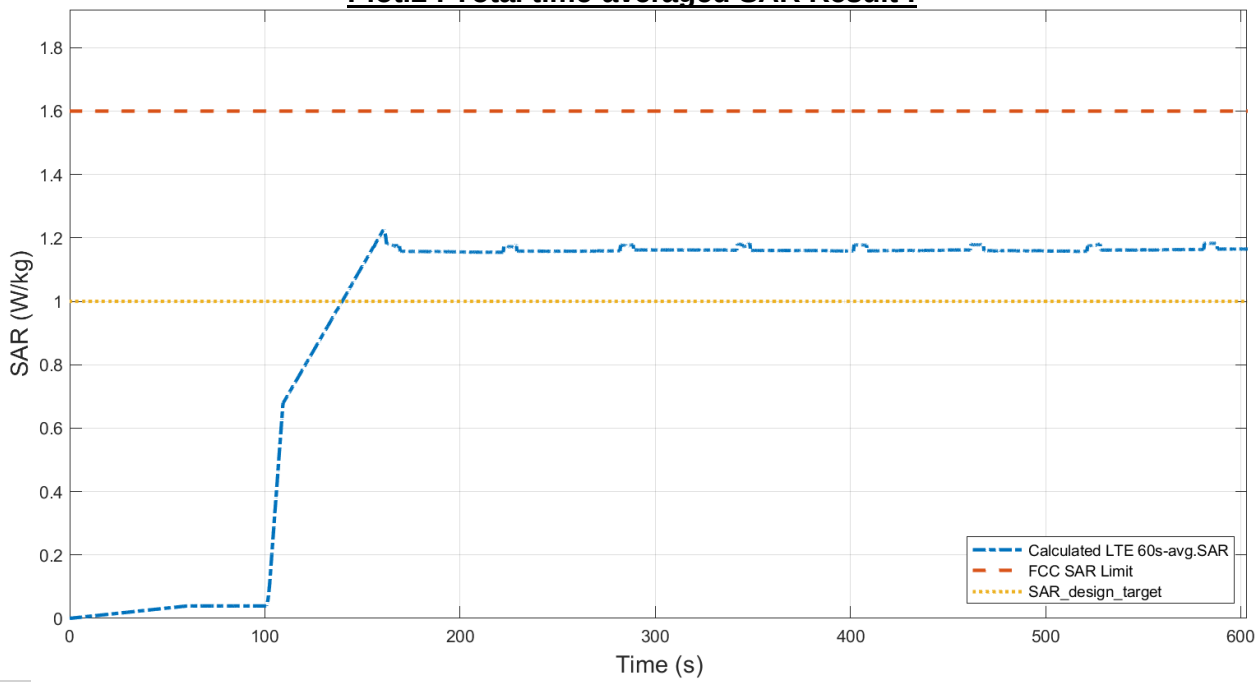
(TC33: GSM Band_Time_Varying_Tx_Power)

Plot.1 : Time average conducted power Result :



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 : Total time-averaged SAR Result :



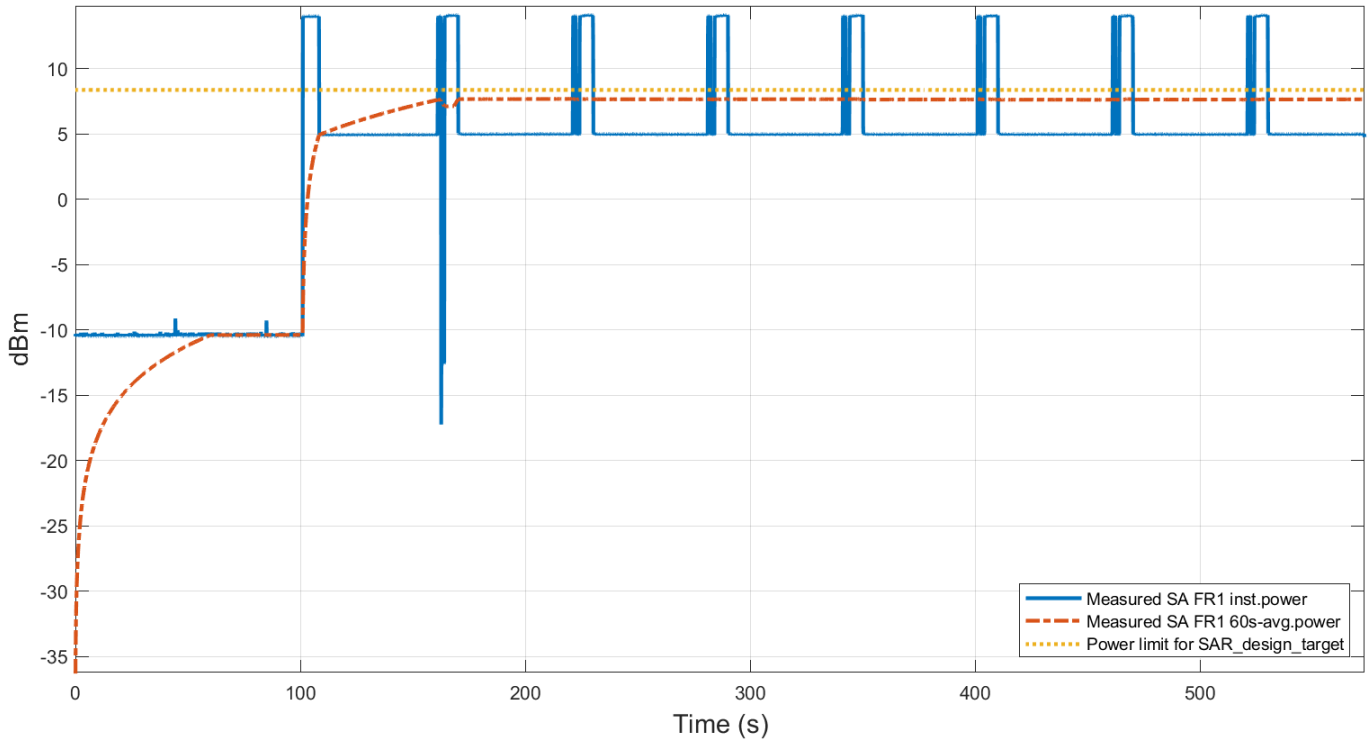
Plot.2 shows the plot of calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.227**	W/kg
Device uncertainty	**1.0**	dB

5.4. TC05: Change in call test results

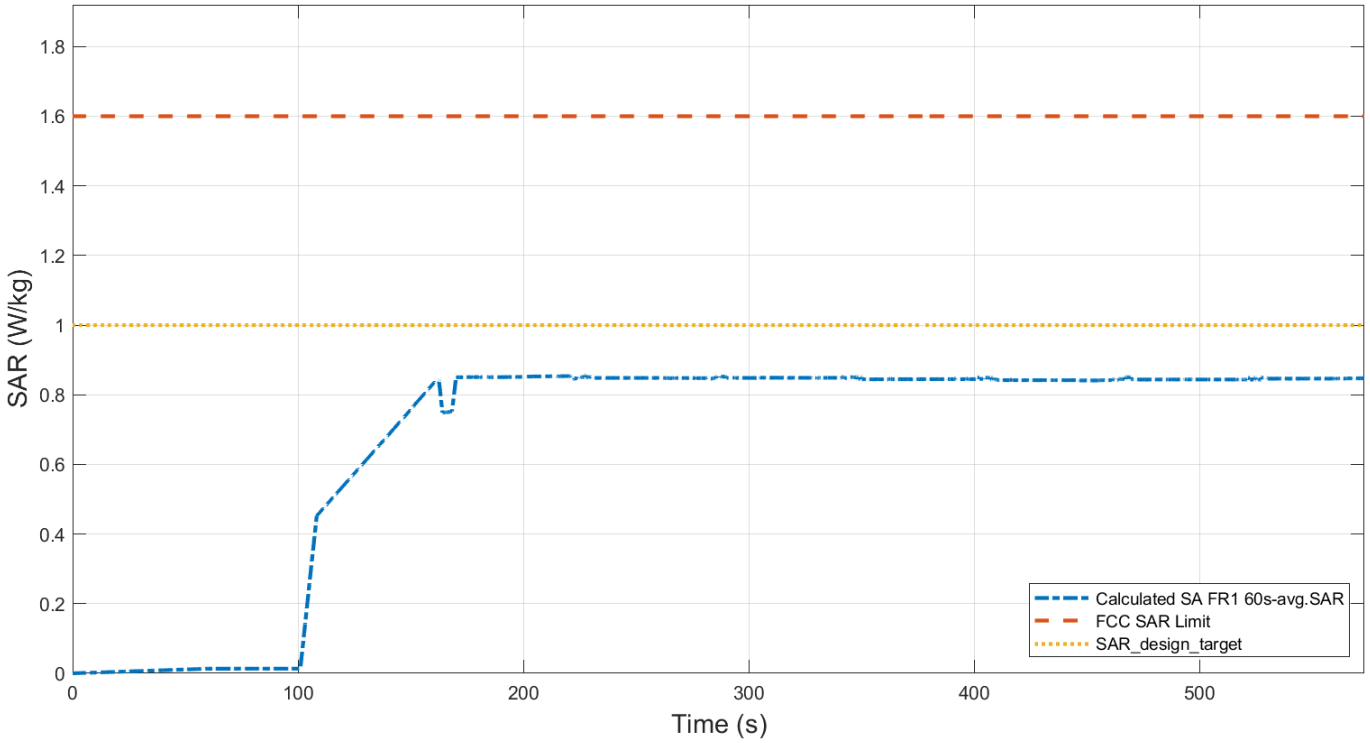
The test results in this section are obtained following the procedure in Section 3.3.2. The test case corresponds to TC05 in Table 5.2.1.

Plot.1 : Conducted Tx power in Call_Disconnect_Re-establishment :



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 : Total time-averaged SAR Result :



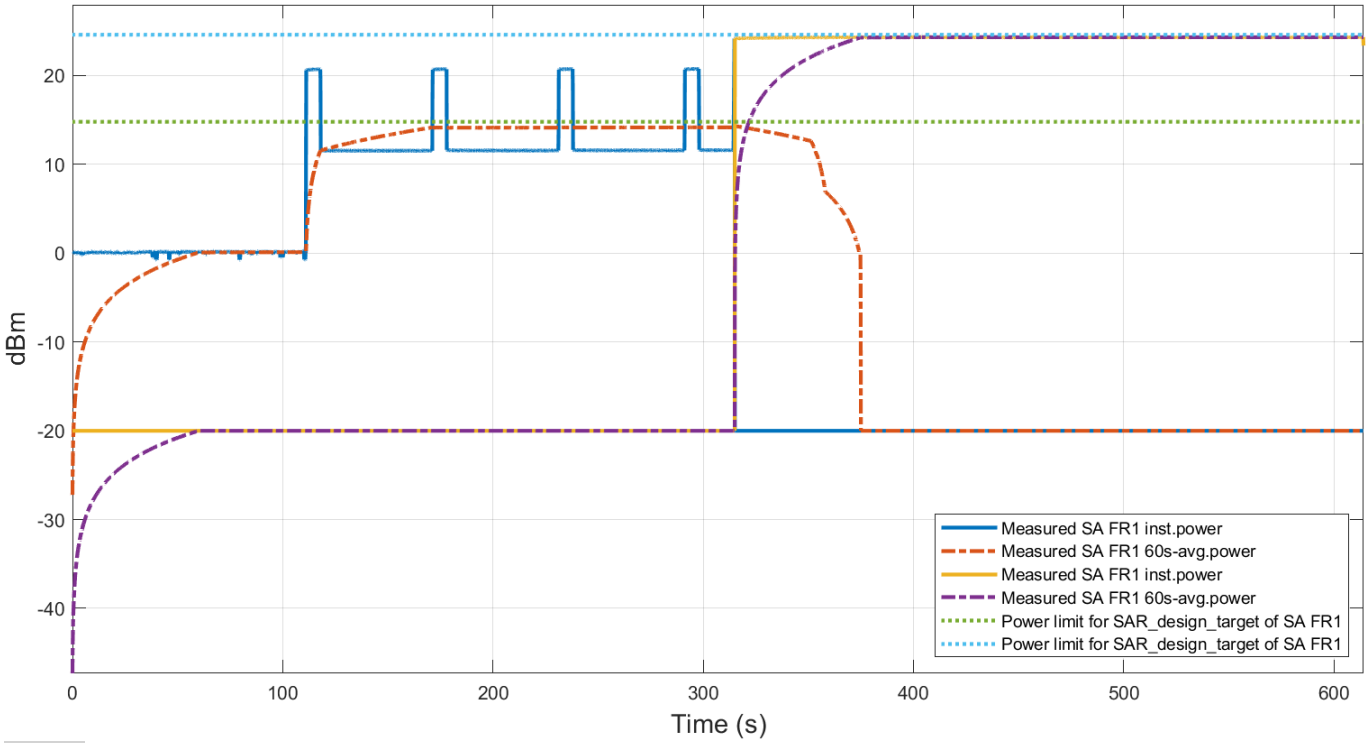
Plot.2 shows calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/Kg. Looking at the results, it can be seen that even if transmission is stopped due to a call drop, the SAR value measured for a period of time window is stored in the window section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

FCC1g SAR limit	**1.6** W/kg
Max 60s-time averaged 1gSAR (blue curve)	**0.856** W/kg
Device uncertainty	**1.0** dB

5.5. TC13: Change in RSI value results

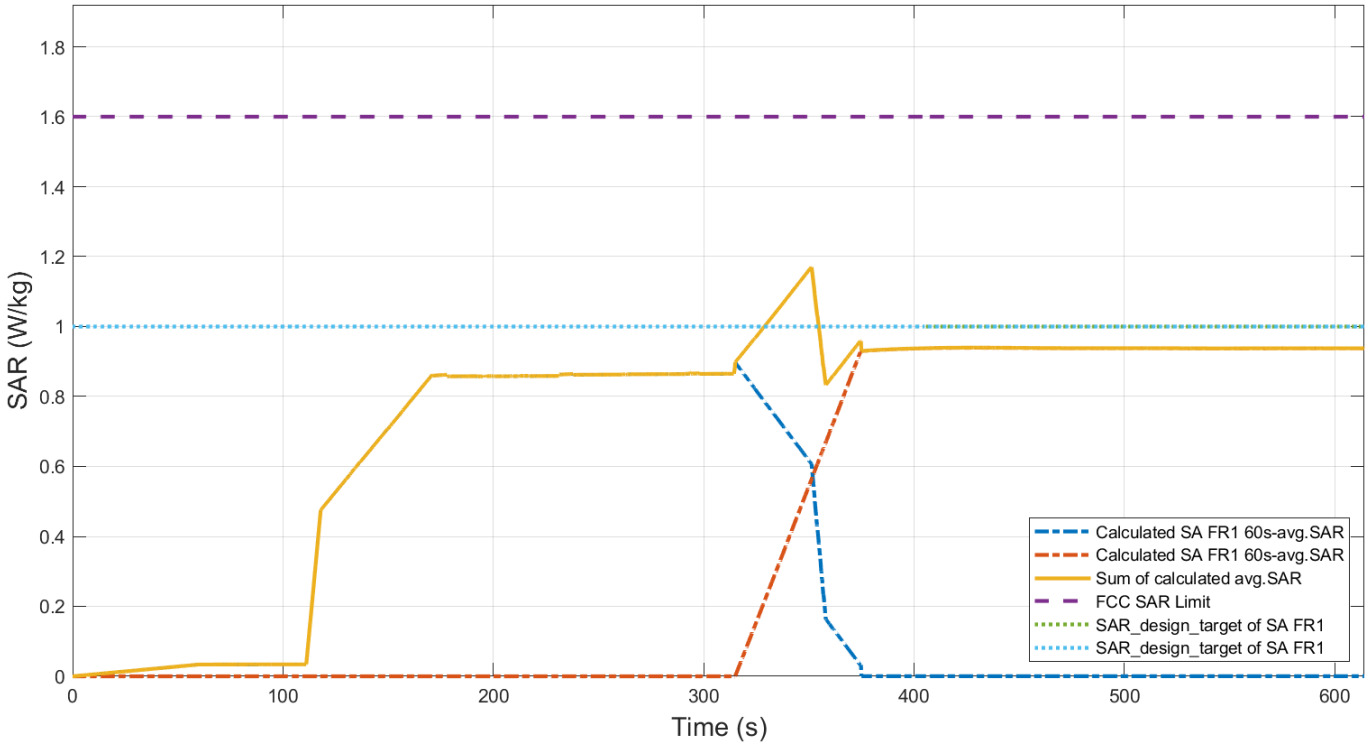
The test results in this section are obtained following the procedure in Section 3.3.4. The test cases correspond to TC13 in Table 5.2.1.

Plot.1 : Conducted Tx power for SAR RSI change :



Plot.1 shows the instantaneous and time-averaged conducted Tx power for both NR Band n5 for the duration of the test. Around time stamp of ~310s, the RSI value is changed from RSI(Grip) to RSI(Free), which increases the target time-averaged power of NR Band n5. It can be seen that Plimit value of RSI(Grip) is lower than that of RSI (Free), so in RSI(Grip) region, more Tx power is limited compared to RSI(Free) region. Figure below shows the time-averaged 1gSAR value for each of RSI value, 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 : Total time-averaged SAR Result :



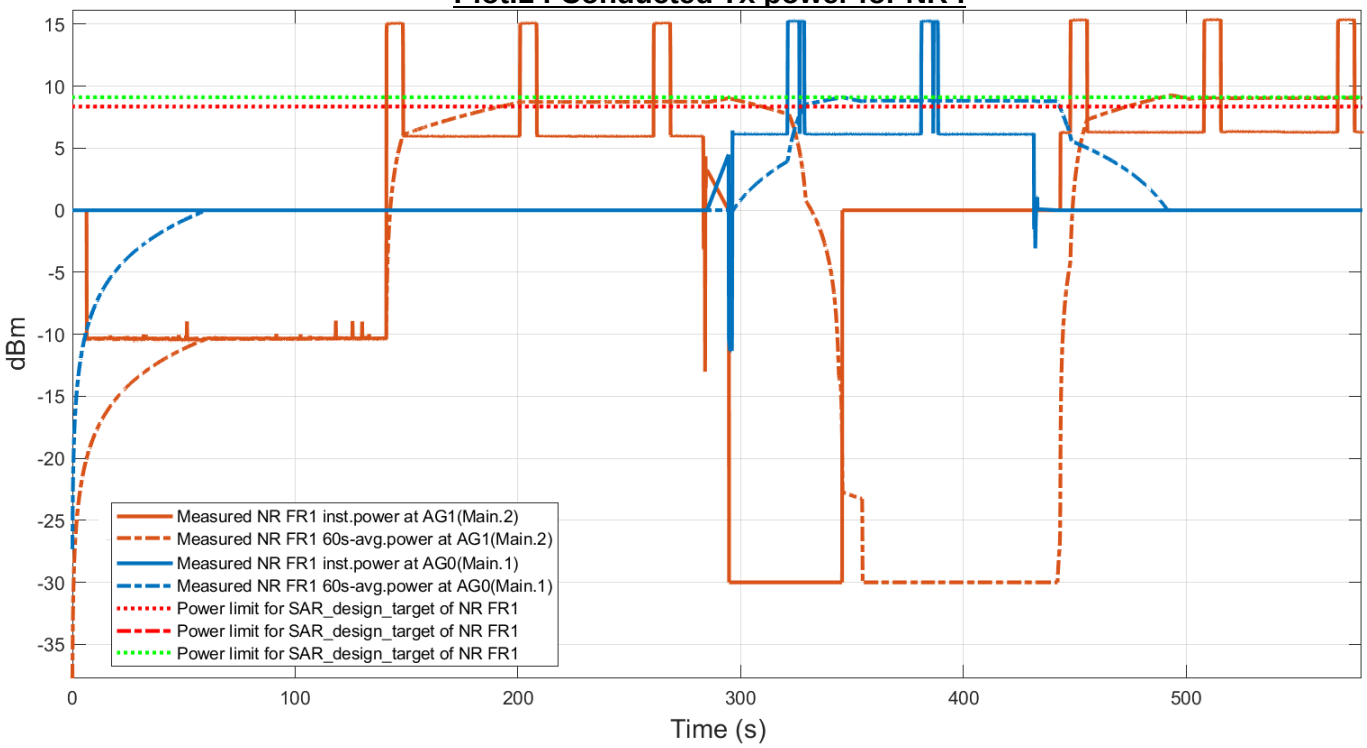
Plot.2 shows the time-averaged 1gSAR value for each of low and high RSI value, as well as the total SAR value. We can see that the total 1gSAR is higher during the band transitions, but is always under the total FCC limit of 1.6W/Kg.

FCC1g SAR limit	**1.6** W/kg
Max 60s-time averaged 1gSAR (orange curve)	**1.170** W/kg
Device uncertainty	**1.0** dB

5.6. TC24 : Antenna switching with spatial TAS test results

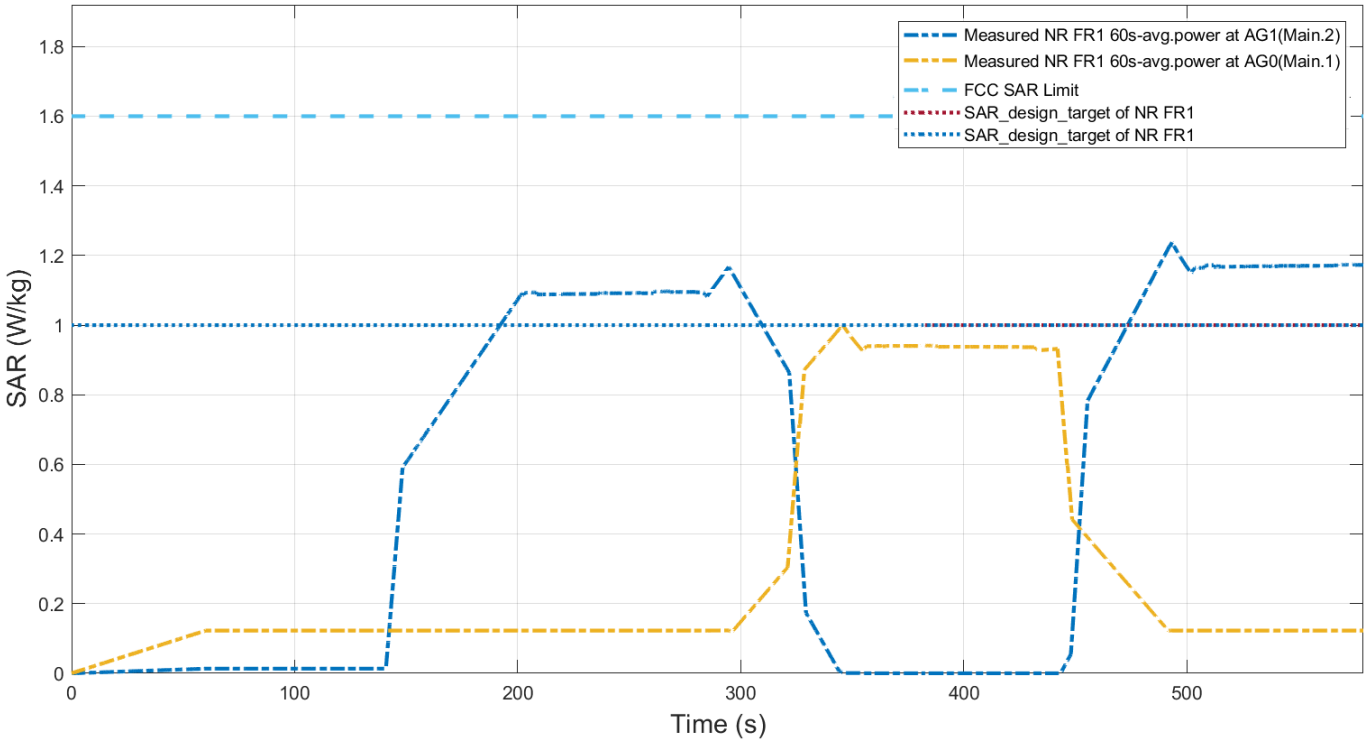
The test results in this section are obtained following the procedure in Section 3.3.8. The test cases correspond to TC24 in Table 5.2.1.

Plot.1 : Conducted Tx power for NR :



Plot.1 shows the instantaneous and time-averaged conducted Tx power at each different antenna groups. Transmission is initialized on AG1 where it was set for very low power for ~100s. After that, a maximum power is requested and the TAS starts to cycle. After ~240s a band change happens to other band switch operates at AG1 and an average maximum power is requested. Since the coupling between AG1 and AG0 is 0, then transmission at AG0 will start from maximum power regardless of the transmission at AG1 and will continue transmission for ~90s. Next, another band change is done to the first band and so an antenna switching to AG1 happens where a maximum power is request which yields a transmission at Pmax.

Plot.2 : Total time-averaged SAR Result :



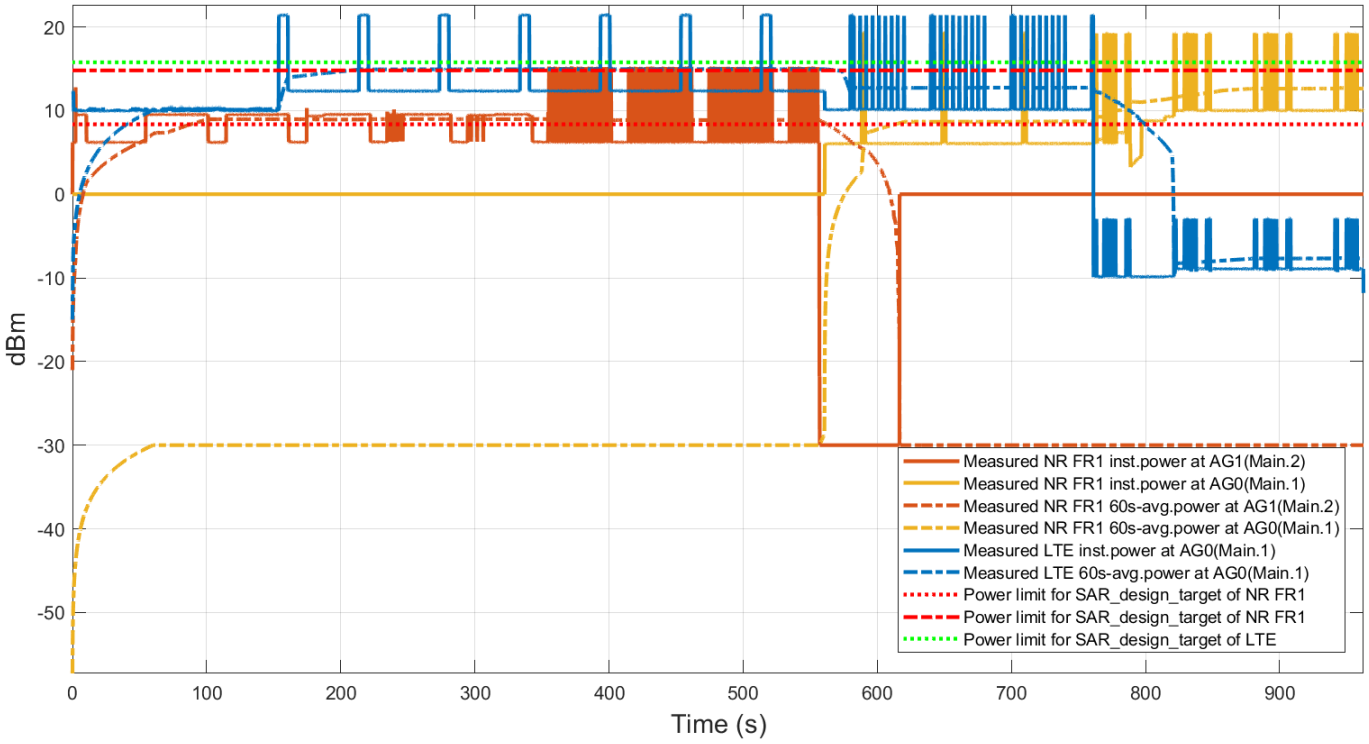
Plot.2 shows consequently the average SAR is below 1.0W/kg(± Uc) which is below the FCC limit of 1.6 W/kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	AG1(Main.2)	**1.233** W/kg
Max 60s-time averaged 1gSAR (yellow curve)	AG0(Main.1)	**1.000** W/kg
Device uncertainty	**1.0**	dB

5.7. TC26 : NSA(EN-DC) antenna switching with spatial TAS test results

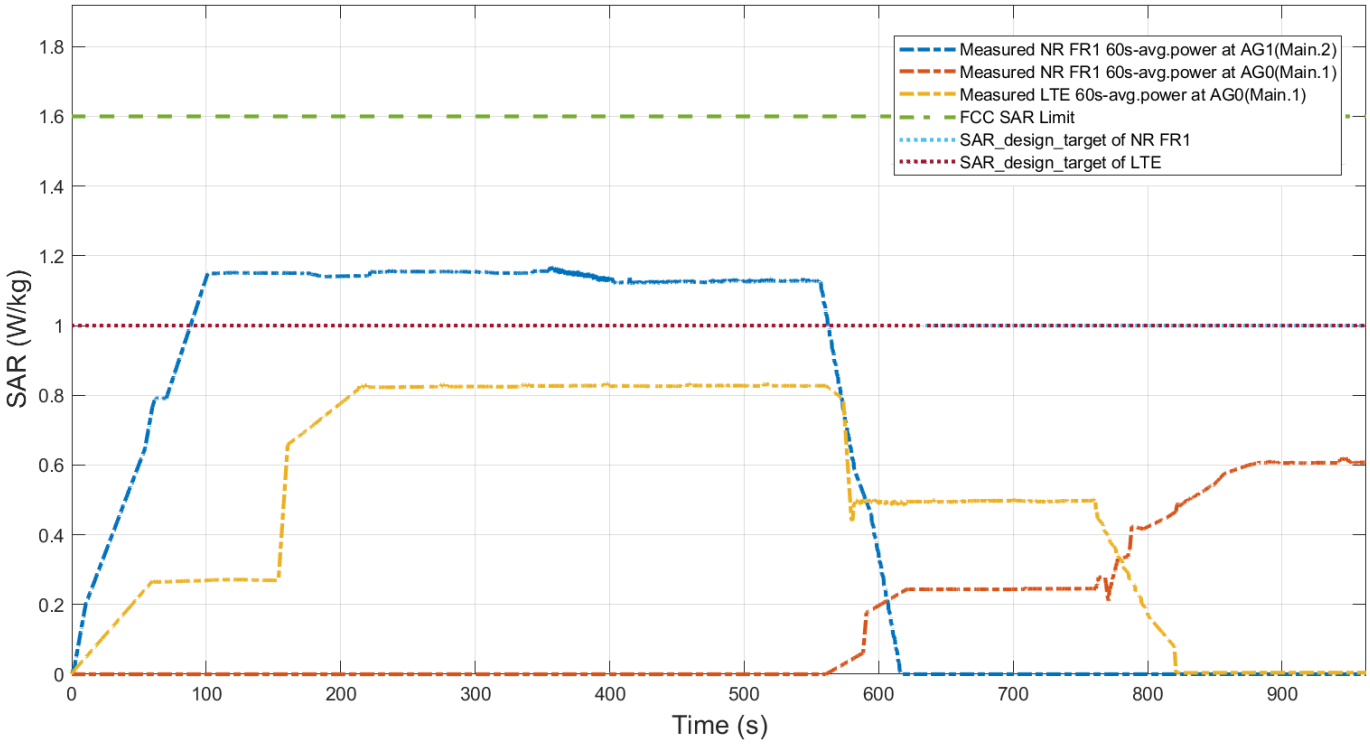
The test results in this section are obtained following the procedure in Section 3.3.8. The test cases correspond to TC26 in Table 5.1.2.

Plot.1 : Conducted Tx power for LTE and NR :



Plot.1 shows the instantaneous and time-averaged conducted Tx power for a NSA operation where LTE is transmitting at AG0's antennas and NR FR1 at AG1's antennas and AG0's antennas. After the EN-DC connection establishment, Both LTE and NR FR1 are set to transmit at 10dBm Tx power for ~150s. Next, a transmission starts with LTE requesting full max power and no transmission for NR FR1 and continue for ~200s. After that, a maximum power is requested for NR FR1 band and transmission is done on AG1's antennas and continue for ~200s. Next, FR1 will switch to other NR FR1 band which will require and antenna switch to AG0's antennas where NR FR1 requests maximum power and transmission continues for ~200s. Since AG0 and AG1 are fully uncoupled, each RAT will operate with full Plimit, where the average power of each RATs is close to Plimit. Next, The LTE transmission is down while NR FR1 continues transmission.

Plot.2 : Total time-averaged SAR Result :



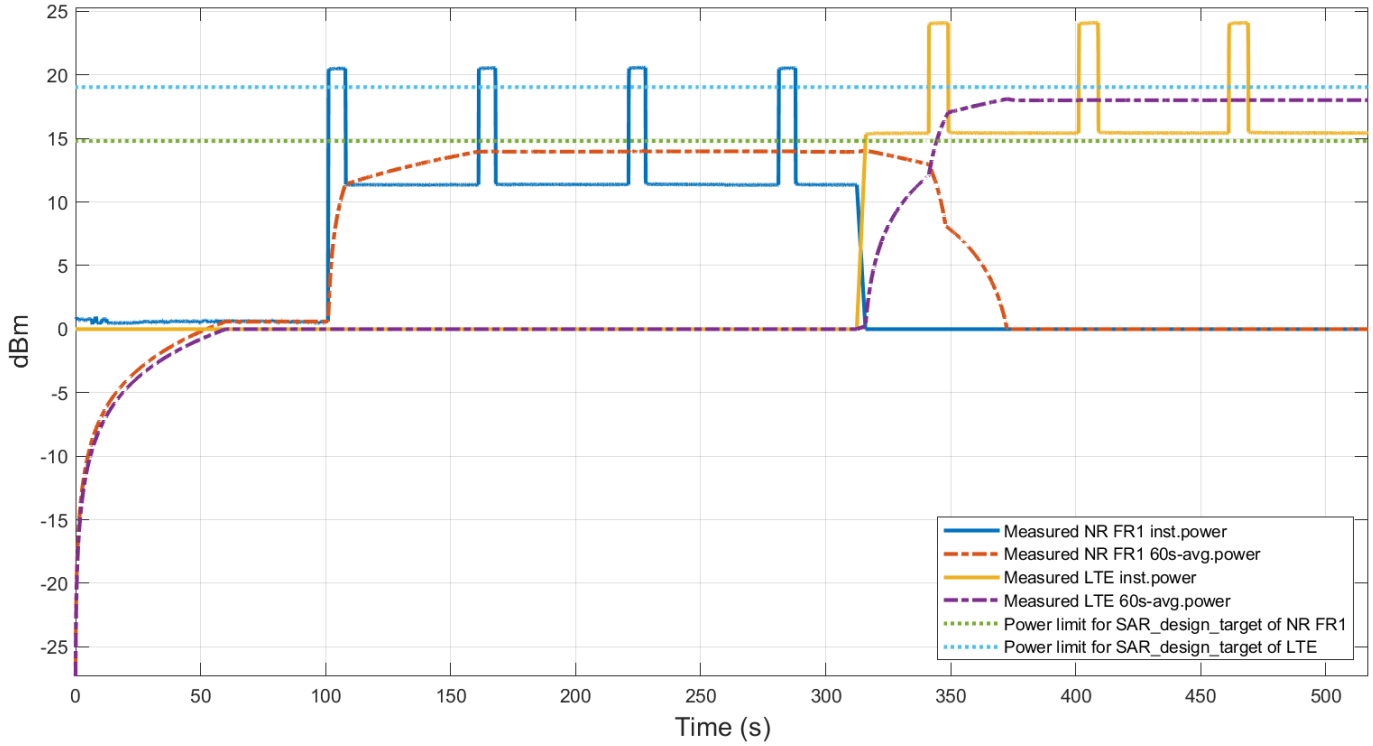
Plot.2 shows consequently the average SAR is below 1.0W/kg(± Uc) which is below the FCC limit of 1.6 W/kg.

FCC1g SAR limit	**1.6** W/kg
Max 60s-time averaged 1gSAR (blue curve)	**1.166** W/kg
Max 60s-time averaged 1gSAR (yellow curve)	**0.831** W/kg
Device uncertainty	**1.0** dB

5.8. TC30: Re-selection in call test results (60s averaging for all bands)

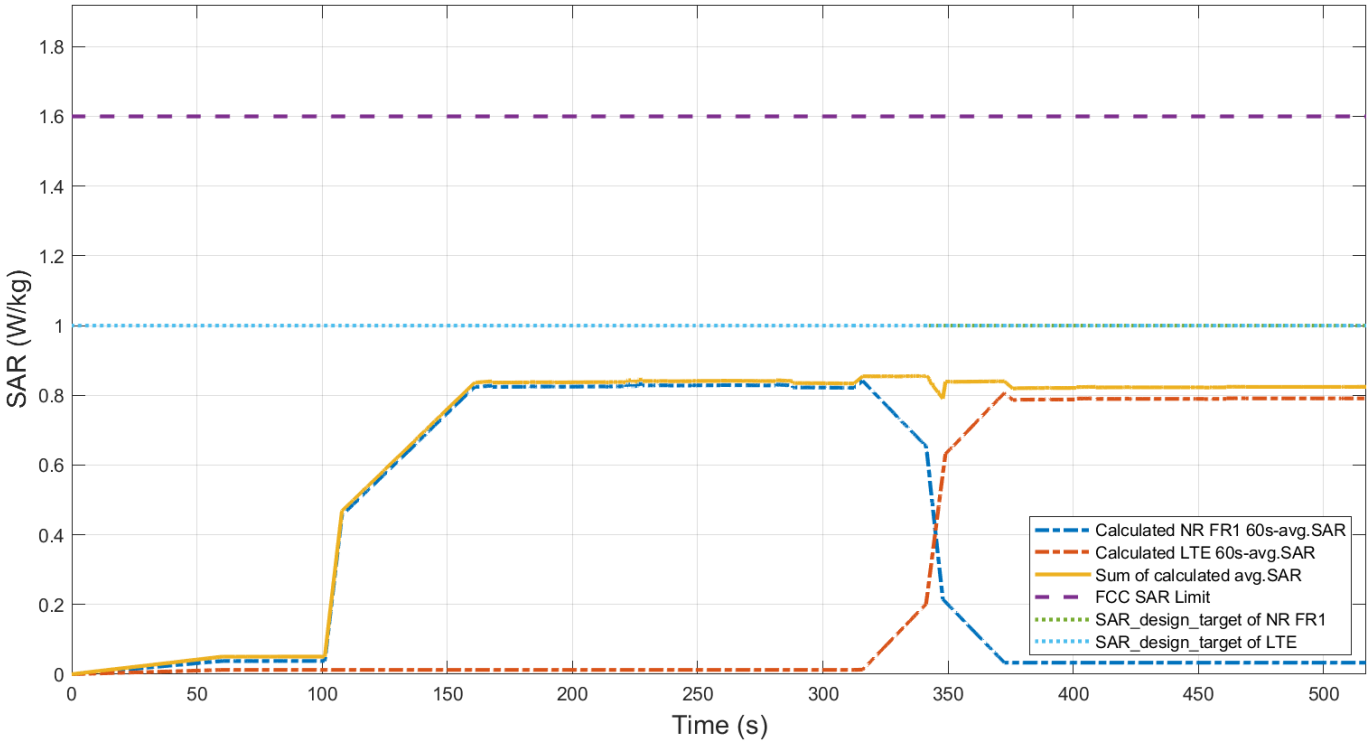
The test results in this section are obtained following the procedure in Section 3.3.3. The test cases correspond to TC30 in Table 5.2.1.

Plot.1 : Conducted Tx power for SAR IRAT re-selection :



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 ~310s, a RAT re-selection from NR FR1 Band to LTE Band was executed, resulting in reduction of time-averaged power of NR FR1 Band and simultaneous increase in time-averaged power of LTE Band.

Plot.2 : Total time-averaged SAR Result :



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 is higher during the band transitions, but is always under the total FCC limit of 1.6W/Kg.

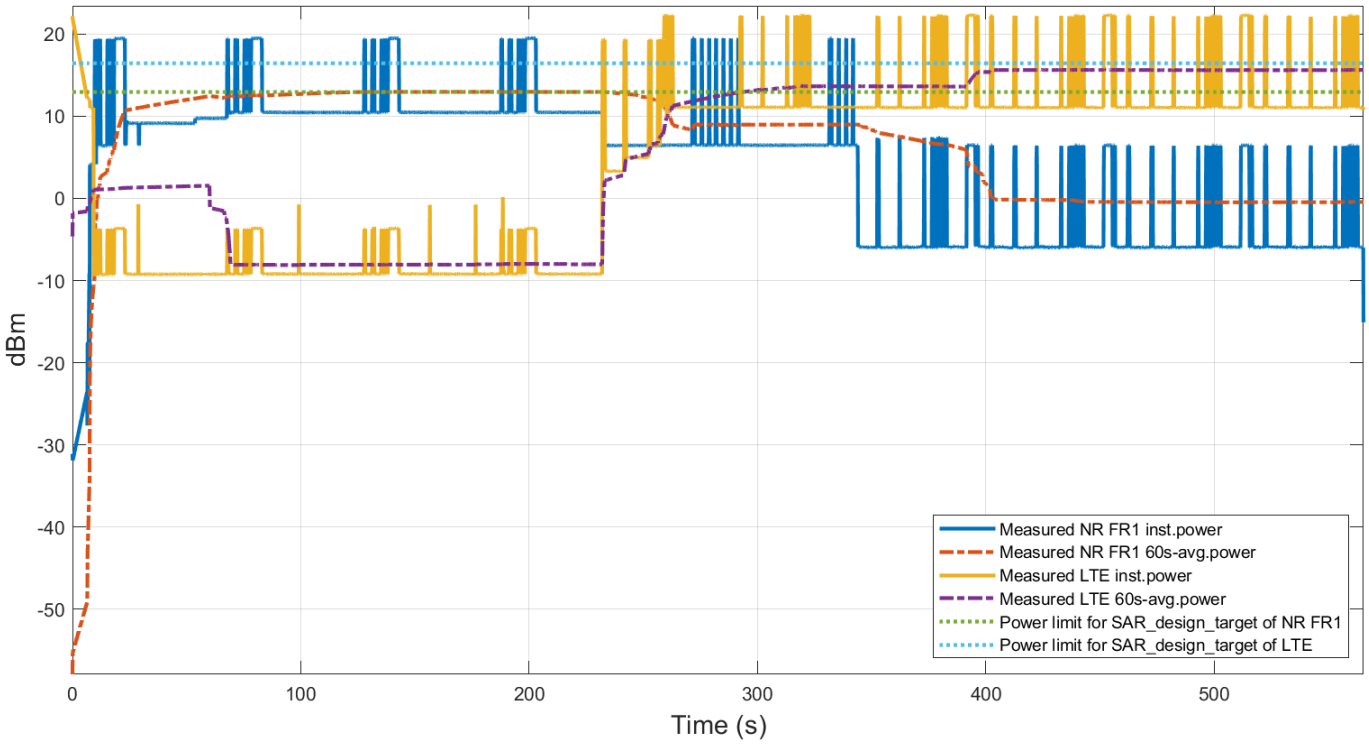
FCC1g SAR limit	**1.6** W/kg
Max 60s-time averaged 1gSAR (orange curve)	**0.856** W/kg
Device uncertainty	**1.0** dB

5.9. TC31 : Switch in SAR exposure (ENDC) test results (60s averaging for all bands)

The test results in this section are obtained following the procedure in Section 3.3.5. The test cases correspond to TC31 in Table 5.2.1.

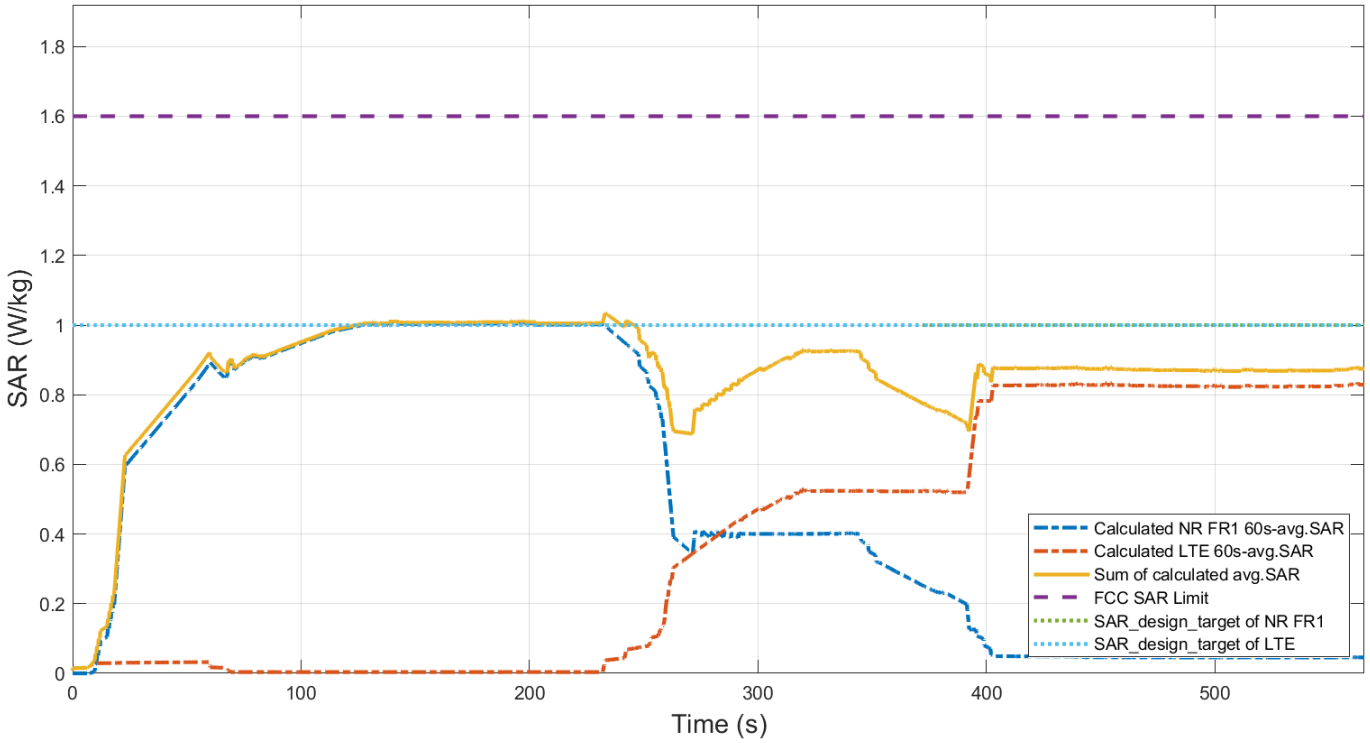
In this LTE+FR1 NSA scenario, we first establish LTE and NR call. In the first part of test, LTE is sent to lowest transmit power using “ALL DOWN” power control commands from call box while NR is sent to maximum power using “ALL UP” power control commands from call box. This would correspond to FR1 dominant 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 220s. Finally, both LTE and NR connections are released.

Plot.1 :Time average SAR of LTE and FR1 in EN-DC case :



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 : Total time-averaged SAR Result :



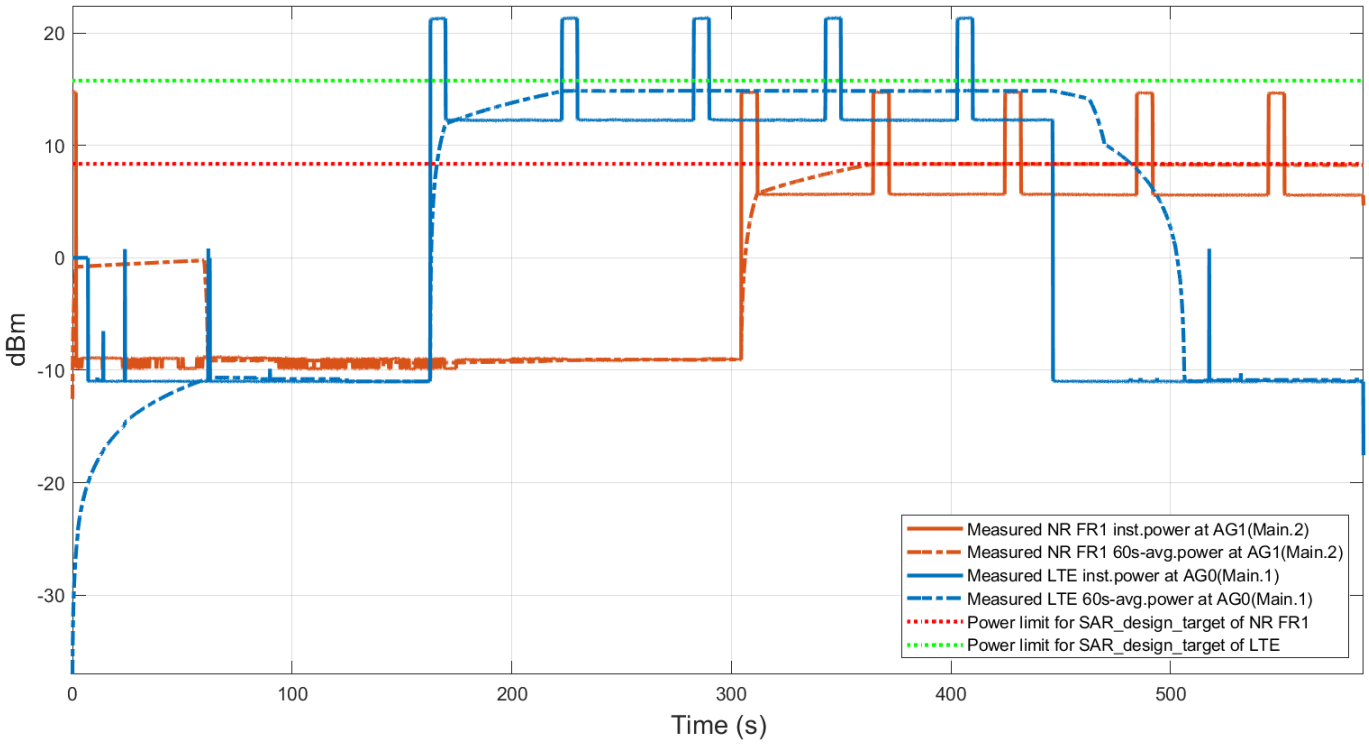
Plot.2 shows the computed time-averaged SAR value for LTE and FR1 as well as the sum. It was confirmed that algorithm operated under the total SAR design target limit of 1.0W/Kg(± Uc), while also being under the FCC limit of 1.6W/Kg at all times. After the operation of FR1 is turned off, it can also be seen that the average power of LTE increases.

FCC1g SAR limit	**1.6** W/kg
Max 60s-time averaged 1gSAR (orange curve)	**1.035** W/kg
Device uncertainty	**1.0** dB

5.10. TC34 : NSA(EN-DC) with spatial TAS test result (60s averaging for all bands)

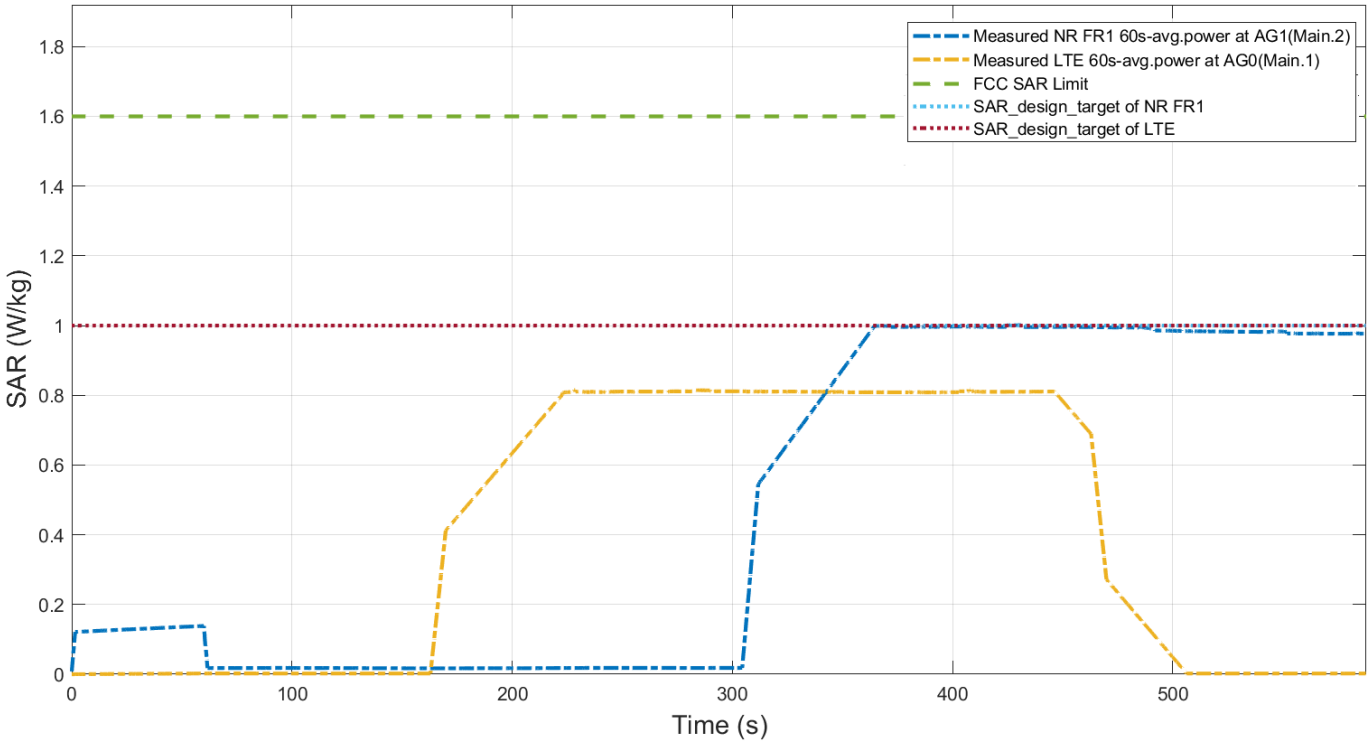
The test results in this section are obtained following the procedure in Section 3.3.8. The test cases correspond to TC34 in Table 5.2.1.

Plot.1 : Conducted Tx power for LTE and NR :



Plot.1 shows the instantaneous and time-averaged conducted Tx power for a NSA operation where LTE is transmitting at AG0's antennas and NR FR1 at antennas of AG1. After EN-DC(NSA) connection establishment, Both LTE and NR FR1 are set to no transmission for ~160s. Next, a transmission starts with LTE requesting full max power and no transmission for NR FR1 and continue for ~140. After that, a maximum power is requested for NR FR1 and transmission is done on AG1's antennas and continue for ~140s. Since both AGs are fully uncoupled, each RAT will operate with full Plimit, where average power of LTE and average power of NR FR1 are closed to Plimit. Next, the LTE transmission is down while NR FR1 continue transmission.

Plot.2 : Total time-averaged SAR Result :



Plot.2 shows consequently the average SAR is within 1.0W/kg(± Uc) which is below the FCC limit of 1.6 W/kg.

FCC1g SAR limit	**1.6**	W/kg
Max 60s-time averaged 1gSAR (blue curve)	AG1(Main.2)	**1.000** W/kg
Max 60s-time averaged 1gSAR (yellow curve)	AG0(Main.1)	**0.811** W/kg
Device uncertainty	**1.0**	dB

6. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Conducted test

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Peak Power Sensor	Anritsu	MA24408A	12797	2025-08-07
Peak Power Sensor	Anritsu	MA24408A	12916	2025-08-07
Directional Coupler	MINI-CIRCUITS	ZMDC10-83-S+	2316	2026-01-02
Directional Coupler	MINI-CIRCUITS	ZMDC10-83-S+	2316	2026-01-02
Band Pass Filter	MINI-CIRCUITS	VBFZ-925-S+	S0236	2026-01-03
Band Pass Filter	MINI-CIRCUITS	VBFZ-2000-S+	S0239	2026-01-03
Band Pass Filter	MINI-CIRCUITS	VBFZ-3590-S+	S0243	2026-01-03
Resistive Power Splitter	WEINSCHEL	1534	S0244	2025-07-24
Resistive Power Splitter	WEINSCHEL	1534	S0247	2025-07-24
Radio Communication Test Station	Anritsu	MT8000A	6272466165	2025-08-20
Radio Communication Analyzer	Anritsu	MT8821C	6161094351	2025-08-20

Note(s):

All equipments were used until Cal.Due data.

7. Conclusions

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 to *SAR_design_target* + Device uncertainty for all the transmission scenarios described in Section 2.

Section A. Test Sequences

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

1. Measured maximum power (P_{max})
2. Measured Tx power (P_{limit}) to satisfy SAR Compliance
3. Setup time to make SAR Remaining be full
4. Do test according to test sequence

A.2 Test sequence A waveform :

Based on the parameters above, the Test Sequence A is generated with one or two power levels where one of the levels is maximum power level (Pmax) which is applied at least for 100s. Based on the second level this test sequence is sub-categorized into four different sequences used:

a. Test Sequence A.i where after Pmax, a second level of Plimit is requested till the end of the test
b. Test Sequence A.ii where after Pmax, a second level of Pmax-3dB is requested till the end of the test
c. Test Sequence A.iii where after Pmax, a second level of Plimit-3dB is requested till the end of the test
d. Test Sequence A.iv where only Pmax is requested till the end of the test

A.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.

Table A.3.1 Table of test sequence B

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

Section B. References

The following documents contain reference in this technical document.

[1] 3GPP TR 37.815: Study on high power User Equipment (UE) (power class 2) for E-UTRA (Evolved Universal Terrestrial Radio Access) – NR Dual Connectivity (EN-DC) (1 LTE FDD band + 1 NR TDD band)
[2] [OEM][2024-09-30] Samsung S.LSI TAS report_v.3.3

Appendixes

Refer to separated files for the following appendixes.

S-4791591721-S1 FCC SAR Part2 App A Photos

End OF REPORT