

# TEST REPORT

## PART 2: RF Exposure Compliance Test of SM-S731B/DS

### APPLICANT

Samsung Electronics. Co., Ltd.

### REPORT NO.

HCT-SR-2507-FC011-R1

### DATE OF ISSUE

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# TEST REPORT

PART 2 RF Exposure  
Compliance Test  
for certification

**REPORT NO.****HCT-SR-2507-FC011-R1****DATE OF ISSUE****Jul. 22, 2025****FCC ID****A3LSMS731B****Applicant**

**SAMSUNG Electronics Co., Ltd**  
**129, Samsung-ro, Yeongtong-gu, Suwon-Si, Gyeonggi-do, 16677, Korea**

**Product Name****Mobile Phone****Model Name****SM-S731B/DS****Additional Model Name****SM-S731B****Date of Test****Jun. 25, 2025 ~ Jul. 17, 2025****Location of Test**

☒ **Permanent Testing Lab**    ☐ **On Site Testing Lab**  
**(Address: 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si,**  
**Gyeonggi-do, 17383 KOREA)**

**FCC Rule Part(s)****CFR § 2.1093****Results****Pass**

## REVISION HISTORY

The revision history for this test report is shown in table.

| Revision No. | Date of Issue | Description     |
|--------------|---------------|-----------------|
| 0            | Jul. 17, 2025 | Initial Release |
| 1            | Jul. 22, 2025 | Revised page 8  |

## Notice

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### Content

The results shown in this test report only apply to the sample(s), as received, provided by the applicant, unless otherwise stated.

The test results have only been applied with the test methods required by the standard(s).

The laboratory is not accredited for the test results marked \*.

Information provided by the applicant is marked \*\*.

Test results provided by external providers are marked \*\*\*.

When confirmation of authenticity of this test report is required, please contact [www.hct.co.kr](http://www.hct.co.kr)

The test results in this test report are not associated with the ((KS Q) ISO/IEC 17025) accreditation by KOLAS (Korea Laboratory Accreditation Scheme) / A2LA (American Association for Laboratory Accreditation) that are under the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Agreement (MRA).

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## 1. RF Exposure Limits

### 1.1 RF Exposure Limits for Frequencies < 6 GHz

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

#### 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 made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

**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.

## 1.2 Interim Guidance for Time Averaging

Per October 2023 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.

| Frequency (GHz):                                                                 | < 3 | 3–6 | 6–10 | 10-16 | 16-24 | 24-42 | 42-95 |
|----------------------------------------------------------------------------------|-----|-----|------|-------|-------|-------|-------|
| Max. Averaging Time (s):                                                         | 100 | 60  | 30   | 14    | 8     | 4     | 2     |
| From: Oct. 2018 TCBC Workshop, " <a href="#">RF Exposure Order/NPRM Issues</a> " |     |     |      |       |       |       |       |

Note:

S.LSI's TAS algorithm applies an overall average time of 60 seconds for communication modes below 6 GHz frequency, 4 seconds for 24 – 42 GHz to control the output in the worst case.

## 2. Test Location

### 2.1 Test Laboratory

|              |                                                                                 |
|--------------|---------------------------------------------------------------------------------|
| Company Name | HCT Co., Ltd.                                                                   |
| Address      | 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383 KOREA |
| Telephone    | 031-645-6300                                                                    |
| Fax.         | 031-645-6401                                                                    |

### 2.2 Test Facilities

Our laboratories are accredited and approved by the following approval agencies according to ISO/IEC 17025.

|       |                                                         |
|-------|---------------------------------------------------------|
| Korea | National Radio Research Agency (Designation No. KR0032) |
|       | KOLAS (Testing No. KT197)                               |

### 2.3 General Information of the EUT

|                       |                               |
|-----------------------|-------------------------------|
| Model Name            | SM-S731B/DS                   |
| Additional Model Name | SM-S731B                      |
| Equipment Type        | Mobile Phone                  |
| FCC ID                | A3LSMS731B                    |
| Application Type      | Certification                 |
| Applicant             | SAMSUNG Electronics Co., Ltd. |

### 3. DEVICE UNDER TEST DESCRIPTION

#### 3.1 DUT specification

| Device Wireless specification overview |                                                                                                                                                                                        |                             |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Band & Mode                            | Operating Mode                                                                                                                                                                         | Tx Frequency                |
| GSM850                                 | Voice / Data                                                                                                                                                                           | 824.2 MHz ~ 848.8 MHz       |
| GSM1900                                | Voice / Data                                                                                                                                                                           | 1 850.2 MHz ~ 1 909.8 MHz   |
| UMTS Band 2                            | Voice / Data                                                                                                                                                                           | 1 852.4 MHz ~ 1 907.6 MHz   |
| UMTS Band 4                            | Voice / Data                                                                                                                                                                           | 1 712.4 MHz ~ 1 752.6 MHz   |
| UMTS Band 5                            | Voice / Data                                                                                                                                                                           | 826.4 MHz ~ 846.6 MHz       |
| LTE FDD Band 2 (PCS)                   | Voice / Data                                                                                                                                                                           | 1 850.7 MHz ~ 1 909.3 MHz   |
| LTE FDD Band 4 (AWS)                   | Voice / Data                                                                                                                                                                           | 1 710.7 MHz ~ 1 754.3 MHz   |
| LTE FDD Band 5 (Cell)                  | Voice / Data                                                                                                                                                                           | 824.7 MHz ~ 848.3 MHz       |
| LTE FDD Band 12                        | Voice / Data                                                                                                                                                                           | 699.7 MHz ~ 715.3 MHz       |
| LTE FDD Band 13                        | Voice / Data                                                                                                                                                                           | 779.5 MHz ~ 784.5 MHz       |
| LTE FDD Band 17                        | Voice / Data                                                                                                                                                                           | 706.5 MHz ~ 713.5 MHz       |
| LTE FDD Band 25                        | Voice / Data                                                                                                                                                                           | 1 850.7 MHz ~ 1 914.3 MHz   |
| LTE FDD Band 26                        | Voice / Data                                                                                                                                                                           | 814.7 MHz ~ 848.3 MHz       |
| LTE TDD Band 41                        | Voice / Data                                                                                                                                                                           | 2 498.5 MHz ~ 2 687.5 MHz   |
| LTE FDD Band 66 (AWS)                  | Voice / Data                                                                                                                                                                           | 1 710.7 MHz ~ 1 779.3 MHz   |
| NR FDD Band n2 (PCS)                   | Voice / Data                                                                                                                                                                           | 1 852.5 MHz ~ 1 907.5 MHz   |
| NR FDD Band n5                         | Voice / Data                                                                                                                                                                           | 826.5 MHz ~ 846.5 MHz       |
| NR FDD Band n25 (PCS)                  | Voice / Data                                                                                                                                                                           | 1 852.5 MHz ~ 1 912.5 MHz   |
| NR TDD Band n41                        | Voice / Data                                                                                                                                                                           | 2 501.01 MHz ~ 2 685 MHz    |
| NR FDD Band n66                        | Voice / Data                                                                                                                                                                           | 1 712.5 MHz ~ 1 777.5 MHz   |
| NR TDD Band n77                        | Voice / Data                                                                                                                                                                           | 3 705 MHz ~ 3 975 MHz       |
| NR TDD Band n77 DoD                    | Voice / Data                                                                                                                                                                           | 3 445.01 MHz ~ 3 544.98 MHz |
| U-NII-1                                | Voice / Data                                                                                                                                                                           | 5 180 MHz ~ 5 240 MHz       |
| U-NII-2A                               | Voice / Data                                                                                                                                                                           | 5 260 MHz ~ 5 320 MHz       |
| U-NII-2C                               | Voice / Data                                                                                                                                                                           | 5 500 MHz ~ 5 720 MHz       |
| U-NII-3                                | Voice / Data                                                                                                                                                                           | 5 745 MHz ~ 5 825 MHz       |
| U-NII-4                                | Voice / Data                                                                                                                                                                           | 5 845 MHz ~ 5 885 MHz       |
| U-NII-5                                | Voice / Data                                                                                                                                                                           | 5 925 MHz ~ 6 425 MHz       |
| U-NII-6                                | Voice / Data                                                                                                                                                                           | 6 425 MHz ~ 6 525 MHz       |
| U-NII-7                                | Voice / Data                                                                                                                                                                           | 6 525 MHz ~ 6 865 MHz       |
| U-NII-8                                | Voice / Data                                                                                                                                                                           | 6 865 MHz ~ 7 115 MHz       |
| 2.4 GHz WLAN                           | Voice / Data                                                                                                                                                                           | 2 412 MHz ~ 2 472 MHz       |
| Bluetooth / LE 5.4                     | Data                                                                                                                                                                                   | 2 402 MHz ~ 2 480 MHz       |
| NFC                                    | Data                                                                                                                                                                                   | 13.56 MHz                   |
| Device Serial Numbers                  | Mode                                                                                                                                                                                   | Serial Number               |
|                                        | 2G/3G/4G/5G Sub 6 NR                                                                                                                                                                   | YFI1681M                    |
|                                        | WLAN, C-TAS                                                                                                                                                                            | YFI1658M                    |
|                                        | The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics are within operational tolerances expected for production units. |                             |

### Measurement Results Summary Table (FR1)

| TC# | Test scenario                                                                          | Tech    | Band | Antenna  | RSI | Measured<br>1g SAR | Max averaged<br>time 1g SAR | Test<br>Result |
|-----|----------------------------------------------------------------------------------------|---------|------|----------|-----|--------------------|-----------------------------|----------------|
|     |                                                                                        |         |      |          |     | (W/kg)             | (W/kg)                      |                |
| 1   | Time varying Tx<br>power Sequence 1                                                    | LTE     | 25   | Main1(A) | 0   | 0.962              | 1.017                       | Verified       |
| 2   |                                                                                        | SA/FR1  | n25  | Main1(A) | 0   | 0.851              | 0.849                       | Verified       |
| 3   |                                                                                        | UMTS    | 2    | Main1(A) | 0   | 0.980              | 1.070                       | Verified       |
| 4   |                                                                                        | GSM     | 1900 | Main1(A) | 0   | 0.851              | 0.897                       | Verified       |
| 5   | Time varying Tx<br>power Sequence 2                                                    | LTE     | 25   | Main1(A) | 0   | 0.962              | 0.846                       | Verified       |
| 6   |                                                                                        | SA/FR1  | n25  | Main1(A) | 0   | 0.851              | 0.820                       | Verified       |
| 7   |                                                                                        | UMTS    | 2    | Main1(A) | 0   | 0.980              | 1.016                       | Verified       |
| 8   |                                                                                        | GSM     | 1900 | Main1(A) | 0   | 0.851              | 0.806                       | Verified       |
| 9   | Change in Call                                                                         | LTE     | 25   | Main1(A) | 0   | 0.962              | 0.946                       | Verified       |
| 10  | Re-selection in call<br>(Tech Swith)                                                   | SA/FR1  | n25  | Main1(A) | 0   | 0.851              | 1.089                       | Verified       |
|     |                                                                                        | LTE     | 25   | Main1(A) |     | 0.962              |                             | Verified       |
| 11  | Antenna Band Switch                                                                    | LTE     | 25   | Main1(A) | 0   | 0.962              | 0.900                       | Verified       |
|     |                                                                                        | LTE     | 41   | Main2(B) |     | 0.834              |                             |                |
| 12  | SAR exposure switch<br>(NSA, same group)                                               | NSA/FR1 | n25  | Main1(A) | 0   | 0.851              | 0.920                       | Verified       |
|     |                                                                                        | LTE     | L12  | Main1(A) |     | 0.913              |                             |                |
| 13  | Change in RSI                                                                          | SA/FR1  | n25  | Main1(A) | 0   | 0.851              | 0.867                       | Verified       |
|     |                                                                                        |         |      | Main1(A) | 1   | 0.204              |                             |                |
| 14  | NSA antenna<br>switching with Spatial<br>TAS<br>(same group,NSA -><br>other group,NSA) | LTE     | 12   | Main1(A) | 0   | 0.913              | 0.978                       | Verified       |
|     |                                                                                        | NSA/FR1 | n41  | Main2(B) |     | 0.321              |                             |                |
|     |                                                                                        | NSA/FR1 | n77  | Sub2(F)  |     | 0.601              |                             |                |

Measurement Results Summary Table (WLAN/Bluetooth)

| WTC# | Test scenario                                   | Tech | Band    | Antenna | RSI | Measured<br>1g SAR | Max<br>averaged<br>time 1g SAR | Test<br>Result |
|------|-------------------------------------------------|------|---------|---------|-----|--------------------|--------------------------------|----------------|
|      |                                                 |      |         |         |     | (W/kg)             | (W/kg)                         |                |
| 1    | Tx Power of WLAN<br>TAS Test<br>(Bluetooth off) | WLAN | 2.4 GHz | Sub4(H) | 0   | 0.537              | 0.581                          | Verified       |
|      |                                                 |      |         |         | 1   | 0.421              |                                |                |
| 2    |                                                 |      | 5 GHz   | Sub4(H) | 0   | 0.409              | 0.493                          | Verified       |
|      |                                                 |      |         |         | 1   | 0.524              |                                |                |
| 3    |                                                 |      | 6 GHz   | Sub4(H) | 0   | 0.130              | 0.138                          | Verified       |
|      |                                                 |      |         |         | 1   | 0.070              |                                |                |

Note: RSI(0) – Non-Head, RSI(1) – Head FCC SAR Limit [W/kg]: 1.6W/kg, 1g

The SAR Design Target for Main Band is 1.0W/kg, WLAN mode is 0.8W/kg, and an uncertainty of 1dB is applied to each mode

### Measurement Results Summary Table (Combined-TAS)

The C-TAS (Combined-TAS) algorithm is applied to this model to control the output Power of the S.LSI TAS algorithm in the main band and the TAS algorithm in WLAN/BT mode to ensure that the FCC limit is always complied with.

| C-TC# | Test scenario | Tech      | Band | Antenna | RSI | TER <1.0 | TEST Result |
|-------|---------------|-----------|------|---------|-----|----------|-------------|
| 1     | Combined TAS  | LTE       | 66   | Sub2(F) | 0   | 0.560    | Verified    |
|       |               | WLAN      | 5GHz | Sub4(H) |     |          |             |
|       |               | Bluetooth | BDR  | Sub4(H) |     |          |             |
| 2     | Combined TAS  | SA/FR1    | n77  | Sub2(F) | 0   | 0.587    | Verified    |
|       |               | WLAN      | 5GHz | Sub4(H) |     |          |             |
|       |               | Bluetooth | BDR  | Sub4(H) |     |          |             |

The verification test of the C-TAS algorithm was performed by selecting the worst case of the main band and the worst case of the WLAN/BT mode and evaluating them simultaneously under the worst conditions to verify compliance with FCC limits.

In each test case in Part 2, the measured time-averaged power deviated from the device's  $P_{\text{limit}}$  within an uncertainty of 1dB, and the SAR value calculated under the measured time-averaged power condition complied with FCC limits.

## 4. TAS algorithm description

### 4.1 High-level algorithm concept

The RF exposure limit is defined based on time-average exposure during a certain amount of time window. Basically, the length of time window is adjustable in current TAS algorithm implementation. As representative values, following time window sizes are introduced in the report. Time window size 60 seconds and 4 seconds are used for SAR (Sub 6GHz) and PD (Above 6GHz) respectively in this evaluation report aligning with the FCC requirement. TAS algorithm ensures the DUT can meet the FCC compliance at all times over test duration. As we will establish via lab characterization, both SAR and PD are directly proportional to terminal Tx(transmitter)power, so TAS algorithm scales transmitter power level dynamically to meet compliance.

Samsung S.LSI proprietary TAS algorithm considers 4G and 5G NR cellular RAT, and connectivity technologies such as Wi-Fi and BT (Bluetooth) because the DUT should keep the total amount of radiation below the level defined by regulations. To do this, modem controls transmitter power in real time. Because FR2 systems can have different PD impacts depending on beam index and module selection, operation scenarios that change those are considered as well.

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

- Maximum Tx power limit for a particular RAT is calculated considering SAR/PD compliance using some pre-characterization data.

- Instantaneous Tx power can go over Tx power limit but average value during any measurement window will be maintained below the Tx power limit. This operation is depicted in Figure 4.1-1.

- In a simultaneous multi-RAT scenario, TAS algorithm also has to meet TER (Total Exposure Ratio), which is sum of actual SAR/PD to the compliance limits across all RATs. TER of the DUT will be equal to or less than 1at all time.

- To preserve the radio link quality and call connection, TAS algorithm provides the concept of priority of each RAT's transmit power. For instance, a certain minimum value of max transmit power limit will be ensured for anchor RAT such as LTE in EN-DC.

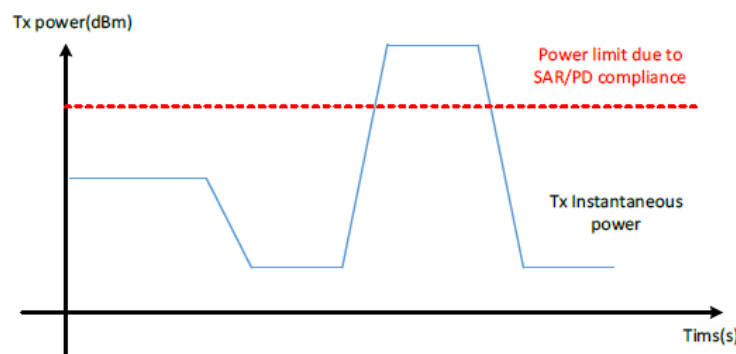
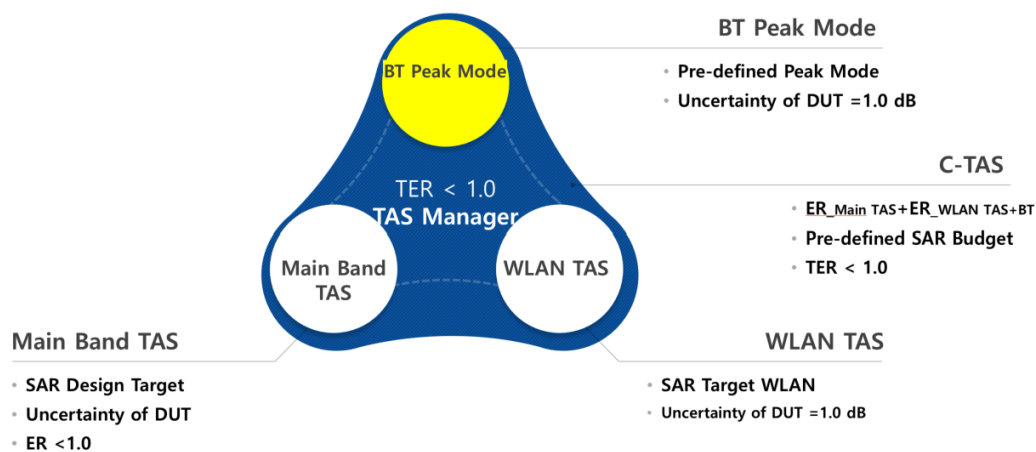


Figure 4.1-1 TAS algorithm concept

## 4.2 Algorithm operation and configurable parameters for each RAT

This model applies S.LSI's main band -TAS algorithm, S.LSI's WLAN/BT -TAS algorithm, and C-TAS, a TAS manager that controls these two algorithms to comply with FCC Limits. So, the validity of all applied TAS algorithms was tested and verified.



Samsung S.LSI proprietary TAS algorithm operates as follows.

Define the minimum duration of SAR/PD calculation. This duration is the 'SAR/PD average window' consists of N slots. Any measurement duration or time-averaging duration as specified by FCC for the particular RAT will then consist of M such windows. The product of FCC limit of SAR/PD limit (or equivalently the Tx power for this limit as used in the algorithm) and M is then defined as a SAR budget for such measurement durations.

For a particular window, calculate the amount of average SAR consumed during the window duration by computing average of instantaneous transmit power value per slot. Because SAR value isn't given directly, Tx power value is used to calculate consumed SAR value.

Estimates the total SAR consumed during the SAR/PD measurement duration in the past which includes the above window. This value will be the sum of SAR/PD consumed by all windows in the measurement duration.

Monitor the remaining SAR budget continuously for every window and control the maximum Tx power for the next window to comply with SAR/PD regulation

Below figure illustrates the detailed operation of the TAS algorithm. Please keep in mind the unit of TAS/PD evaluation is average power (unit: Watt) during the measurement duration. Then total SAR budget can be defined as required average SAR \* measurement duration to comply with FCC requirements. So, 'SAR Budget' is defined as an integrated SAR value during measurement duration. To monitor the risk of test failure with fine granularity, the measurement duration is divided into fine sub-time blocks called 'window's, and a maximum power limit is imposed for each window. TAS algorithm updates consumed SAR in the current window and remaining budget exploiting moving average window concept. As mentioned above, we don't know SAR value directly, so Tx power is used for calculation.

Whenever N slots have passed, TAS algorithm discards a past window and adds a new window to update SAR status. From the result, TAS algorithm calculates permissible max Tx power (Tx MaxPower) for next window to meet SAR compliance test. By ensuring that the DUT does not transmit higher power than this max Tx power, we are guaranteed that the consumed SAR/PD for any measurement duration will not exceed the SAR/PD budget. Because slot (TTI) is very short time interval and fine enough granularity, DUT can handle various events and respond promptly. The reason why N is defined is for flexibility of implementation. If N=1, budget will be updated every slot. It can reflect Tx power change promptly, but too frequent updates can increase CPU software processing burden when TAS algorithm is implemented in modem software.

In this implementation, the length of each window needs to be small enough to respond promptly to various event scenarios. For instance, allowed SAR consumption limit may need to be adjusted by events. Hence proper value of window size is applied for each RAT to comply with this requirement.

By considering remaining SAR budget, maximum SAR for next window is determined. It could be larger or smaller than SAR\_design\_target as instant power. Figure 3.2-1 shows the overall concept of TAS measurement duration and window. In each consumed SAR is saved in each window, and window size is fixed in same RAT. If RAT is changed the window size could be changed.

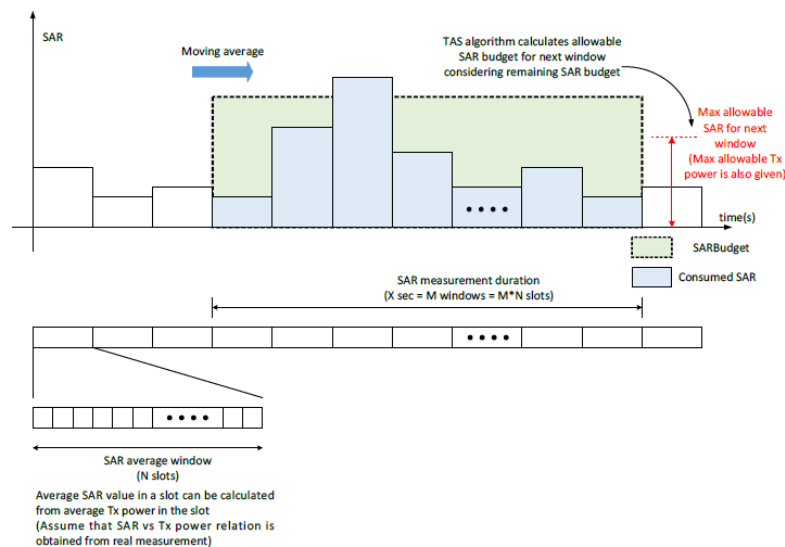


Figure 4.2-1 SAR measurement from Tx power using block-wise processing

LTE/FR1 and legacy transmitter should follow SAR requirements for sub6 GHz. On the other hand, FR2 transmitter has to follow MPE (Maximum Permissible Exposure) requirements or PD limit. But EN-DC and other various cases should be supported in real usage as well as other NR combinations. For these cases, total exposure ratio (TER) criteria calculated at any instance 't' is defined as follows.

-For sub-6 transmissions only:

$$TER(t) = \frac{\sum_{l_{SAR}=0}^{L_{SAR}-1} SAR_{avg,l_{SAR}}(t)}{SAR_{limit,FCC}} \leq 1 \quad (4-1)$$

-For both sub-6 and mmWave transmissions:

$$TER(t) = \frac{\sum_{l_{SAR}=0}^{L_{SAR}-1} SAR_{avg,l_{SAR}}(t)}{SAR_{limit,FCC}} + \frac{\sum_{l_{PD}=0}^{L_{PD}-1} PD_{avg,l_{PD}}(t)}{PD_{limit,FCC}} \leq 1 \quad (4-2)$$

where  $SAR_{avg,l_{SAR}}(t)$  is the average SAR over a period of  $T_{SAR,l_{SAR}}$  (for example 60s) for the ' $l_{SAR}$ -th' RF source operating below 6 GHz and is defined as

$$SAR_{avg,l_{SAR}}(t) = \frac{1}{T_{SAR,l_{SAR}}} \int_{u=t-T_{SAR,l_{SAR}}}^t SAR_{l_{SAR}}(u) du \quad (4-3)$$

and  $PD_{avg,l_{PD}}(t)$  is the average PD over a period of  $T_{PD,l_{PD}}$  (for example 4s) for the ' $l_{PD}$ -th' mmwave RF source and is defined as

$$PD_{avg,l_{PD}}(t) = \frac{1}{T_{PD,l_{PD}}} \int_{u=t-T_{PD,l_{PD}}}^t PD_{l_{PD}}(u) du \quad (4-4)$$

In addition, SAR represents sub-6 GHz average power, PD stands for power density of MPE regulation,  $R$  is the number of fixed, mobile or portable RF sources using SAR-based formula and  $L_{PD}$  is the number of fixed, mobile or portable RF sources using PD (MPE)-based formula. Please keep in mind that each carrier can be regarded as a transmitter. Considering a whole platform terminal, Wi-Fi and BT should be counted in as well. Real time information sharing between a cellular CP (Communication Processor) and Wi-Fi/BT processor isn't feasible due to communication interface delay in most cases. More proper way is assigning normalized SAR budget to Wi-Fi and BT. Then the TER equations above are given like follows.

-For sub-6 transmissions only:

$$TER(t) = \frac{\sum_{l_{SAR}=0}^{L_{SAR}-1} SAR_{avg,l_{SAR}}(t)}{SAR_{limit,FCC}} \leq 1 - SAR_{WiFi, Norm} - SAR_{BT, Norm} \quad (4-5)$$

-For both sub-6 and mmWave transmissions:

$$TER(t) = \frac{\sum_{l_{SAR}=0}^{L_{SAR}-1} SAR_{avg,l_{SAR}}(t)}{SAR_{limit,FCC}} + \frac{\sum_{l_{PD}=0}^{L_{PD}-1} PD_{avg,l_{PD}}(t)}{PD_{limit,FCC}} \leq 1 - SAR_{WiFi, Norm} - SAR_{BT, Norm} \quad (4-6)$$

$SAR_{WiFi, Norm}$  is the normalized SAR value of Wi-Fi and  $SAR_{BT, Norm}$  is the normalized SAR value of BT and these can be figured out by lab characterization tests at highest allowed powers for Wi-Fi/BT. These values are zero if the transmitters of these technologies are disabled. We can keep the simple TER criteria considering all components in a platform in this way. Please note that in this report TAS does not control the Wi-Fi or the Bluetooth radio, so the values of  $SAR_{WiFi, Norm}$  and  $SAR_{BT, Norm}$  are considered fixed regardless of the state of these transmitters. In addition, these values can be allocated by the OEM either in a fixed or varying manner. For instance, the OEM can determine these normalized Wi-Fi and Bluetooth SAR values at any instant 't' as in Eqn. (4-3).

To measure TER, measure method of SAR and PD should be defined. Most important parameter is the required average time. The maximum averaging time for SAR measurement for FCC is 60 or 100 seconds depends on carrier frequency (whether higher or lower than 3GHz, respectively). On the other hand, 4 second scan can be considered for PD measurement average duration. The value of measurement duration in the algorithm can be flexibly adjusted based on the actual requirement of SAR/PD compliance even if they are changed later. In legacy and FR1 cases, measured time for one window is considered as 250ms and 50ms for FR2. There are N slots in one window, and all power used in each slot is averaged and stored in one window.

## 5. SAR/PD baseline characterization

### 5.1 Parameters and design targets for TAS

To determine the parameters for the TAS algorithm operation, the terms in Table 5.1-1 are defined first.

**Table 5.1-1 Definitions for TAS algorithm**

| Term                                      | Description                                                                                                                                                                                         |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $P_{max}$                                 | Maximum Tx power that can be transmitted physically from RFIC for a given RAT                                                                                                                       |
| $SAR_{regulatory\_limit}$                 | SAR value limit specified by FCC                                                                                                                                                                    |
| $PD_{regulatory\_limit}$                  | PD value limit specified by FCC                                                                                                                                                                     |
| $SAR_{desing\_target}$                    | Target SAR level using in TAS algorithm. This SAR value should be less than above regulatory limit and should be determined after accounting for all uncertainties and other design considerations. |
| $PD_{design\_target}$                     | Target PD level using in TAS algorithm. This PD value should be less than $Spec$ and should be determined accounting for all uncertainties and other design considerations.                         |
| $P_{limit}$                               | Power level corresponds to the SAR or PD design target.                                                                                                                                             |
| Time window size for SAR<br>(Sub 6 GHz)   | Time window size 60 seconds                                                                                                                                                                         |
| Time window size for SAR<br>(Above 6 GHz) | Time window size 30 seconds                                                                                                                                                                         |

First, it is  $P_{max}$ , which means maximum Tx power that can be transmitted physically from RFIC under the constraints of the technology specification. The regulatory limit is a value required by FCC standards, and it is defined as 1.6 W/Kg in 1gSAR condition. The  $SAR_{design\_target}$  is the achievable SAR value determined in consideration of uncertainty, and the power at the corresponding  $SAR_{design\_target}$  is defined as the  $P_{limit}$  value. For example, if the power corresponding to 1.6W/Kg is 23dBm and the  $SAR_{design\_target}$  is 1.0W/Kg, the  $P_{limit}$  is 20.96dBm. If  $P_{limit}$  is expressed as an equation, it can be expressed as follows.

$$P_{limit} = P_{max} + 10 \times \log_{10}\left(\frac{SAR_{design\_target}}{SAR} @ P_{max}\right) \quad (5-1)$$

For sub 6 GHz and legacy modem, maximum Tx power( $P_{max}$ )and allowable limit power ( $P_{limit}$ ) has to be defined. In general cases, if  $P_{max} < P_{limit}$ , TAS algorithm doesn't need to work when other RATs are not enabled. However, when single Wi-Fi or RSDB (Real simultaneous dual band) operations are considered, the TAS operation is determined based on condition  $P_{max} + \delta < P_{limit}$ . In this case, the  $\delta$  value means an additional margin value to turn off TAS operation. For mmWave, power limit of each beam and module should be controlled because they have different PD impacts.

The design target value should themselves be determined to ensure that DUT can comply with FCC SAR/PD regulation limit even after accounting all device uncertainties. This is the bare minimum of design target value and additional offset can be considered to have more margin.

$$SAR_{design\_target} < SAR_{regulatory\_limit} \times 10^{-total\_uncertainty_{SAR}/10} \quad (5-2)$$

$$PD_{design\_target} < PD_{regulatory\_limit} \times 10^{-total\_uncertainty_{PD}/10} \quad (5-3)$$

**Table 5.1-2 Definitions for uncertainty and design target**

| Term                         | Description                                                                                                                                                                                                                                                                                                                                              |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>SAR_regulatory_limit</i>  | 1.6W/Kg at 1gSAR for head<br>1.6 W/Kg at 1gSAR for body (Hotspot)<br>4.0W/Kg at 10gSAR for extremity                                                                                                                                                                                                                                                     |
| <i>Total_uncertainty_SAR</i> | 1.0 dB(considering Tx power variation, part to part deviation, etc.)                                                                                                                                                                                                                                                                                     |
| <i>SAR_desing_target</i>     | <i>SAR_design_target</i> should be less than 1.27W/Kg<br>Considering safety margin, 1.0 W/Kg is used as the value of <i>SAR_design_target</i>                                                                                                                                                                                                            |
| <i>PD_regulatory_limit</i>   | 10 W/m <sup>2</sup> (averaged over 4cm <sup>2</sup> area), 200 W/m <sup>2</sup> (1cm <sup>2</sup> )                                                                                                                                                                                                                                                      |
| <i>Total_uncertainty_PD</i>  | 2.3dB(considering Tx EIRP variation, part to part deviation, etc.)                                                                                                                                                                                                                                                                                       |
| <i>PD_design_target</i>      | <i>PD_design_target</i> should be less than 5.89 W/m <sup>2</sup> and 118 W/m <sup>2</sup> according to equation (5.2.2) for 4cm <sup>2</sup> and 1cm <sup>2</sup> respectively.<br>Considering safety margin, 5.9W/Kg and 118 W/m <sup>2</sup> is used as the value of <i>SAR_design_target</i> for 4cm <sup>2</sup> and 1cm <sup>2</sup> respectively. |

A mmWave transmitter is more sensitive to environment and temperature. EIRP variation is also substantial to sub 6GHz technology and large uncertainty needs to be applied on. Even though very conservative SAR design target is applied for single RAT case, this value needs to be relaxed considering multi-transmitter source application (EN-DC, cellular + connectivity, etc.) Therefore, *SAR\_design\_target* < 1.27W/Kg is applied here for sum of all sources' SAR. Please note that Tx EIRP in this document is the EIRP of bore-sight direction when bore-sight beam is used. Because EIRP can vary according to beam code setting in mmWave, a certain representative metric is required. Therefore, EIRP using bore-sight code at bore-sight direction is defined as Tx EIRP in this report. And the same amount of antenna input power setting is used for other beams as well as bore-sight beam.

## 6. Tx Varying Transmission Test Cases and Test Proposal.

In order to validate the TAS algorithm, we propose many test cases to confirm that TAS can ensure the compliance for different operation scenarios. In this section, we explain the reasoning for the selection of test cases and how the performance is validated.

As described in Section 6 the RF exposure is proportional to the Tx power for both sub-6 GHz, and FR2 technologies. Thus, we rely on conducted power measurements for sub-6 GHz RATs (such as 2G, WCDMA, LTE and FR1) and radiated power measurements (FR2) in each dynamic case to demonstrate that overall RF exposure is within the FCC limit. Detailed test case numbering, procedures and test configurations are covered in Sections 7,9 and 10. The final performance validation results for all test cases are then provided in Sections 10 and 11. Here we provide a general explanation of how the tests carried out and some examples of the way results will be presented.

The overall procedure for validating any test case is summarized below:

1. Measure conducted power for any sub-6GHz RAT (such as LTE and FR1) over time, denoted as  $TxPower_{sub6GHz}(t)$ , and radiated Power EIRP(FR2) over time, denoted  $EIRP_{FR2}(t)$ , with time index  $t$ . These are measured values reported by the power meter referenced back to the UE antenna planes.
2. Convert measured powers to RF exposure values using linear relationship shown below. In below expression,  $P_{limit,sub6GHz}$ , would be the measured power at which the sub-6GHz technology meets measured SAR level of  $SAR_{design\_target}$ . Similarly,  $P_{limit,FR2}$  would be the measured EIRP at which FR2 technology meets the measured PD level of  $PD_{design\_target}$

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

Eqn. (1)

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

Eqn. (2)

3. Compute the total RF exposure over the most recent measurement duration which are denoted as  $T_{SAR,2G}$ ,  $T_{SAR,WCDMA}$ ,  $T_{SAR,LTE}$ ,  $T_{SAR,FR1}$  and  $T_{PD}$  for 2G, WCDMA, LTE, FR1 and FR2, respectively. The maximum values for these durations are as specified by FCC. As an example, this total exposure within the measurement duration is given by adding up  $SAR_{inst,sub6GHz}(u)$  and  $PD_{inst,FR2}(u)$  for different RATs and bands for all time instances  $u$  within time intervals such as  $[t - T_{SAR,LTE}, t]$ ,  $[t - T_{SAR,FR1}, t]$  and  $[t - T_{PD}, t]$  for LTE, FR1 and FR2, respectively.
4. Divide the total RF exposure for sub-6GHz RATs and FR2 by corresponding FCC limit and ensure the sum denoted as  $TER(t)$  (or total exposure ratio at time  $t$ ) is less than 1 for all  $t$ . Please

refer to the equations in Algorithm operation which describes the detailed calculation of TER and its target constraint.

$$TER(t) = \frac{\sum_{I_{SAR}=0}^{I_{SAR}^{L-1}} SAR_{avg,I_{SAR}}(t)}{SAR_{limit,FCC}} + \frac{\sum_{I_{PD}=0}^{I_{PD}^{L-1}} PD_{avg,I_{PD}}(t)}{PD_{limit,FCC}} \leq 1 \quad \text{Eqn. (3)}$$

Since TAS is implemented for different technologies (LTE, NR, WCDMA, and 2G), separate test cases are chosen to show that TAS guarantees the compliance for all supported technologies. We have chosen the test scenarios such that each technology is represented by at least one test case (or a part of a test) that shows its standalone operation using different requested power sequences in a single band.

Usually, the maximum transmit power request at long durations will exercise the TAS algorithm fully to restrict allowed maximum power per window (when  $P_{limit} < P_{max}$ ).

However, some requested transmit power change sequences (in FR1) or beam change (in FR2) are also included to show that TAS maintains SAR/PD usage history in dynamic cases.

Additionally, tests cases are provided for different operations that can occur while still being connected to the same technology (rather than power request change). For example, TC involves inter-Band ULCA operation for FR1, which shows how TAS can handle the different operations of transmitting over two bands simultaneously and the addition/removal of a band/cell. Other cases that are included to confirm the UE maintains and tracks SAR usage history are call disconnect/re-establishment and also RSI change tests (where  $P_{limit}$  can be changed during operation due to device state change). Moreover, UL-MIMO tests are included for rank 2 transmission over two antennas in addition to tests that include switching of operating bands.

Other scenarios include multi-RAT operations where two technologies can transmit simultaneously (such as EN-DC) or there is dynamic switching between each other (during inter-RAT handover). These scenarios include transitions when switching happens between technologies or a RAT/band is added or removed. LTE and NR are chosen with some specific bands to verify TER compliance in different scenarios which have multi-radio operations. Since the TAS operation is band/technology agnostic, only a few combinations are sufficient for testing. As an example, inter-RAT represents a switch of operation from one technology to another while both are not operating simultaneously. For simultaneous transmission of technologies, the EN-DC operation between LTE and FR1 and the NR-DC operation between FR1 and FR2, respectively. These cases include the different scenarios such as addition/removal of a technology and the simultaneous operation between the two RATs.

Please note that these multi-technology/transmitters operations are the considered as the worst-case scenarios specially during the transitions of operations. To allow a separate TAS for each RAT, the SAR adjustment algorithm that handles the splitting of SAR budget between the RATs should control the increase of SAR allocation at any RAT in a very conservative manner such that compliance is ensured at any moment. In addition, sometime this algorithm enforces harsher actions (like setting lower power levels) if one RAT is consuming high amount SAR or even if this RAT is reducing its consumed SAR slower than the intended rate of SAR reduction. In addition, while ensuring compliance, the SAR adjustment algorithm aims to optimize the operation during transitions to allow a reasonable power level of transmission for both RATs.

In addition, our TAS algorithm supports another feature that can deal with the spatial properties of the antennas which we call Spatial TAS(S-TAS). This feature could boost the transmitted power as it takes into consideration the coupling between the different antennas and bands.

Spatial TAS allows each of two simultaneous transmitters that use two uncoupled antennas to transmit at an average power equal to their P<sub>limit</sub> values. This means that the total power is doubled while ensuring the compliance. In addition, Spatial TAS has a major benefit for a single transmitter when switching between antennas.

If the antennas are uncoupled, then if the transmission was happening at Ant1 and switched to Ant2, Spatial TAS will start transmission at Ant2 without taking into consideration the consumed SAR at Ant1. This will enhance the capability of the transmitter at Ant2 to transmit with more power while ensuring that the TER/SAR is below the compliance limit at any time.

Please note that, coupling between antennas depends on the OEM device used. So, the OEM has to construct a coupling matrix that includes the coupling between each two antennas/antenna groups.

For this feature, the test cases are mainly chosen to show how the transmission on uncoupled antennas enhances the transmit power performance while still ensuring RF exposure compliance. The tests are chosen mainly to include multiple antennas transmissions (simultaneous transmission or switching between antennas) with different operations such as EN-DC and inter-band ULCA. For spatial TAS, several test cases are shown where multiple antennas are used for transmission. In summary, 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 switch in SAR exposure-to prove that TAS feature can handle multi-RAT transmission with transitions in operation.
6. During UL CA-to prove that TAS feature can handle adding/removing CC and can handle both single CC and CA.
7. During UL MIMO-to prove that TAS feature can handle Tx power variations with Rank2 transmission.
8. During usage of Spatial TAS with uncoupled antennas for two transmit scenarios.
9. During usage of 60s averaging in <3 GHz FR1 bands in addition to the previously supported 100s duration.

## 7. SAR Time Averaging Validation Test Procedures

Test Plan and test procedure for validating Samsung S.LSI TAS algorithm for FR1 scenarios.

### 7.1 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 levels ( $P_{max}$ ) which is applied at least for 150s. The other level is set at the target power level plus  $2\text{dB}(P_{limi}(\text{dBm})+2\text{dB})$  and it lasts for at least 200s.
2. Test Sequence B is generated at multiple power levels that are specified in the Appendix as a function of  $P_{max}$  and  $P_{limit}$ .

### 7.2. Test configuration selection for Validation TAS

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

#### 7.2.1 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  $P_{limit}$  and  $P_{max}$  as determined in SAR Char Report. Essentially, we need to pick this combination such that  $P_{limit}$  is less than  $P_{max}$  so that the TAS algorithm will enforce power restriction.

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

The criteria to select the technology/band for transition between call setup and call drop is to choose the one with least  $P_{limit}$  among all bands. The test is performed with DUT requested power at  $P_{max}$  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.

#### 7.2.3 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 from SAR Char. Report such that  $P_{limit}$  is less than  $P_{max}$  for both states. However, to show the performance of the TAS algorithm in this document, the case of low  $P_{limit}$  is considered, which is shown in Table 9.2.1.

#### 7.2.4 Test configuration for change in modulation

The criteria for selecting test case to demonstrate compliance across modulation change within a radio. The two module states are chosen by pick a technology/band from SAR Char. Report such that  $P_{limit}$  is less than  $P_{max}$  for both states. However, to show the performance of the TAS algorithm in this document, the case of low  $P_{limit}$  is considered, which is shown in Table 9.2.1.

#### 7.2.5 Test configuration for SAR exposure switching

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

#### 7.2.6 Test configuration for change in technology/band/antenna

FCC specifies different measurement durations for time averaging based on operating frequency. The criteria for selecting test case to demonstrate compliance is to pick a technology/band/antenna corresponding to antenna groups from Table 9.2.1 such that  $P_{limit}$  is less than  $P_{max}$ .

#### 7.2.7 Test configuration for Uplink CA

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

#### 7.2.8 Test configuration for Uplink MIMO

The criteria for selecting test case is to demonstrate the compliance of the TAS algorithm when a rank2 SA FR1 transmission is done over 2 Tx antennas. This test shows that the TAS algorithm compliance by ensuring a total average SAR below the designated compliance level.

#### 7.2.9 Test configuration for NSA antenna switching

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

#### **7.2.10 Test configuration for NTN**

The criteria of selecting this test configuration is to demonstrate that Samsung S.LSI algorithm is independent of bands or technology used. We will show that the algorithm can control the transmitted power of an NTN transmission when a maximum power is requested.

#### **7.2.11 Test configuration for foldable status**

The criteria of selecting this test configuration is to demonstrate that Samsung S.LSI algorithm is independent of bands or technology used. We will show that the algorithm can control the transmitted power of an NTN transmission when a maximum power is requested.

## 7.3 Test procedures for conducted power measurements

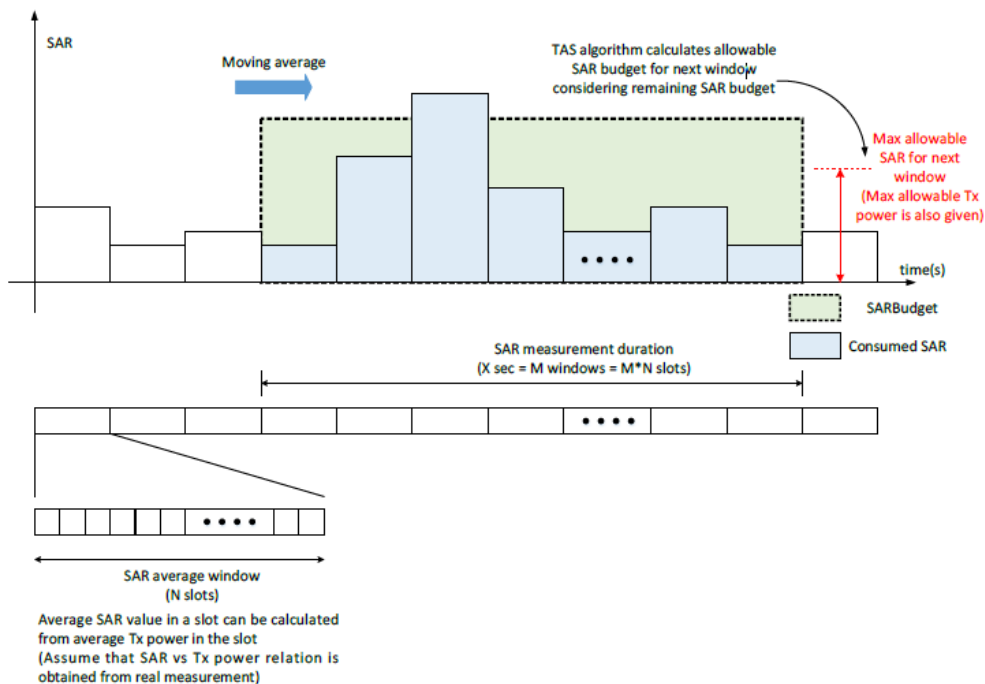
This section provides general conducted power measurement procedures to perform compliance test under dynamic scenarios.

### 7.3.1 Time-varying Tx power transmission scenario

This test is performed with two pre-defined test sequences as described in Section 6.1 for all technologies operating on sub-6GHz applying to GSM, WCDMA, LTE and FR1. 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.

#### 7.3.1.1 Test procedure

1. Using the Pmax and Plimit obtained in Table 9.2.1, 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



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 60s using instantaneous values from Step 2
  - D. Power level P<sub>limit</sub> which is determined as meeting SAR target in Table 9.2.1(P<sub>max</sub> P<sub>limit</sub> Table)
5. Make a second plot containing the following information:
  - A. Computed time-averaged 1gSAR versus time determined in Step 2
  - B. 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 P<sub>limit</sub> at any time in the plot in Step 4.

### 7.3.2 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.

#### 7.3.2.1 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 0dBm for 60s.
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 150s 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 and continue till the end of the test/
6. Release LTE connection.
7. 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
8. 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.

### 7.3.3 Change in RSI

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 Hotspot mode to manage body exposure, which is represented using RSI = 0, the head exposure can be distinguished through audio receiver mode, represented as RSI = 1.

#### 7.3.3.1 Test procedure for change in RSI

1. Establish radio connection of DUT with call box e.g. using NR SA FR1
2. Configure DUT to send at low Tx power of 0 dBm for 60s and set the RSI index corresponding to Plimit
3. Configure call box to send "ALL UP" power control commands and continue SA FR 1 transmission from DUT so that maximum power of Pmax is achieved. Continue the transmission for 150s.
4. Change the RSI index corresponding to lower value and continue the transmission for another 150s
5. Release the SA FR1 connection.
6. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level Plimit which is determined as meeting SAR target
7. 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 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.

### 7.3.4 Change in technology/band/antenna

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.

$$SAR_1(t) = \frac{TxPower_1(t)}{P_{limit,1,FR1}} * SAR\_design\_target_1 \quad (7.3-1)$$

$$SAR_2(t) = \frac{TxPower_2(t)}{P_{limit,2,FR1}} * SAR\_design\_target_2 \quad (7.3-2)$$

where  $P_{limit,1,FR1}$  would correspond to measured power at which first technology/band meets measured SAR level of  $SAR\_design\_target$  as described in Table 11.2.1 with time-averaging duration of  $T_{1SAR}$ . Similarly, the quantities  $P_{limit,2,FR1}$ ,  $SAR\_design\_target_2$ ,  $T_{2SAR}$  are defined for the second technology/band/antenna/ In this document, 60s is considered for all sub 6GHz including below 3GHz.

#### 7.3.4.1 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 60s.
3. Configure call box to send “ALL UP” power control commands and continue SA FR1 transmission from DUT so that maximum power of Pmax is achieved. Continue transmission at the maximum power for 150s.
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 150s.
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 over 60s using instantaneous values and (c) Power level Plimit which is determined as meeting SAR target
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.(7.3-1) and (7.3-2), and (c) FCC 1g SAR 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.

SAR versus time for each RAT (b) Sum of time-averaged SAR computed according to Eqn. (7.3-1) and (7.3-2), 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/antenna change occurs in-between.

#### 7.3.4.2 Test procedure for band/antenna Change

1. Establish radio connection of DUT with call box e.g. using LTE technology in Band48 on Ant.2-4.
2. Configure call box to set DUT Tx power to a low value of 0dBm for 60s.
3. Configure call box to send “ALL UP” power control commands and continue LTE Band A transmission from DUT so that maximum power of Pmax is achieved. Continue transmission for 150s.
4. Change band from LTE Band A to LTE Band B and configure call box to send “ALL UP” power control commands in LTE for another 150s.
5. Release LTE connection.
6. 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 over 60s using instantaneous values and (c) Power level P<sub>limit</sub> which is determined as meeting SAR target.
7. Make a second plot containing the following information (a) Computed time-averaged 1g

### 7.3.5 Uplink CA

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

#### 7.3.5.1 Test procedure for intra-band uplink CA

1. Establish LTE connection of DUT with call box over Cell 1 E.g. one cell of the band Combo CA.
2. Configure the call box to set DUT Tx power to a low value of 0dBm for 60s.
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 transmission for 150s
4. Establish LTE connection of DUT with call box over Cell 2 E.g. other cell of the band Combo CA and configure call box to send “ALL UP” power control command on cell 2 for 150s.
5. Release LTE connection for both cells
6. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level Plimit which is determined as meeting SAR target.
7. 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 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 intra-band change occurs.

### 7.3.5.2 Test procedure for inter-band uplink CA

1. Establish LTE/NR connection of DUT with callbox PCC
2. Configure call box to set DUT Tx power to a low value of 0dBm for 60s.
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 transmission for 150s.
4. Establish an inter-band ULCA connection by attaching a secondary cell connection SCC and configure call box to send “ALL UP” power control commands for 150s.
5. Release the LTE/NR connection
6. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level P<sub>limit</sub> which is determined as meeting SAR target.
7. 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 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 inter-band change occurs.

### 7.3.6 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.

#### 7.3.6.1 Test procedure for SAR exposure switching

1. Establish LTE and NR radio connection in NSA case with both call boxes, e.g. LTE and NR FR1 Technology.
2. Configure the LTE and NR call box to set DUT Tx power to a low value of 0dBm for 60s.
3. Configure the NR call box to send “ALL UP” power control commands and continues transmission from DUT so that maximum power of Pmax is achieved. Continue transmission for 150s
4. In the second part of test configure the LTE call box to send “ALL UP” power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE and NR. This stage of test is continued for another 150s.
5. 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 150s.
6. Release the both LTE and NR connections.
7. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level P<sub>limit</sub> which is determined as meeting SAR target.
8. 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 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 dominant power is changed in EN-DC.

### 7.3.7 Test procedure for NSA antenna switching

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle change of NSA antenna switching in the case of two simultaneous active RATs. It involves changing the Tx antenna 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.

#### 7.3.7.1 Test procedure

1. Establish LTE and NR radio connection in NSA case with both call boxes
2. Configure the LTE and NR call box to set DUT Tx power to a low value of 0dBm for 60s.
3. Configure the LTE call box to send “ALL UP” power control commands and continues transmission from DUT so that maximum power of Pmax is achieved. Continue transmission for 150s.
4. In the second part of test, 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 150s.
5. In the third part of test, change band from NR SA FR1 on AG(a) to AG(b) and configure call box to send “ALL UP” power control commands in NR for another 150s.
6. Release the both LTE and NR connections.
7. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level P<sub>limit</sub> which is determined as meeting SAR target.
8. 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 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 Tx antenna is changed in EN-DC

### 7.3.8 NTN with maximum power transmission

The test is to demonstrate that Samsung S.LSI TAS feature can properly handle the SAR exposure for NTN while requesting a maximum power.

#### 7.3.8.1 Test Procedure

1. Establish NTN connection of DUT with call box on NTN
2. Configure MAC padding in DL & UL in connected mode so that maximum power ( $P_{max}$ ) is achieved and continue transmission for 150s.
3. Release NTN connection

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 in all NTN region.

### 7.3.9 Foldable status

This test is to demonstrate that Samsung S.LSI TAS feature can properly handle the change of the foldable device status in the case of two simultaneous active RATs.

#### 7.3.9.1 Test procedure

1. Establish LTE and NR radio connection in an NSA case with both call boxes, e.g., LTE in Band 5 and NR in band n77
2. C Configure the LTE and NR call box to set DUT Tx power to a low value of 0dBm for 60s.
3. Configure the LTE and NR call box to send an "ALL UP" power control commands and continues transmission from DUT so that maximum power of Pmax is achieved while setting the device to the unfolded status. Continue transmission for 150s.
4. Switch the device setting to the folded status and continue transmission for 150s.
5. Switch the device setting to the unfolded status and continue transmission for 150s
6. Release the both LTE and NR connections.
7. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level P<sub>limit</sub> which is determined as meeting SAR target..
8. 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 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 Tx antenna is changed in EN-DC

## 7.4 Spatial TAS

For the test cases with spatial TAS, we will consider 4 antennas (Ant A, B and F, I) with two antenna groups where each antenna group consists of two antennas and multiple bands as in Table 5-1.

Table 7-1 Antennas and bands used in the spatial TAS conducted tests

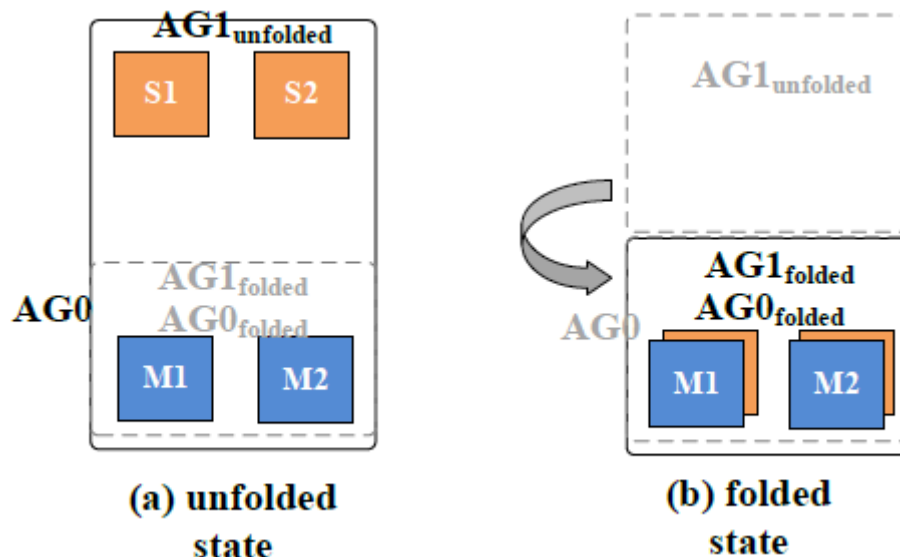
| AG# | Antenna  | Band                                                                  |
|-----|----------|-----------------------------------------------------------------------|
| AG0 | Ant A, B | GSM 1900, UMTS B2,<br>LTE 12, 25, 41,<br>NR n2, n5, n7, n25, n41, n66 |
| AG1 | Ant F    | NR n77                                                                |

The coupling matrix considered during the tests is

$$R = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

## 7.5 Foldable status

For the SAR evaluation for this test case, we consider a device with a folding capability with two sets of physical antennas. In the unfolded state, as shown in Figure 9.14-1(a), one set is located at the upper side of the device (which includes S1 and S2 antennas) which we call AG<sub>1uf</sub> and the other is located at the lower side of the device (which includes M1 and M2 antennas) which we call AG<sub>0uf</sub>. In the folded state, as shown in Figure 9.14-1(b), the two sets become at the same location where we call them AG<sub>0f</sub> and AG<sub>1f</sub>.



So, this is equivalent to having four antenna groups which are {AG<sub>0uf</sub>, AG<sub>1uf</sub>, AG<sub>0f</sub>, AG<sub>1f</sub>} with a coupling matrix

$$R = \begin{bmatrix} 1 & r_{0uf,1uf} & r_{0uf,0f} & r_{0uf,1f} \\ r_{0uf,1uf} & 1 & r_{1uf,0f} & r_{1uf,1f} \\ r_{0uf,0f} & r_{1uf,0f} & 1 & r_{0f,1f} \\ r_{0uf,1f} & r_{1uf,1f} & r_{0f,1f} & 1 \end{bmatrix}$$

Where the subscript ‘f’ means folded, the subscript ‘uf’ means unfolded and  $r_{i,j}$  represents the coupling coefficient between AG<sub>i</sub> and AG<sub>j</sub>.

For this test, we assume that the location of the lower part of the device is fixed in the folded or the unfolded state. So, AG<sub>0uf</sub> and AG<sub>0f</sub> are considered coupled (i.e.,  $r_{0uf,0f} = 1$ ). In addition, in the unfolding state we assume that the upper and lower sets of antennas are uncoupled. Hence, AG<sub>0uf</sub>, AG<sub>1uf</sub> becomes uncoupled (i.e.,  $r_{0uf,1uf} = 0$ ). Also, in the foldable state, the antenna groups AG<sub>0f</sub> and AG<sub>1f</sub> are considered coupled (i.e.,  $r_{0f,1f} = 1$ ). Next, according to the locations of the antenna groups based on the folding state, we can deduce that

$$r_{0uf,1f} = 1$$

$$r_{1uf,0f} = 0$$

$$r_{1uf,1f} = 0$$

Thus, the equivalent coupling matrix becomes

$$R = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{bmatrix}$$

So, the instantaneous SAR at any time ‘t’ at each antenna group can be calculated as

$$SAR_{AG0uf}(t) = SAR_{AG0f}(t) = SAR_{AG1f}(t) = S_{Tx,AG0uf}(t) + S_{Tx,AG0f}(t) + S_{Tx,AG1f}(t) = SAR_1(t)$$

$$SAR_{AG1uf}(t) = S_{Tx,AG1uf}(t) = SAR_2(t)$$

Where the subscript ‘Tx’ represents the actual transmitted SAR at that AG. From the previous equations, since the SAR for AG<sub>0uf</sub>, AG<sub>0f</sub> and AG<sub>1f</sub> are equal, and since no other antenna groups transmissions are affecting the average SAR at AG<sub>1uf</sub>, so for compliance, we will show that the total 60s average SAR for each of SAR<sub>1</sub> and SAR<sub>2</sub> is below the compliance level.

## 8. PD Time Averaging Validation Test Procedures

In this section, we cover the test plan and test procedure for validating Samsung S.LSI TAS feature for FR2 scenarios.

### 8.1 Test sequence determination for validation

In FR2 transmissions, the test sequence for validation is with the callbox requested maximum power for FR2 at all time.

### 8.2 Test configuration selection criteria for validating TAS

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

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

Since the TAS feature is independent of band and beams for a given technology, demonstration with one band will be sufficient.

#### 8.2.2 Test configuration selection for SAR vs PD exposure switch during transmission

The TAS feature works for both types of exposure (SAR or PD) and ensures total time-averaged exposure ratio meets the FCC limit of 1. One scenario of each LTE or NR SA FR1bandwith FR2 band is sufficient, while exposure condition can be varied between SAR dominant, SAR+PD scenario and PD dominant scenarios for demonstration.

#### 8.2.3 Test Configuration selection for mmWave uplink CA

The criteria for selecting this test case is to demonstrate the compliance of the TAS algorithm when an FR2 transmission is done over multiple CC. This test shows that the TAS algorithm compliance is independent on the Transmission scenarios (single CC or CA) of any RAT used.

#### 8.2.4 Test configuration selection for change of beam

Since the TAS feature is independent of band and beams for a given technology, demonstration with one pair of beams for switching between them will be sufficient.

#### 8.2.5 Test Configuration selection for foldable status

The criterion of selecting this test configuration is to demonstrate tha Samsung S.LSI algorithm supports foldable status. The test is performed with both RATs connected in an EN-DC FR2 Scenario.

### 8.3 Test Procedures for FR2 radiated power measurements

For FR2 testing, we need to perform conducted power measurements for LTE and radiated power measurements for FR2. This section provides general procedures for test setup to validate the compliance in dynamic scenarios outlines in section 6.

#### 8.3.1 FR2 max power transmission

##### 8.3.1.1 Test procedure

1. Set the phone in an anechoic chamber for FR2 radiated transmission. In a non-signaling transmission mode for FR2 at maximum target EIRP, adjust the position of the DUT via rotation within the chamber to obtain the maximum measured radiated EIRP using the fixed test antenna. Keep the DUT in this fixed position for the remainder of the test.
2. Reset the DUT state to normal signaling mode and establish both LTE/FR1 and FR2 connections with the call box
3. Configure the LTE/FR1 and FR2 call box to set DUT Tx power to a low value of 0dBm for 60s.
4. Configure the FR2 call box to send "ALL UP" power control commands and continues transmission from DUT so that maximum EIRP condition. Continue transmission for 150s.
5. In the second part of test, configure LTE/FR1 call box to send "ALL UP" power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE/FR1 and FR2. This stage of test is continued for another 300s.
6. Release LTE/FR1 and FR2 connection.
7. After the end of the test, convert the instantaneous LTE Tx power into 1g SAR value using Plimit and Eqn. (1), and then divide by FCC limit of 1.6W/Kg to obtain normalized SAR versus time. Perform 60s time averaging to determine normalized average 1g SAR versus time.
8. Similar to Step 7, convert the instantaneous radiated FR2 EIRP into PD value using Plimit and Eqn. (2), and then divide by FCC limit of 10W/m<sup>2</sup> for 4cm<sup>2</sup> spatial averaging to obtain instantaneous normalized PD versus time. Perform 4s time averaging to determine normalized average PD versus time.
9. Make one plot containing (a) Instantaneous conducted power for LTE versus time, (b) Computed time-averaged power over 60s using instantaneous values for LTE, (c) Instantaneous EIRP for FR2 versus time, (d) Computed time-average power over 4s using instantaneous values for FR2 and (e) Power level Plimit which is determined as meeting SAR target for LTE and PD target for FR2
10. Make a second plot containing (a) normalized 60s time-averaged SAR for LTE (b)

normalized 4s time-averaged PD for FR2, (c) TER (Total Exposure Ratio) corresponding total normalized time-averaged RF exposure (using sum of 10(a) and 10(b)) versus time

Pass condition is to demonstrate that TER is kept under 1.0 throughout the test. This ensures that criteria defined Eqn. (3) is met at all times.

### 8.3.2 SAR vs PD exposure switch during transmission

This test is to ensure that Samsung S.LSI TAS feature works for any nature of exposure (SAR or PD) and accurately accounts for switching among SAR dominant, SAR+PD, and PD dominant scenarios, and ensured total time-averaged RF exposure compliance at all times.

#### 8.3.2.1 Test procedure

1. Set the phone in an anechoic chamber for FR2 radiated transmission. In a non-signaling transmission mode for FR2 at maximum target EIRP, adjust the position of the DUT via rotation within the chamber to obtain the maximum measured radiated EIRP using the fixed test antenna. Keep the DUT in this fixed position for the remainder of the test.
2. Reset the DUT state to normal signaling mode and establish both LTE/FR1 and FR2 connections with the call box
3. Configure the LTE/FR1 and FR2 call box to set DUT Tx power to a low value of 0dBm for 60s.
4. Configure the FR2 call box to send "ALL UP" power control commands and continues transmission from DUT so that maximum EIRP condition. Continue transmission for 150s.
5. In the second part of test, configure LTE/FR1 call box to send "ALL UP" power control commands and all transmissions are continued, resulting in maximum power requested from DUT for both LTE/FR1 and FR2. This stage of test is continued for another 150s.
6. In the third part of test, configure LTE/FR1 call box to send "ALL Dwon" power control commands so that FR2 becomes the dominant power radio. This stage is continued for another 150s
7. Release LTE/FR1 and FR2 connection.
8. After the end of the test, convert the instantaneous LTE Tx power into 1g SAR value using Plimit and Eqn. (1), and then divide by FCC limit of 1.6W/Kg to obtain normalized SAR versus time. Perform 60s time averaging to determine normalized average 1g SAR versus time.
9. Similar to Step 8, convert the instantaneous radiated FR2 EIRP into PD value using Plimit and Eqn. (2), and then divide by FCC limit of 10W/m<sup>2</sup> for 4cm<sup>2</sup> spatial averaging to obtain instantaneous normalized PD versus time. Perform 4s time averaging to determine normalized average PD versus time.
10. Make one plot containing (a) Instantaneous conducted power for LTE versus time, (b) Computed time-averaged power over 60s using instantaneous values for LTE, (c) Instantaneous EIRP for FR2 versus time, (d) Computed time-average power over 4s using instantaneous values for FR2 and (e) Power level Plimit which is determined as meeting SAR target for LTE and PD target for FR2
11. Make a second plot containing (a) normalized 60s time-averaged SAR for LTE (b) normalized 4s time-averaged PD for FR2, (c) TER (Total Exposure Ratio) corresponding

total normalized time-averaged RF exposure (using sum of 11(a) and 11(b)) versus time

Pass condition is to demonstrate that TER is kept under 1.0 throughout the test. This ensures that criteria defined Eqn. (3) is met at all times.

### 8.3.3 mmWave Uplink CA

The test is to demonstrate that Samsung S.LSI TAS feature can properly handle the PD exposure for FR2 with the addition and/or removal of another intra-band FR2 CC

#### 8.3.3.1 Test procedure

1. Set the phone in an anechoic chamber for FR2 radiated transmission. In a non-signaling transmission mode for FR2 at maximum target EIRP, adjust the position of the DUT via rotation within the chamber to obtain the maximum measured radiated EIRP using the fixed test antenna. Keep the DUT in this fixed position for the remainder of the test.
2. Reset the DUT state to normal signaling mode and establish both LTE/FR1 and FR2 cell 1 and cell 2 connections with the call box
3. Configure the LTE/FR1 and FR2 call box to set DUT Tx power to a low value of 0dBm for 60s.
4. Configure the FR2 cell 1 call box to send “ALL UP” power control commands and continues transmission from DUT so that maximum EIRP condition. In this case, FR2 cell 1 radio will comprise the dominant exposure condition using PD metric.
5. After 50s, configure the FR2 cell 2 call box to send “ALL UP” power control commands to send FR2 cell 2 radio to maximum EIRP condition and continue transmission more than 100s.
6. Release Both LTE and FR2(Cell 1 and 2) connections.
7. After the end of the test, convert the instantaneous LTE Tx power into 1g SAR value using Plimit and Eqn. (1), and then divide by FCC limit of 1.6W/Kg to obtain normalized SAR versus time. Perform 60s time averaging to determine normalized average 1g SAR versus time.
8. Similar to Step 7, convert the instantaneous radiated FR2 EIRP into PD value using Plimit and Eqn. (2), and then divide by FCC limit of 10W/m<sup>2</sup> for 4cm<sup>2</sup> spatial averaging to obtain instantaneous normalized PD versus time. Perform 4s time averaging to determine normalized average PD versus time.
9. Make one plot containing (a) Instantaneous conducted power for LTE versus time, (b) Computed time-averaged power over 60s using instantaneous values for LTE, (c) Instantaneous EIRP for FR2 versus time, (d) Computed time-average power over 4s using instantaneous values for FR2 and (e) Power level Plimit which is determined as meeting SAR target for LTE and PD target for FR2
10. Make a second plot containing (a) normalized 60s time-averaged SAR for LTE (b) normalized 4s time-averaged PD for FR2, (c) TER (Total Exposure Ratio) corresponding total normalized time-averaged RF exposure (using sum of 10(a) and 10(b)) versus time

Pass condition is to demonstrate that TER is kept under 1.0 throughout the test. This ensures that criteria defined Eqn. (3) is met at all times.

### 8.3.4 Change of Beam

This test is to demonstrate that Samsung S.LSI TAS feature can account for change of beam in FR2 and still meet total RF exposure compliance.

#### 8.3.4.1 Test procedure

1. Set the phone in an anechoic chamber for FR2 radiated transmission. In a non-signaling transmission mode for FR2 at maximum target EIRP, adjust the position of the DUT via rotation within the chamber to obtain the maximum measured radiated EIRP using the fixed test antenna.
2. Reset the DUT state to normal signaling mode and establish both LTE and FR2 connections with the call box.
3. Immediately send "ALL DOWN" power control commands from LTE call box to send LTE to the lowest transmission power. Next, configure the FR2 call box to send "ALL UP" power control commands to send FR2 radio to maximum EIRP condition. In this case, the FR2 radio will comprise the dominant exposure condition using PD metric.
4. After 20s, the test equipment turns the DUT by 45degrees (horizontal=45, vertical=0) to change best module and correspondingly a beam change.
5. After 20s, the test equipment turns the DUT by 45degrees (horizontal=90, vertical=0) to change best module again and correspondingly a beam change
6. Continue the LTE and FR2 transmissions for another 20s.
7. Record the conducted power of LTE and radiated EIRP of FR2 radio and per beam at all times during the test.
8. Release LTE and FR2 connection.
9. After the end of the test, convert the instantaneous LTE Tx power into 1g SAR value using Plimit and Eqn. (1), and then divide by FCC limit of 1.6W/Kg to obtain normalized SAR versus time. Perform 60s time averaging to determine normalized average 1g SAR versus time.
10. Similar to Step 9, convert the instantaneous radiated FR2 EIRP into PD value using Plimit and Eqn. (2), and then divide by FCC limit of 10W/m<sup>2</sup> for 4cm<sup>2</sup> spatial averaging to obtain instantaneous normalized PD versus time for each beam. Perform 4s time averaging to determine normalized average PD versus time. Note that for each beam, we have to use the corresponding Plimit values before converting to the PD values
11. Make one plot containing (a) Instantaneous conducted power for LTE versus time, (b) Computed time-averaged power over 60s using instantaneous values for LTE, (c) Instantaneous EIRP for FR2 versus time per beam, (d) Computed time-average power over 4s using instantaneous values for FR2 per beam and (e) Power level Plimit which is determined as meeting SAR target for LTE and PD target for FR2
12. Make a second plot containing (a) normalized 60s time-averaged SAR for LTE (b) normalized 4s time-averaged PD for FR2 per beam, (c) TER (Total Exposure Ratio) corresponding total normalized time-averaged RF exposure (using sum of 12(a) and

12(b)) versus time as computed equation below

$$\frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^t SAR(t') dt'}{FCC SAR_{limit}} + \frac{\frac{1}{T_{PD}} \int_{t-T_{PD}}^t PD_1(t') dt'}{FCC PD_{limit}} + \frac{\frac{1}{T_{PD}} \int_{t-T_{PD}}^t PD_2(t') dt'}{FCC PD_{limit}} \leq 1$$

Pass condition is to demonstrate that TER is kept under 1.0 throughout the test. This ensures that criteria defined above Eqn. is met at all times.

### 8.3.5 Foldable status

#### 8.3.5.1 Test procedure

1. Set the phone in an anechoic chamber for FR2 radiated transmission. In a non-signaling transmission mode for FR2 at maximum target EIRP, adjust the position of the DUT via rotation within the chamber to obtain the maximum measured radiated EIRP using the fixed test antenna. Keep the DUT in this fixed position for the remainder of the test.
2. Reset the DUT state to normal signaling mode and establish both LTE and FR2 connections with the call box.
3. Configure the LTE and FR2 call box to set DUT Tx power to a low value of 0dBm for 60s with unfolded status.
4. Configure the LTE and FR2 call box to send an “ALL UP” power control commands and continues transmission from DUT so that maximum power of Pmax is achieved while setting the device to the unfolded status. Continue transmission for 150s.
5. Switch the device setting to the folded status and continue transmission for 150s.
6. Switch the device setting to the unfolded status and continue transmission for 150s.
7. Release LTE and FR2 connection.
8. After the end of the test, convert the instantaneous LTE Tx power into 1gSAR value using Plimit and Eqn.(5-2), and then divide by FCC limit of 1.6W/Kg to obtain normalized SAR versus time. Perform 60s time averaging to determine normalized average 1gSAR versus time.
9. Similar to Step 7, convert the instantaneous radiated FR2 EIRP into PD value using Plimit and Eqn.(5-3), and then divide by FCC limit of 10W/m<sup>2</sup> for 4cm<sup>2</sup> spatial averaging to obtain instantaneous normalized PD versus time. Perform 4s time averaging to determine normalized average PD versus time.
10. Make one plot containing (a) Instantaneous conducted power for LTE versus time, (b) Computed time-averaged power over 60s using instantaneous values for LTE, (c) Instantaneous EIRP for FR2 versus, (d) Computed time-average power over 4s using instantaneous values for FR2 and (e) Power level Plimit which is determined as meeting SAR target for LTE and PD target for FR2

11. Make a second plot containing (a) normalized 60s time-averaged SAR for LTE computed in Step 7 (b) normalized 4s time-averaged PD for FR2, (c) TER (Total Exposure Ratio) corresponding total normalized time-averaged RF exposure (using sum of 10(a) and 10(b)) versus time
12. Pass condition is to demonstrate that TER is kept under 1.0 throughout the test. This ensures that criteria defined in Eqn.(3) is met at all times. The detailed criteria for the test to pass is illustrated in Section 7.5.

## 8.4 WLAN and Bluetooth

### 8.4.1 Test procedure for WLAN (Bluetooth off)

1. Establish WLAN connection of DUT with call box.
2. Set DUT TAS algorithm Enable.
3. Configure to set DUT so that Plimit Power[RSI=0] for 360s
4. After Configure to set DUT so that Plimit Power[RSI=1] for 360s
5. Release WLAN connection.
6. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level Plimit which is determined as meeting SAR target.
7. 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.

#### 8.4.2 Test procedure for WLAN (Bluetooth on)

1. Establish WLAN connection of DUT with call box.
2. Set DUT TAS algorithm Enable.
3. Configure to set DUT so that Plimit Power[RSI=0] for 180s
4. Establish Bluetooth connection of DUT with call box
5. Continue connection for 180s simultaneously
6. Configure to set DUT so that Plimit Power[RSI=1] for 180s with Bluetooth connection
7. Release Bluetooth connection and continue WLAN[RSI=1] connection for 180s
8. Release WLAN connection.
9. After the completion of the test, prepare one plot with the following information (a) Instantaneous Tx power versus time (b) Time-averaged power over 60s using instantaneous values and (c) Power level Plimit which is determined as meeting SAR target.
10. 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.

## 8.5 Combined TAS

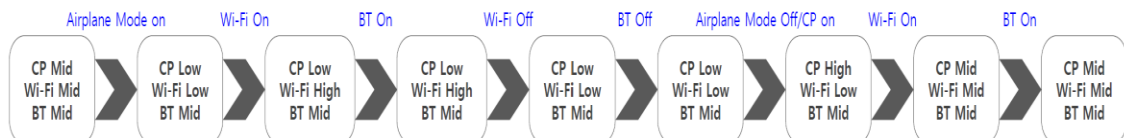
The C-TAS algorithm controls the simultaneous output power of the communication modes implemented in each chipset of the DUT to ensure that it always complies with FCC regulations within the TAS algorithm.

Assess SAR limit compliance at the system level for all communication modes through validation of multiple TASs controlled by C-TAS, TAS Manager.

To demonstrate the time averaged RF exposure compliance continuity during technology transition in both single-radio and multi-radio transmission scenarios and under both TAS modes (i.e., ON and airplane) of WWAN modem and WLAN modem

### 8.5.1 Test procedure for Combined TAS

#### Test Scenario -Tech Switch Compliance Test [Airplane OFF-ON-OFF]



1. Establish two call boxes (e.g., LTE/NR FR1 and Wi Fi, BT technology) and LTE/NR and Wi Fi, BT connections in the combined TAS case.
2. Connect Cellular to call box and set max power (worst case) Connect to Wi Fi access point and transmit data using Iperf tool Data rate is set the lowest value for max power (worst case / ex. 11a : 6Mbps, 11ac : MCS 0) Connect to reference phone(or call box) by BT and transmit data (DUT Mode, Ant0) Hold on Status for more than 120 seconds
3. Airplane mode on(All tech off ) Hold on Status for more than 120 seconds
4. Wi Fi on and connect to Wi Fi access point (or call box) and transmit data using Iperf tool Data rate is set the lowest value for max power (worst case / ex. 11a : 6Mbps, 11ac : MCS 0 Hold on Status for more than 120 seconds Continue connection for 180s simultaneously
5. BT on and connect to reference phone (or call box) by BT and transmit data Hold on Status for more than 120 seconds
6. Wi Fi feature off Hold on Status for more than 120 seconds
7. BT feature off Hold on Status for more than 120 seconds
8. Airplane mode off and connect Cellular to call box and set max power (worst case) Hold on Status for more than 120 seconds
9. Wi Fi on and connect to Wi Fi access point(or call box) and transmit data using Iperf tool Data rate is set the lowest value for max power (worst case / ex. 11a : 6Mbps, 11ac : MCS 0) Hold on Status for more than 120 seconds
10. BT on and connect to reference phone (or call box) by BT and transmit data Hold on Status for more than 120 seconds

## 9. Test Configurations

| Plim values in green indicate Plimit < Pmax                        |        |         | Plim values in grey indicate Plim > Pmax |               |                                                           |             |
|--------------------------------------------------------------------|--------|---------|------------------------------------------|---------------|-----------------------------------------------------------|-------------|
| Plimit corresponding to 1 W/kg (1g) 2.5W/kg(10g) SAR Design_target |        |         | Pmax                                     |               |                                                           |             |
| SAR Exposure Position                                              |        |         | Body (Non-Head)                          | Head (RCV ON) | Maximum Tune-up Output Power (Frame Averaged Power) [dBm] | UL:DL Ratio |
| Averaging volume                                                   |        |         | 1g                                       | 1g            |                                                           |             |
| separation Distance                                                |        |         | 5 mm                                     | 0 mm          |                                                           |             |
| Mode                                                               | Band   | Antenna | RSI=0                                    | RSI=1         |                                                           |             |
| GSM/GPRS/EDGE                                                      | 850    | A       | 19.8                                     | 19.8          | 27.3                                                      | 48.2%       |
| GSM/GPRS/EDGE                                                      | 850    | E       | 19.8                                     | 19.8          | 27.3                                                      | 48.2%       |
| GSM/GPRS/EDGE                                                      | 1900   | A       | 14.8                                     | 33.2          | 22.1                                                      | 36.1%       |
| UMTS                                                               | 2      | A       | 14.0                                     | 32.5          | 23.5                                                      | 100%        |
| UMTS                                                               | 4      | A       | 14.0                                     | 31.6          | 23.5                                                      | 100%        |
| UMTS                                                               | 5      | A       | 23.0                                     | 32.5          | 24.0                                                      | 100%        |
| UMTS                                                               | 5      | E       | 19.0                                     | 20.0          | 24.0                                                      | 100%        |
| LTE FDD                                                            | 25(2)  | A       | 15.0                                     | 31.5          | 24.0                                                      | 100%        |
| LTE FDD                                                            | 25(2)  | F       | 18.0                                     | 18.0          | 24.0                                                      | 100%        |
| LTE FDD                                                            | 66(4)  | A       | 14.0                                     | 31.0          | 24.0                                                      | 100%        |
| LTE FDD                                                            | 66(4)  | F       | 17.0                                     | 17.0          | 24.0                                                      | 100%        |
| LTE FDD                                                            | 12(17) | A       | 22.0                                     | 32.5          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 12     | E       | 21.5                                     | 21.5          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 17     | E       | 20.0                                     | 20.0          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 13     | A       | 22.0                                     | 32.0          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 13     | E       | 21.0                                     | 21.0          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 5      | A       | 22.0                                     | 32.9          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 5      | E       | 20.0                                     | 20.0          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 26     | A       | 22.0                                     | 32.8          | 24.5                                                      | 100%        |
| LTE FDD                                                            | 26     | E       | 20.0                                     | 20.0          | 24.5                                                      | 100%        |
| LTE TDD PC3                                                        | 41     | B       | 18.0                                     | 18.0          | 22.0                                                      | 63.3%       |
| LTE TDD PC3                                                        | 41     | F       | 16.5                                     | 16.5          | 22.0                                                      | 63.3%       |
| LTE TDD PC2                                                        | 41     | B       | 18.4                                     | 18.4          | 22.4                                                      | 43.3%       |
| LTE TDD PC2                                                        | 41     | F       | 16.9                                     | 16.9          | 22.4                                                      | 43.3%       |
| NR FDD                                                             | 25(2)  | A       | 14.0                                     | 31.9          | 24.0                                                      | 100%        |
| NR FDD                                                             | 25(2)  | F       | 18.0                                     | 18.0          | 24.0                                                      | 100%        |
| NR FDD                                                             | 5      | A       | 22.0                                     | 33.1          | 24.5                                                      | 100%        |
| NR FDD                                                             | 5      | E       | 20.0                                     | 20.0          | 24.5                                                      | 100%        |
| NR TDD                                                             | 41     | B       | 14.0                                     | 14.0          | 24.0                                                      | 100%        |
| NR TDD SRS 1                                                       | 41     | F       | 12.0                                     | 12.0          | 21.0                                                      | 100%        |
| NR TDD SRS 2                                                       | 41     | D       | 13.0                                     | 13.0          | 23.0                                                      | 100%        |
| NR TDD SRS 3                                                       | 41     | E       | 12.0                                     | 12.0          | 20.0                                                      | 100%        |
| NR TDD Hopping                                                     | 41     | F       | 17.0                                     | 17.0          | 24.0                                                      | 100%        |
| NR TDD Hopping SRS 1                                               | 41     | B       | 13.0                                     | 13.0          | 20.0                                                      | 100%        |
| NR TDD Hopping SRS 2                                               | 41     | E       | 16.0                                     | 16.0          | 23.0                                                      | 100%        |
| NR TDD Hopping SRS 3                                               | 41     | D       | 10.0                                     | 10.0          | 17.0                                                      | 100%        |
| NR FDD                                                             | 66     | A       | 14.0                                     | 31.4          | 24.0                                                      | 100%        |
| NR FDD                                                             | 66     | F       | 17.0                                     | 17.0          | 24.0                                                      | 100%        |
| NR TDD (PC3)                                                       | 77     | F       | 14.5                                     | 13.5          | 23.0                                                      | 100%        |
| NR TDD (PC3) SRS 1                                                 | 77     | C       | 17.0                                     | 16.0          | 23.0                                                      | 100%        |
| NR TDD (PC3) SRS 2                                                 | 77     | I       | 14.5                                     | 13.5          | 23.0                                                      | 100%        |
| NR TDD (PC3) SRS 3                                                 | 77     | D       | 14.5                                     | 13.5          | 21.0                                                      | 100%        |
| NR TDD (PC2)                                                       | 77     | F       | 14.5                                     | 13.5          | 26.0                                                      | 100%        |
| NR TDD (PC2) SRS 1                                                 | 77     | C       | 17.0                                     | 16.0          | 26.0                                                      | 100%        |
| NR TDD (PC2) SRS 2                                                 | 77     | I       | 14.5                                     | 13.5          | 23.0                                                      | 100%        |
| NR TDD (PC2) SRS 3                                                 | 77     | D       | 14.5                                     | 13.5          | 21.0                                                      | 100%        |
| NR TDD (PC3)                                                       | 77 DoD | F       | 14.5                                     | 13.5          | 23.0                                                      | 100%        |
| NR TDD (PC3) SRS 1                                                 | 77 DoD | C       | 15.0                                     | 14.0          | 23.0                                                      | 100%        |
| NR TDD (PC3) SRS 2                                                 | 77 DoD | I       | 14.5                                     | 13.5          | 22.0                                                      | 100%        |
| NR TDD (PC3) SRS 3                                                 | 77 DoD | D       | 16.0                                     | 15.0          | 21.0                                                      | 100%        |
| NR TDD (PC2)                                                       | 77 DoD | F       | 14.5                                     | 13.5          | 26.0                                                      | 100%        |
| NR TDD (PC2) SRS 1                                                 | 77 DoD | C       | 15.0                                     | 14.0          | 23.0                                                      | 100%        |
| NR TDD (PC2) SRS 2                                                 | 77 DoD | I       | 14.5                                     | 13.5          | 22.0                                                      | 100%        |
| NR TDD (PC2) SRS 3                                                 | 77 DoD | D       | 16.0                                     | 15.0          | 21.0                                                      | 100%        |
| WLAN                                                               | 2.4    | H       | 17.0                                     | 17.0          | 20.0                                                      | 100%        |
| WLAN                                                               | 2.4    | J       | 17.0                                     | 17.0          | 20.0                                                      | 100%        |
| WLAN                                                               | 2.4    | H+J     | 17.0                                     | 17.0          | 20.0                                                      | 100%        |
| WLAN                                                               | 5      | H       | 14.0                                     | 14.0          | 18.0                                                      | 100%        |
| WLAN                                                               | 5      | E       | 14.0                                     | 14.0          | 18.0                                                      | 100%        |
| WLAN                                                               | 5      | H+E     | 14.0                                     | 14.0          | 18.0                                                      | 100%        |
| WLAN                                                               | 6      | H       | 8.0                                      | 8.0           | 16.0                                                      | 100%        |
| WLAN                                                               | 6      | E       | 8.0                                      | 8.0           | 16.0                                                      | 100%        |
| WLAN                                                               | 6      | H+E     | 8.0                                      | 8.0           | 16.0                                                      | 100%        |

**Note**

1. all Plimit and maximum tune up output power Pmax levels entered in above Table correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes (for e.g., GSM, LTE TDD).
2. The maximum time-averaged output power (dBm) for any 2G/3G/4G/5G WWAN and WLAN technology, band, and SAR Exposure condition=minimum of “Plimit” and “Maximum tune up output power: “Pmax” + 1dB device uncertainty.
3. The maximum time averaged output power means Plimit for each modes SAR values in this report were scaled to the maximum allowed output power to determine compliance per KDB Publication 447498 D01v06.

## 10. Test case list

### 10.1 Test case list for sub-6 GHz transmissions

To validate TAS algorithm in various sub-6 GHz conditions, the chosen TC (Test Case) list is defined as in Table 10.1-1

Table 10.1-1 Sub-6 GHz TAS validation test case list

| No.  | Test Scenario                          | Test case                                    | Test configuration            |
|------|----------------------------------------|----------------------------------------------|-------------------------------|
| TC01 | Time-varying Tx power transmission     | Time_Varying_Tx_Power_Case_1(LTE)            | LTE Band 25                   |
| TC02 |                                        | Time_Varying_Tx_Power_Case_1(NR)             | NR Band n25                   |
| TC03 |                                        | Time_Varying_Tx_Power_Case_1(UMTS)           | UMTS B2                       |
| TC04 |                                        | Time_Varying_Tx_Power_Case_1(2G)             | GSM1900                       |
| TC05 |                                        | Time_Varying_Tx_Power_Case_2(LTE)            | LTE Band 25                   |
| TC06 |                                        | Time_Varying_Tx_Power_Case_2(NR)             | NR Band n25                   |
| TC07 |                                        | Time_Varying_Tx_Power_Case_2(UMTS)           | UMTS B2                       |
| TC08 |                                        | Time_Varying_Tx_Power_Case_2(2G)             | GSM1900                       |
| TC09 | Change in call                         | LTE_Call_Disconnect_Reestablishment          | LTE Band 25                   |
| TC10 | Re-selection in call                   | SA_FR1_to_LTE_RAT_Re-selection_Coupling_Case | NR Band n25, LTE Band 25      |
| TC11 | Antenna/Band switching                 | LTE_Antenna_Band_Switching                   | LTE Band 25, 41               |
| TC12 | SAR exposure switch                    | NSA_FR1_Dominant_Power_Switching             | LTE Band 12, NR Band n25      |
| TC13 | Change in RSI                          | SA_FR1_RF_SAR_Index_Change                   | NR Band n25                   |
| TC14 | NSA antenna switching with Spatial TAS | NSA_Ant_switching_Spatial_TAS                | LTE Band 12, NR Band n41, n77 |

## 10.2 Test case list for WLAN/Bluetooth Transmissions

To validate TAS algorithm in WLAN/Bluetooth conditions, the chosen WTC (WLAN Test Case) list is defined as in Table 10.2-1

Table 10.2-1 WLAN/Bluetooth TAS validation test case list

| No.   | Test Scenario                           | Test case                          | Test configuration |
|-------|-----------------------------------------|------------------------------------|--------------------|
| WTC01 | Tx Power of WLAN TAS<br>(Bluetooth off) | TX Power of WLAN TAS(WLAN 2.4 GHz) | WLAN 2.4 GHz       |
| WTC02 |                                         | TX Power of WLAN TAS(WLAN 5GHz)    | WLAN 5 GHz         |
| WTC03 |                                         | TX Power of WLAN TAS(WLAN 6GHz)    | WLAN 6 GHz         |

## 10.3 Test case list for Combined TAS

To validate C- TAS algorithm in Tech Switch conditions between WWAN Band WLAN the chosen Test Case list is defined as in Table 10.3-1

Table 10.3-1 C-TAS test case list

| No.    | Test Scenario                          | Test case           | Test configuration           |
|--------|----------------------------------------|---------------------|------------------------------|
| C-TC01 | <b>Tech Switch<br/>Compliance Test</b> | LTE mode to WLAN/BT | LTETBand66/WLAN 5G/Bluetooth |
| C-TC02 |                                        | NR mode to WLAN/BT  | NRBandn77/WLAN 5G/Bluetooth  |

## 11. Conducted Power Test Results for Sub-6 TAS validation

### 11.1 Measurement set-up

#### 11.1.1 Test setup for Main band

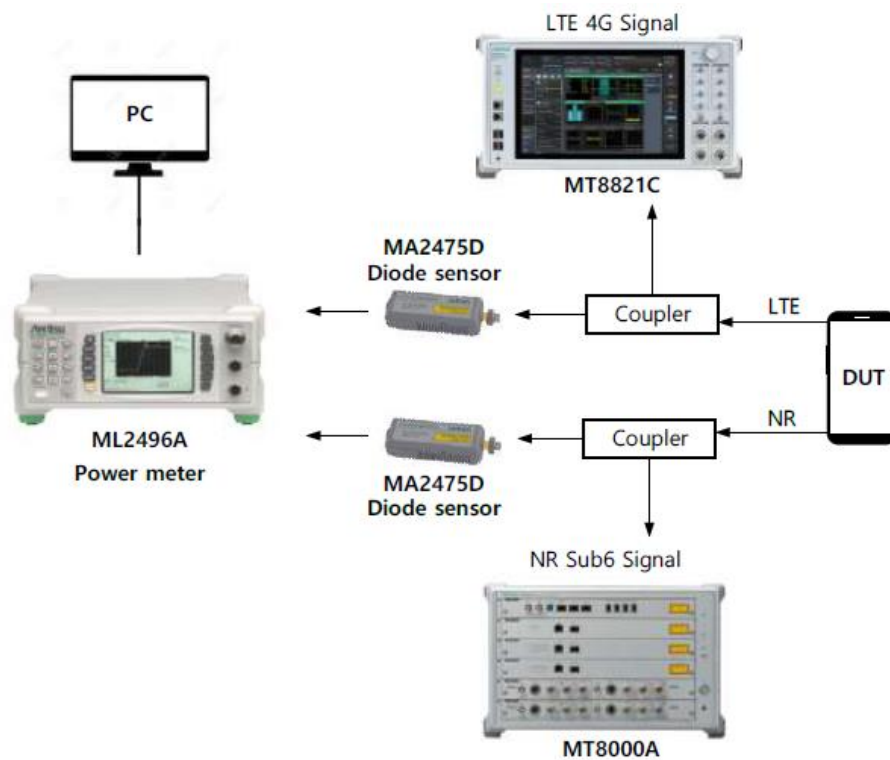


Figure 11.1-1 Test set-up for legacy and sub 6GHz

The test setup for TAS validation with sub-6GHz RATs only is shown in Figure 11.1-1. Normally, a power sensor would measure total power in the entire frequency of its specification e.g. 10MHz to 50GHz for the MA2475D 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 post processing 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. 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 values versus time as described in Section 6.

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.

## 11.1.2 Test set-up for WLAN and Bluetooth

The test setup for TAS validation with WLAN and Bluetooth is shown in Figure 11.1-2. Normally, a power sensor would measure total power in the entire frequency of its specification e.g. 10MHz to 8GHz for the NRP8S 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 post processing at a PC. The signaling call box CMW500 is used to establish the call and data connection to the DUT on those same ports for WLAN and Bluetooth, 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 box to the DUT which can essentially instruct the DUT to change its transmit power.

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.

In summary, the tests have to be executed as following procedure.

1. Measure conduction WLAN and Bluetooth Tx power corresponds to SAR regulation.
2. Start the test
3. Execute time-varying test scenarios. And record power using 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.

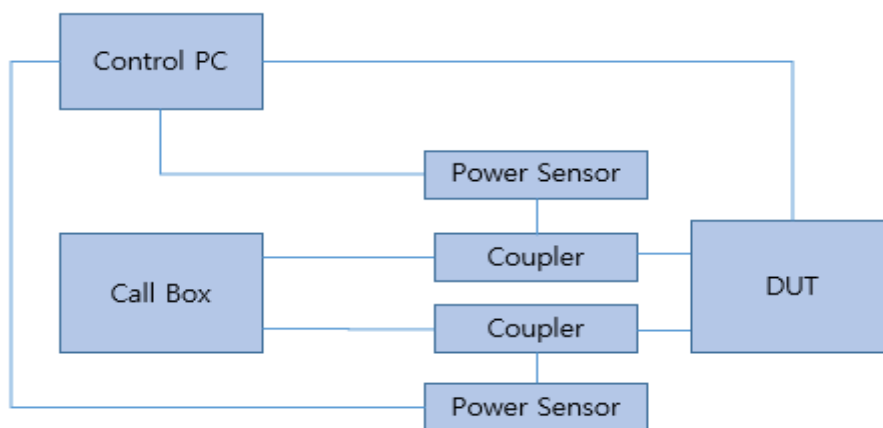


Figure 11.1-2 Test set-up for WLAN and Bluetooth

### 11.1.3 Test set-up for Combined TAS

The test setup for TAS validation with Combined TAS is shown in Figure 11.1-3. Normally, a power sensor would measure total power in the entire frequency of its specification e.g. 10MHz to 8GHz for the NRP8S 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 post processing at a PC. The signaling call boxes CMW500 and MT8000A are used to establish voice and data connections with the DUT (Device Under Test), with the CMW500 handling LTE, WLAN, and Bluetooth over the same ports, and the MT8000A handling NR over a dedicated NR port.

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 box to the DUT which can essentially instruct the DUT to change its transmit power.

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.

In summary, the tests have to be executed as following procedure.

1. Measure conduction Sub 6GHz and WLAN, Bluetooth Tx power corresponds to SAR regulation
2. Start the test
3. Execute time-varying test scenarios. And record power using power meter equipment.
4. Plot the recorded results over measurement time. And evaluate the results for validation.

Note :The WWAN Mode and WLAN/BT output of all C-TAS verification tests are controlled through the Call Box and measured at 100msec intervals through the power sensor.

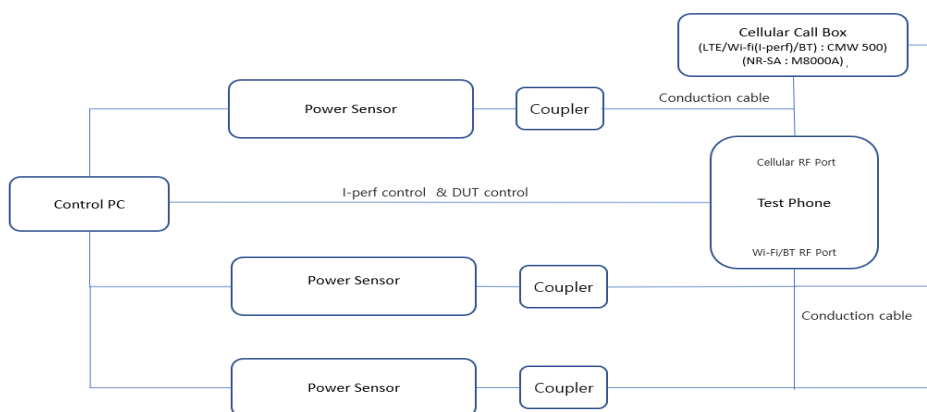


Figure 11.1-3 Test set-up for C-TAS

## 11.2 *Plimit* and *Pmax* measurement results

The measured *Plimit* for all the selected radio configurations are listed in Table 11.2.1. *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 11.2.1 is not actual *Plimit* corresponding to 1W/kg SAR, but our measured averaged power when forcing *Plimit* in our SW based on Table 11.2.1.

| TC# | Test scenario                                                              | Tech    | Band | Antenna  | RSI | RBoffset/BW | Mode     | Configuration | Plimit setting (dBm) | Pmax setting (dBm) | measured Plimit (dBm) Sensor | measured Pmax (dBm) Sensor | Measured 1g SAR | Max averaged time 1g SAR | Test Result |
|-----|----------------------------------------------------------------------------|---------|------|----------|-----|-------------|----------|---------------|----------------------|--------------------|------------------------------|----------------------------|-----------------|--------------------------|-------------|
|     |                                                                            |         |      |          |     |             |          |               |                      |                    |                              |                            | (W/kg)          | (W/kg)                   |             |
|     |                                                                            |         |      |          |     |             |          |               |                      |                    |                              |                            |                 |                          |             |
| 1   | Time varying Tx power Sequence 1                                           | LTE     | 25   | Main1(A) | 0   | 1/49/20     | QPSK     | 5mm/Body      | 15.0                 | 24.0               | 15.35                        | 24.56                      | 0.962           | 1.017                    | Verified    |
| 2   |                                                                            | SA/FRL  | n25  | Main1(A) | 0   | 1/1/40      | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.80                        | 24.41                      | 0.851           | 0.849                    | Verified    |
| 3   |                                                                            | UMTS    | 2    | Main1(A) | 0   |             | RMC      | 5mm/Body      | 14.0                 | 23.5               | 14.50                        | 23.50                      | 0.980           | 1.070                    | Verified    |
| 4   |                                                                            | GSM     | 1900 | Main1(A) | 0   |             | 4Tx      | 5mm/Body      | 15.0                 | 25.2               | 15.12                        | 25.20                      | 0.851           | 0.897                    | Verified    |
| 5   | Time varying Tx power Sequence 2                                           | LTE     | 25   | Main1(A) | 0   | 1/49/20     | QPSK     | 5mm/Body      | 15.0                 | 24.0               | 15.35                        | 24.56                      | 0.962           | 0.846                    | Verified    |
| 6   |                                                                            | SA/FRL  | n25  | Main1(A) | 0   | 1/1/40      | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.80                        | 24.41                      | 0.851           | 0.820                    | Verified    |
| 7   |                                                                            | UMTS    | 2    | Main1(A) | 0   |             | RMC      | 5mm/Body      | 14.0                 | 23.5               | 14.50                        | 23.50                      | 0.980           | 1.016                    | Verified    |
| 8   |                                                                            | GSM     | 1900 | Main1(A) | 0   |             | 4Tx      | 5mm/Body      | 15.0                 | 25.2               | 15.12                        | 25.20                      | 0.851           | 0.806                    | Verified    |
| 9   | Change in Call                                                             | LTE     | 25   | Main1(A) | 0   | 1/49/20     | QPSK     | 5mm/Body      | 15.0                 | 24.0               | 15.35                        | 24.56                      | 0.962           | 0.946                    | Verified    |
| 10  | Re-selection in call (Tech Switch)                                         | SA/FRL  | n25  | Main1(A) | 0   | 1/1/40      | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.80                        | 24.41                      | 0.851           | 1.089                    | Verified    |
|     |                                                                            | LTE     | 25   | Main1(A) | 0   | 1/49/20     | QPSK     | 5mm/Body      | 15.0                 | 24.0               | 15.35                        | 24.56                      | 0.962           |                          | Verified    |
| 11  | Antenna Band Switch                                                        | LTE     | 25   | Main1(A) | 0   | 1/49/20     | QPSK     | 5mm/Body      | 15.0                 | 24.0               | 15.35                        | 24.56                      | 0.962           | 0.900                    | Verified    |
|     |                                                                            | LTE     | 41   | Main2(B) | 0   | 1/0/20      | QPSK     | 5mm/Body      | 18.0                 | 22.0               | 18.00                        | 22.00                      | 0.834           |                          | Verified    |
| 12  | SAR exposure switch (NSA, same group)                                      | NSA/FRL | n25  | Main1(A) | 0   | 1/1/40      | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.80                        | 24.41                      | 0.851           | 0.920                    | Verified    |
|     |                                                                            | LTE     | L12  | Main1(A) | 0   | 1/24/10     | QPSK     | 5mm/Body      | 22.0                 | 24.5               | 22.32                        | 24.50                      | 0.913           |                          | Verified    |
| 13  | Change in RSI                                                              | NSA/FRL | n25  | Main1(A) | 0   | 1/1/40      | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.80                        | 24.41                      | 0.851           | 0.867                    | Verified    |
|     |                                                                            | NSA/FRL | n25  | Main1(A) | 1   |             | 0mm/Head | 24.0          |                      | 24.04              | 24.41                        | 0.204                      | Verified        |                          |             |
| 14  | NSA antenna switching with Spatial TAS (same group,NSA -> other group,NSA) | LTE     | 12   | Main1(A) | 0   | 1/24/10     | QPSK     | 5mm/Body      | 22.0                 | 24.5               | 22.32                        | 24.50                      | 0.913           | 0.978                    | Verified    |
|     |                                                                            | NSA/FRL | n41  | Main2(B) | 0   | 1/1/100     | QPSK     | 5mm/Body      | 14.0                 | 24.0               | 14.02                        | 24.11                      | 0.321           |                          | Verified    |
|     |                                                                            | NSA/FRL | n77  | Sub2(F)  | 0   | 1/1/100     | QPSK     | 5mm/Body      | 14.5                 | 26.0               | 14.53                        | 25.70                      | 0.601           |                          | Verified    |

Table 11.2.1.

\* *Plimit* and Tune up output power *Pmax* in above table correspond to average power level after accounting for duty cycle in the case of TDD Modulation schemes (GSM, LTE TDD, NR TDD)

WLAN Test configurations are listed on Table 11.2.2

| W_TC# | Test scenario                            | Tech | Band   | Antenna | RSI | Mode  | Configurat<br>ion   | Plimit setting<br>(dBm) | Pmax<br>setting<br>(dBm) | measured<br>Plimit (dBm)<br>Sensor | measured<br>Pmax (dBm)<br>Sensor | Measured<br>1g SAR<br>(W/kg) | Max<br>averaged<br>time 1g SAR<br>(W/kg) |
|-------|------------------------------------------|------|--------|---------|-----|-------|---------------------|-------------------------|--------------------------|------------------------------------|----------------------------------|------------------------------|------------------------------------------|
| 1     | Tx Power of WLAN TAS Test(Bluetooth off) | WLAN | 2.4GHz | Sub4(H) | 0   | 1Mbps | 1g/5mm/No<br>n Head | 17.0                    | 20.0                     | 17.55                              | 20.15                            | 0.537                        | 0.581                                    |
|       |                                          |      |        |         | 1   |       | 1g/0mm/Hea<br>d     |                         |                          |                                    |                                  | 0.421                        |                                          |
| 2     |                                          | WLAN | 5GHz   | Sub4(H) | 0   | MCS0  | 1g/5mm/No<br>n Head | 14.0                    | 14.0                     | 13.87                              | 13.87                            | 0.409                        | 0.493                                    |
|       |                                          |      |        |         | 1   |       | 1g/0mm/Hea<br>d     |                         |                          |                                    |                                  | 0.524                        |                                          |
| 3     |                                          | WLAN | 6GHz   | Sub4(H) | 0   | MCS0  | 1g/5mm/No<br>n Head | 8.0                     | 10.0                     | 8.52                               | 10.45                            | 0.130                        | 0.138                                    |
|       |                                          |      |        |         | 1   |       | 1g/0mm/Hea<br>d     |                         |                          |                                    |                                  | 0.070                        |                                          |

Table 11.2.2

C-TAS Test configurations are listed on Table 11.2.3

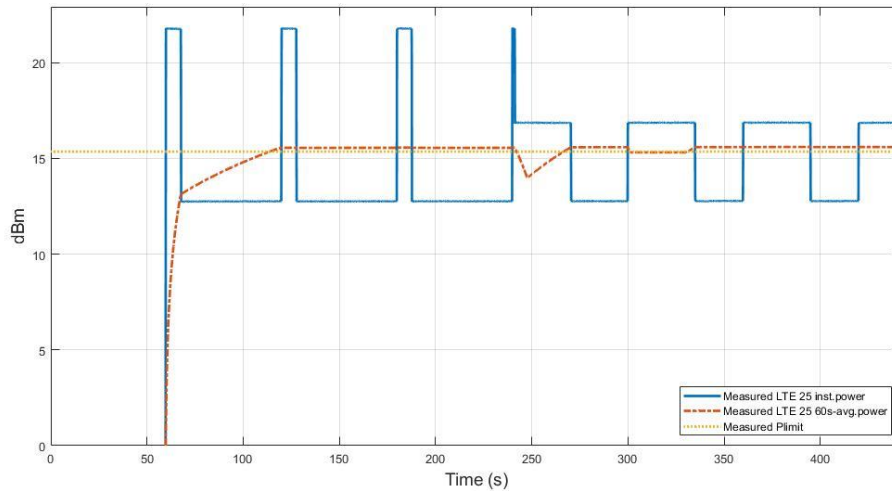
| C-TC# | Test<br>scenario      | Tech      | Band | Antenna | RSI | RB/offset/B<br>W | Mode       | Configurat<br>ion | Plimit<br>setting<br>(dBm) | Pmax<br>setting<br>(dBm) | measured<br>Plimit<br>(dBm)<br>Sensor | measured<br>Pmax (dBm)<br>Sensor | Measured<br>1g SAR<br>(W/kg) | Max Time<br>averaged 1g<br>SAR<br>(W/kg) | TER <1.0 |
|-------|-----------------------|-----------|------|---------|-----|------------------|------------|-------------------|----------------------------|--------------------------|---------------------------------------|----------------------------------|------------------------------|------------------------------------------|----------|
| 1     | Tech<br>Switch<br>LTE | LTE       | 66   | Sub2(F) | 0   | 1/49/20          | QPSK       | 5mm/Non<br>Head   | 17.0                       | 24.0                     | 17.05                                 | 23.75                            | 0.605                        | 0.64                                     | 0.560    |
|       |                       | WLAN      | 5GHz | Sub4(H) |     | N/A              | MCS0       | 5mm/Non<br>Head   | 15.0                       | 15.0                     | 13.62                                 | 13.62                            | 0.409                        | 0.38                                     |          |
|       |                       | Bluetooth | BDR  | Sub4(H) |     | N/A              | 2DH5       | 5mm/Non<br>Head   | 12.0                       | 12.0                     | 11.82                                 | 11.82                            | 0.116                        | 0.12                                     |          |
| 2     | Tech<br>Switch<br>NR  | SA/FR1    | n77  | Sub2(F) | 0   | 1/137/100        | DFT-s QPSK | 5mm/Non<br>Head   | 14.5                       | 26.0                     | 15.02                                 | 25.55                            | 0.601                        | 0.60                                     | 0.587    |
|       |                       | WLAN      | 5GHz | Sub4(H) |     | N/A              | MCS0       | 5mm/Non<br>Head   | 15.0                       | 15.0                     | 13.62                                 | 13.62                            | 0.409                        | 0.37                                     |          |
|       |                       | Bluetooth | BDR  | Sub4(H) |     | N/A              | 2DH5       | 5mm/Non<br>Head   | 12.0                       | 12.0                     | 11.82                                 | 11.82                            | 0.116                        | 0.12                                     |          |

Table 11.2.3

### 11.3 Time-varying Tx power measurement results

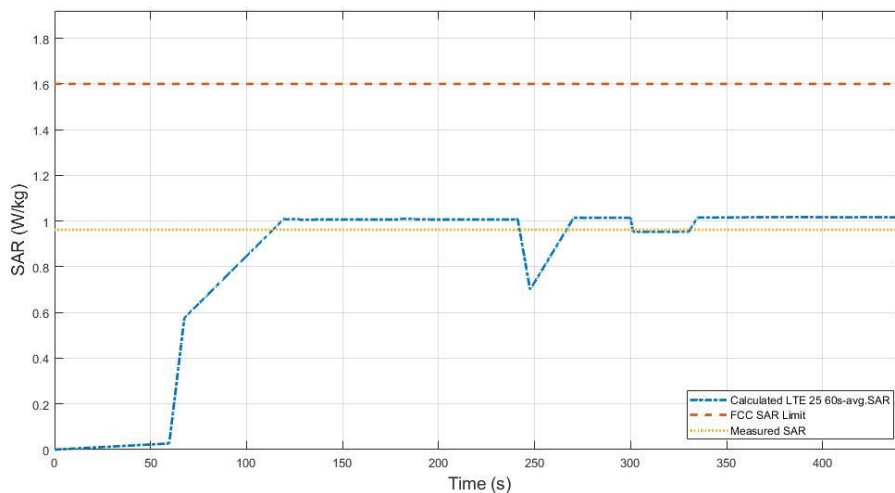
Time-varying Tx power test case can be skipped if measured SAR value in Pmax is less than 90% of target SAR limit. This is because even if Pmax is used for all times, used SAR cannot be reached to the target SAR limit. Following the test procedure in Section 7.3.1, the conducted Tx power measurement 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 and #02 in Table 11.1-1 by generating the test sequence A or B given in Appendix.

### TC01: Time\_Varying\_Tx\_Power\_Case\_1 [LTE B25]



**Figure 11.3-1 Time average conducted power of LTE B25 in TC01**

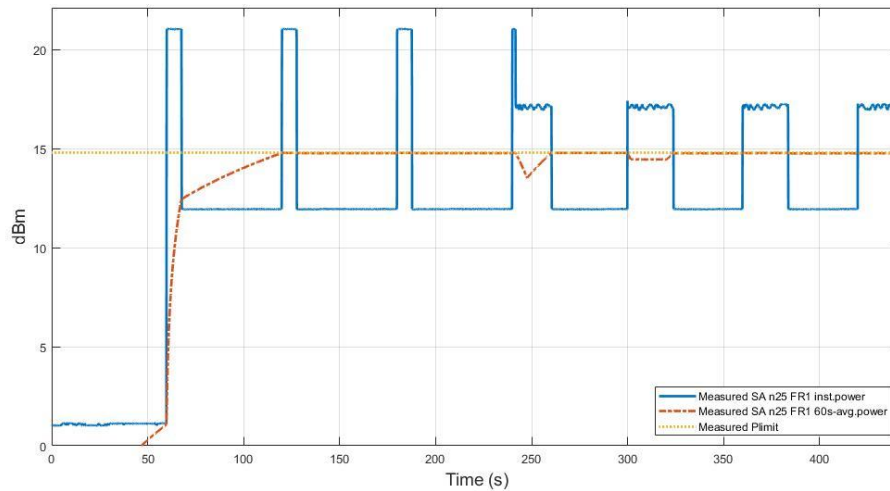
In this test, measured 1g SAR would be 0.962 W/kg at 15.0 dBm. Figure 11.3-1 shows the instantaneous and time-averaged Tx power with test sequence A for LTE B25 with Plimit 15.0 dBm. In addition, Figure 11.3-1 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-2 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-2 Total time-averaged SAR in TC01**

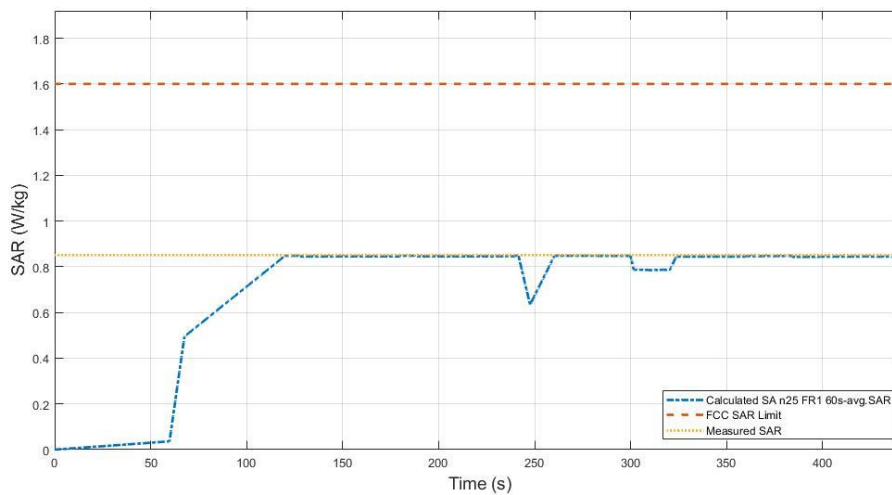
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 1.017 W/kg |
| Device uncertainty                      | 1 dB       |

## TC02: Time\_Varying\_Tx\_Power\_Case\_1 [NR n25]



**Figure 11.3-3 Time average conducted power of NR n25 in TC02**

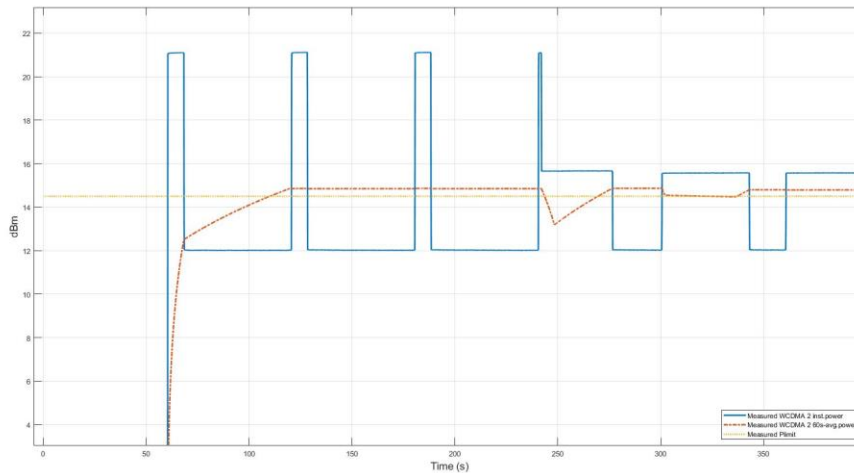
In this test, measured 1g SAR would be 0.851 W/kg at 14.0 dBm. Figure 11.3-3 shows the instantaneous and time-averaged Tx power with test sequence A for NR n77 with Plimit 14.0 dBm. In addition, Figure 11.3-3 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-4 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-4 Total time-averaged SAR in TC02**

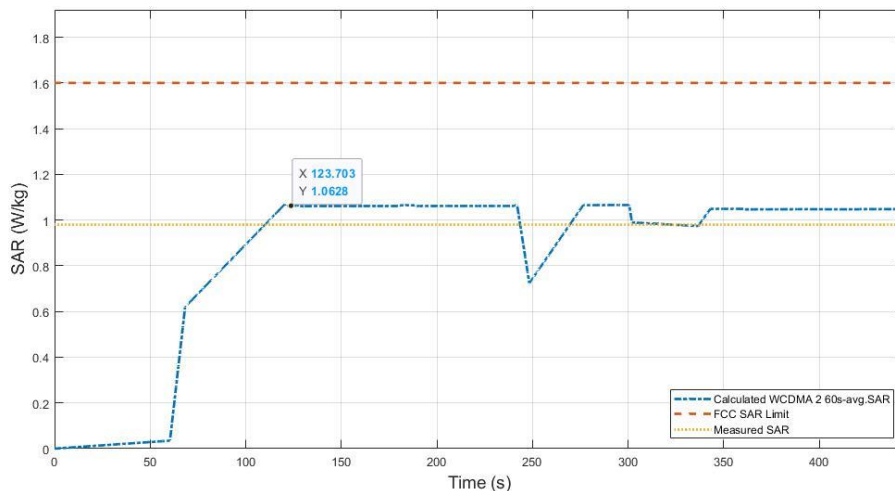
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.849 W/kg |
| Device uncertainty                      | 1 dB       |

## TC03: Time\_Varying\_Tx\_Power\_Case\_1 [UMTS B2]



**Figure 11.3-5 Time-average conducted power of UMTS B2 in TC03**

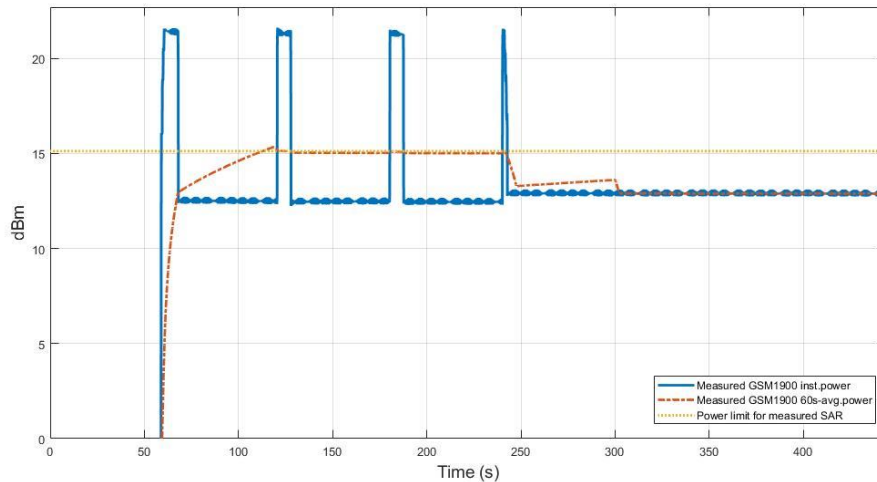
In this test, measured 1g SAR would be 0.980 W/kg at 14.0 dBm. Figure 11.3-5 shows the instantaneous and time-averaged Tx power with test sequence A for UMTS B2 with Plimit 14.0 dBm. In addition, Figure 11.3-5 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-6 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-6 Total time-averaged SAR in TC03**

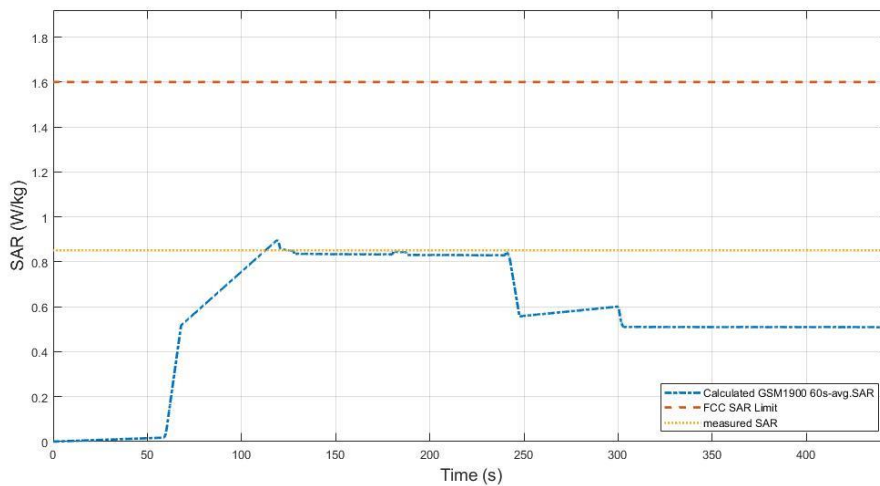
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 1.070 W/kg |
| Device uncertainty                      | 1 dB       |

## TC04: Time\_Varying\_Tx\_Power\_Case\_1 [PCS1900]



**Figure 11.3-7 Time-average conducted power of PCS1900 in TC04**

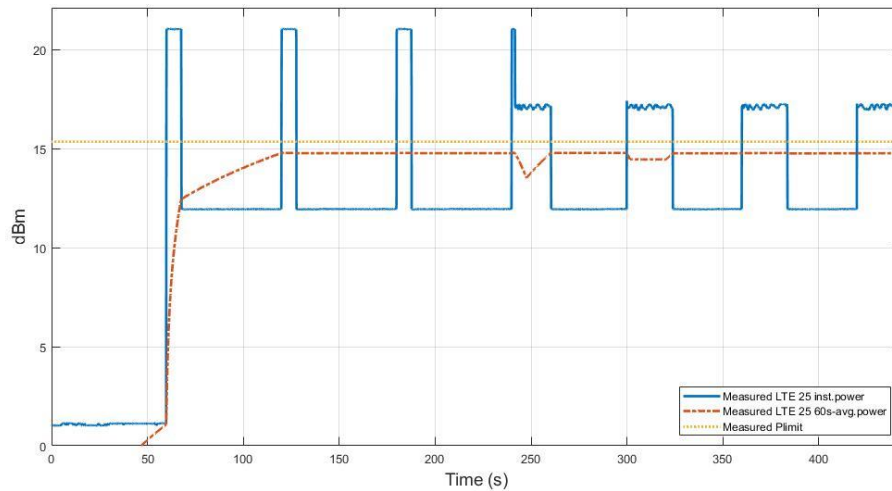
In this test, measured 1g SAR would be 0.851 W/kg at 15.0 dBm. Figure 11.3-7 shows the instantaneous and time-averaged Tx power with test sequence A for PCS1900 with Plimit 15.0 dBm. In addition, Figure 11.3-7 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-8 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-8 Total time-averaged SAR in TC04**

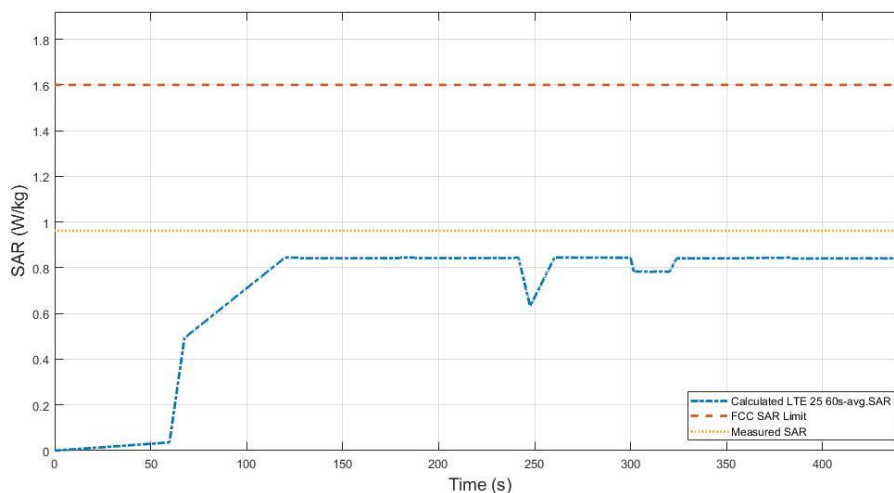
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.897 W/kg |
| Device uncertainty                      | 1 dB       |

## TC05: Time\_Varying\_Tx\_Power\_Case\_2 [LTE B25]



**Figure 11.3-9 Conducted Tx power of LTE B25 in TC05**

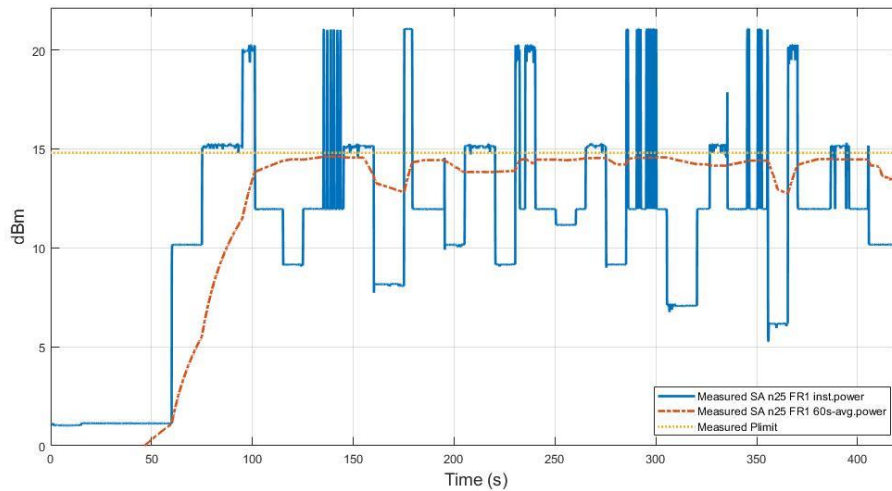
In this test, measured 1g SAR would be 0.962 W/kg at 15.0 dBm. Figure 11.3-9 shows the instantaneous and time-averaged Tx power with test sequence B for LTE B25 with Plimit 15.0 dBm. In addition, Figure 11.3-9 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-10 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-10 Total time-averaged SAR in TC05**

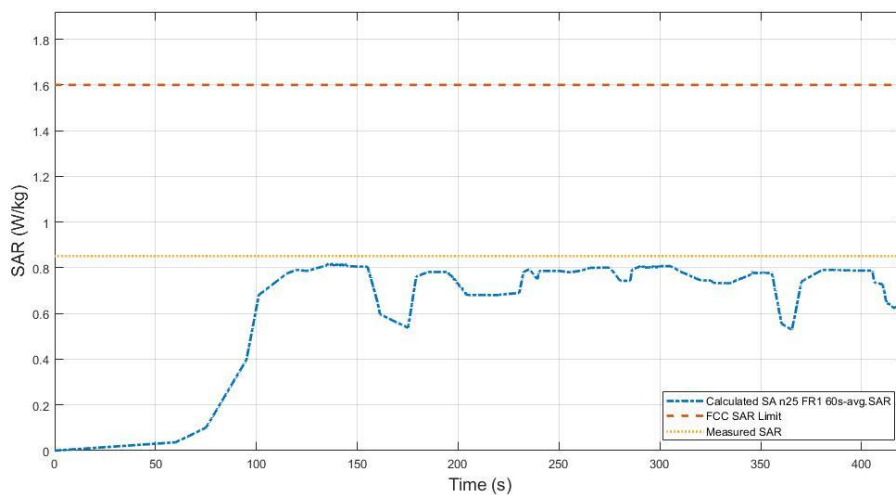
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.846 W/kg |
| Device uncertainty                      | 1 dB       |

## TC06: Time\_Varying\_Tx\_Power\_Case\_2 [NR n25]



**Figure 11.3-11 Conducted Tx power of NR n25 in TC06**

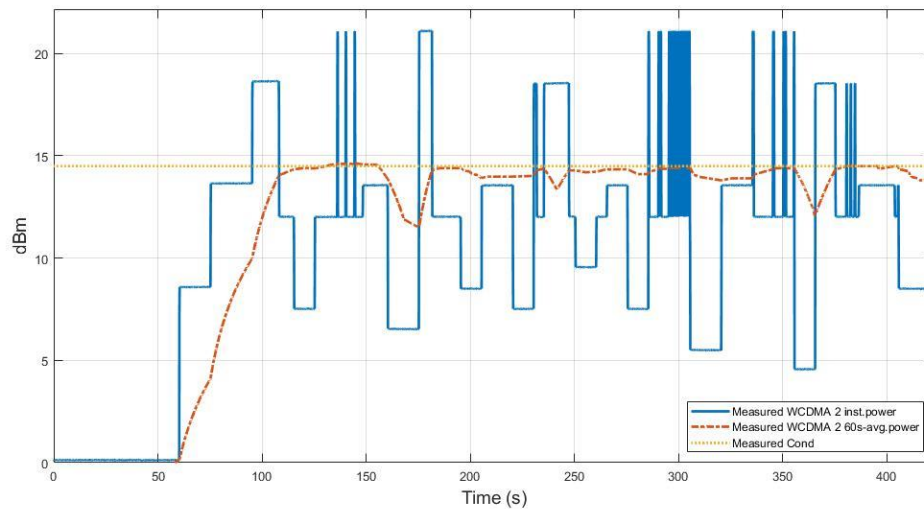
In this test, measured 1g SAR would be 0.851 W/kg at 14.0 dBm. Figure 11.3-11 shows the instantaneous and time-averaged Tx power with test sequence A for NR n66 with Plimit 14.0 dBm. In addition, Figure 11.3-11 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-12 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-12 Total time-averaged SAR in TC06**

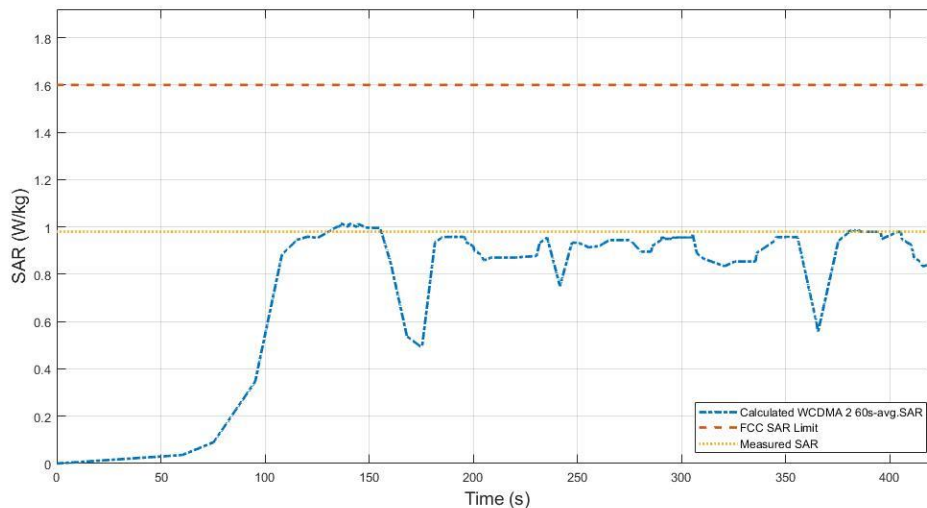
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.820 W/kg |
| Device uncertainty                      | 1 dB       |

### TC07: Time\_Varying\_Tx\_Power\_Case\_2 [UMTS B2]



**Figure 11.3-13 Conducted Tx power for UMTS B2 in TC07**

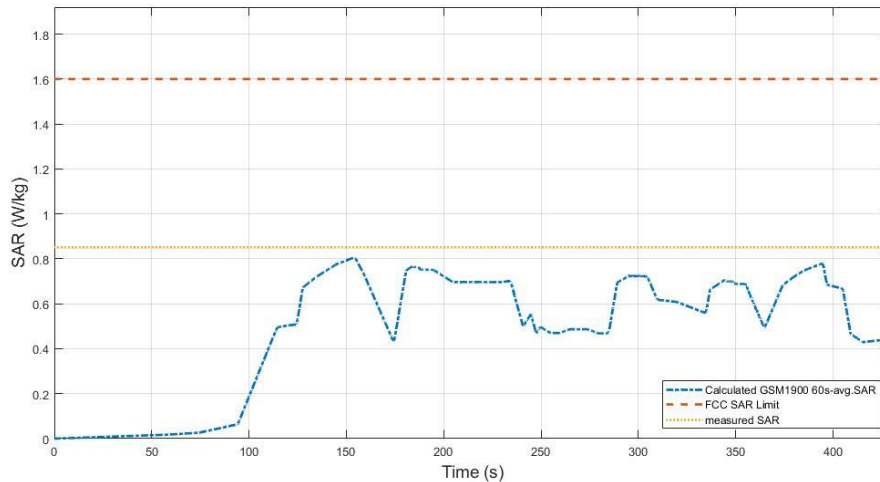
In this test, measured 1g SAR would be 0.980 W/kg at 14.0 dBm. Figure 11.3-13 shows the instantaneous and time-averaged Tx power with test sequence A for UMTS B2 with Plimit 14.0 dBm. In addition, Figure 11.3-13 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-14 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-14 Total time-averaged SAR in TC07**

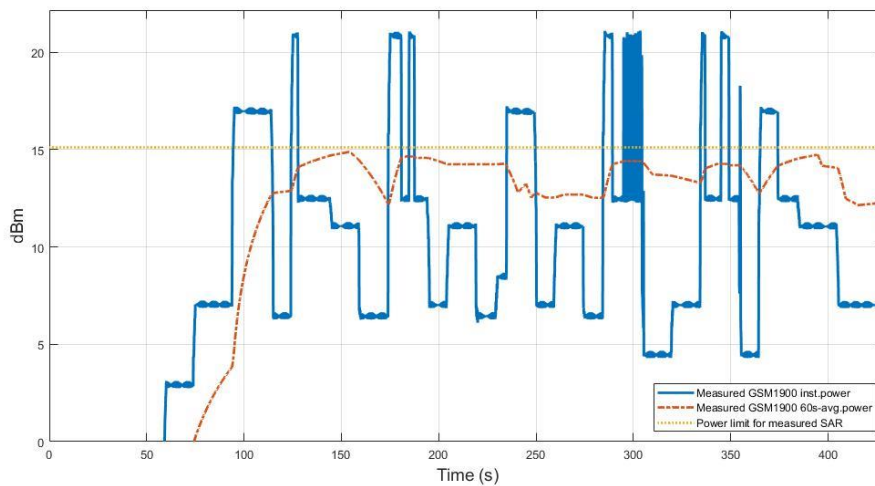
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 1.016 W/kg |
| Device uncertainty                      | 1 dB       |

## TC08: Time\_Varying\_Tx\_Power\_Case\_2 [PCS1900]



**Figure 11.3-15 Conducted Tx power for PCS1900 in TC08**

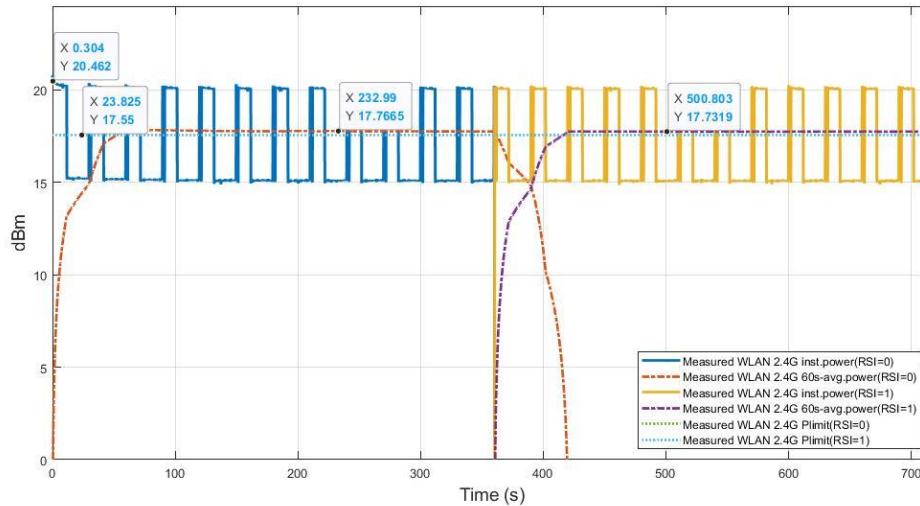
In this test, measured 1g SAR would be 0.851 W/kg at 15.0 dBm. Figure 11.3-15 shows the instantaneous and time-averaged Tx power with test sequence A for PCS1900 with Plimit 15.0 dBm. In addition, Figure 11.3-15 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-16 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-16 Total time-averaged SAR in TC08**

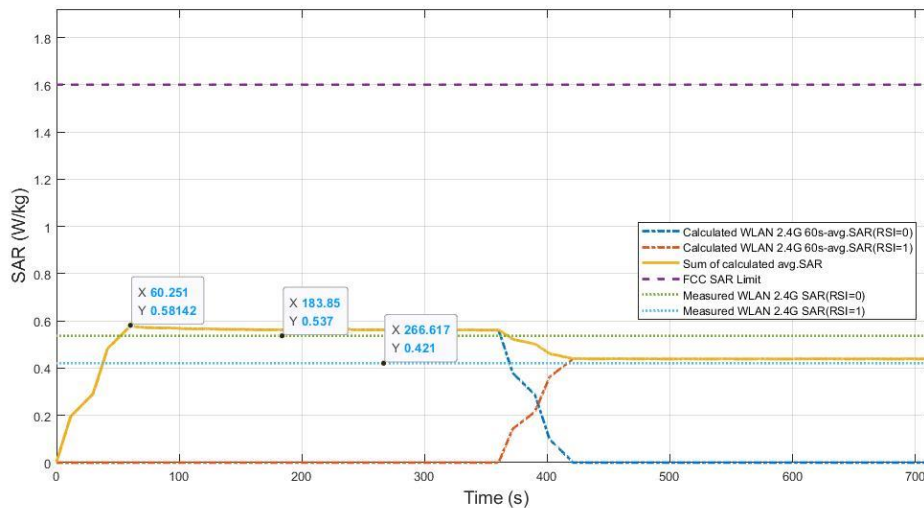
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.806 W/kg |
| Device uncertainty                      | 1 dB       |

## WTC01: Tx Power of WLAN TAS (Bluetooth off) [WLAN 2.4GHz]



**Figure 11.3-17 Conducted Tx power for WLAN 2.4GHz in WTC01**

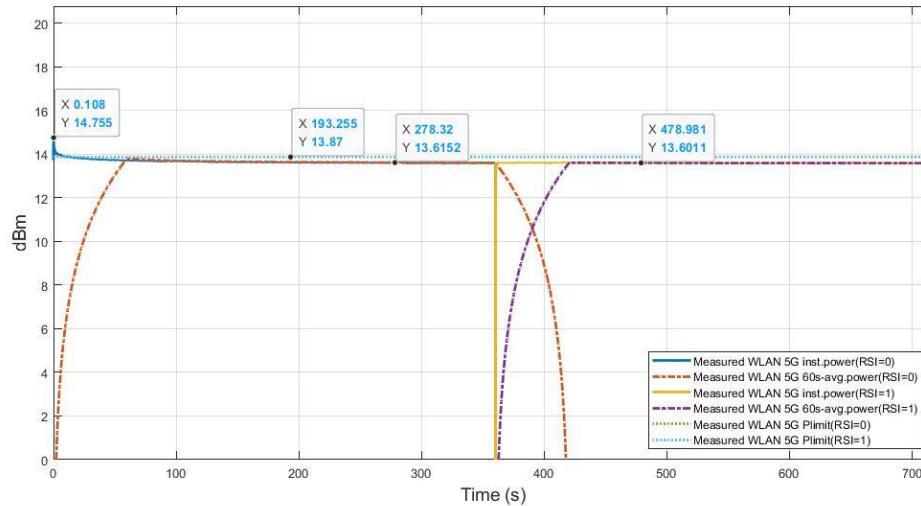
In this test, measured 1g SAR would be 0.537W/kg at 17.0dBm for WLAN 2.4GHz[RSI=0] and 0.421 W/kg at 17.0dBm for WLAN 2.4GHz[RSI=1]. Figure 11.3-17 shows the instantaneous and time-averaged conducted Tx power for WLAN 2.4GHz for the duration of the test. In addition, Figure 11.3-17 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-18 shows the calculated time-averaged 1g SAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-18 Total time-averaged SAR in WTC01**

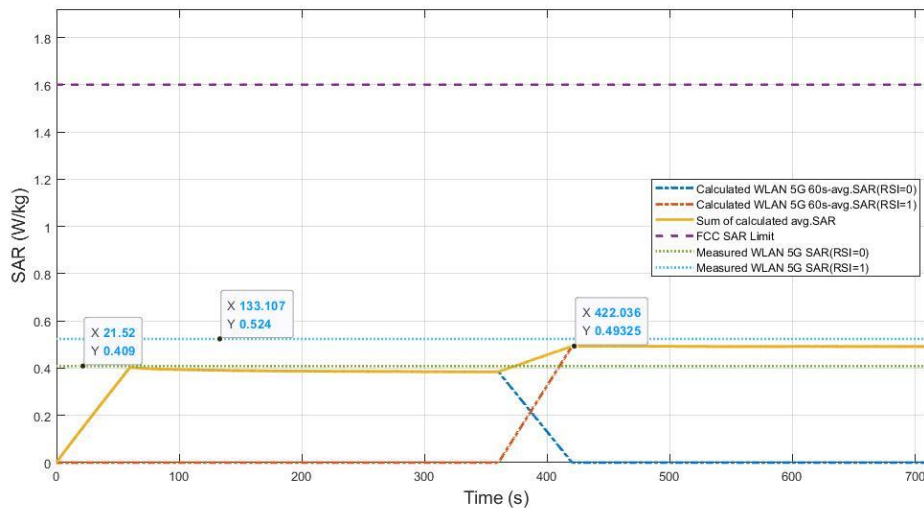
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.581 W/kg |
| Device uncertainty                      | 1 dB       |

## WTC02: Tx Power of WLAN TAS (Bluetooth off) [WLAN 5GHz]



**Figure 11.3-19 Conducted Tx power for WLAN 5GHz in WTC02**

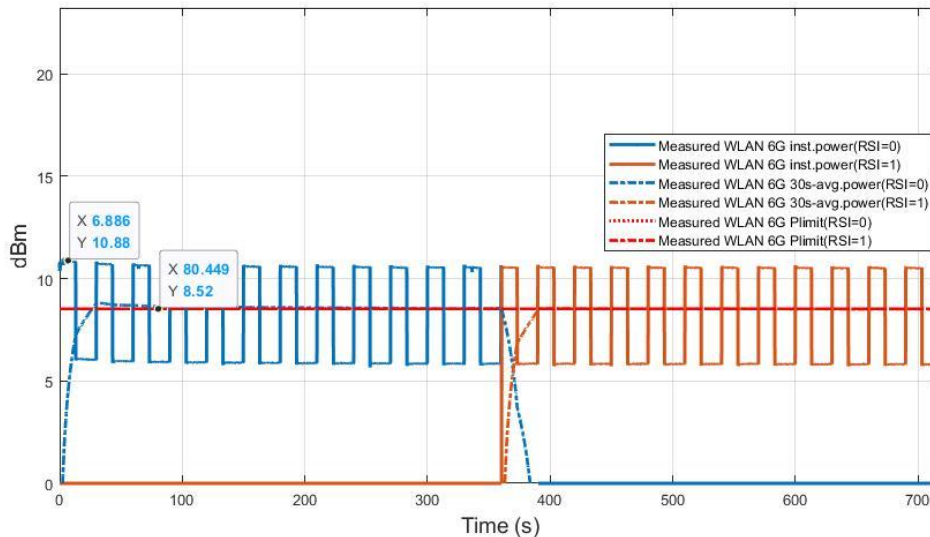
In this test, measured 1g SAR would be 0.409W/kg at 14.0dBm for WLAN 5GHz[RSI=0] and 0.524 W/kg at 14.0dBm for WLAN 5GHz[RSI=1]. Figure 11.3-19 shows the instantaneous and time-averaged conducted Tx power for WLAN 5GHz for the duration of the test. In addition, Figure 11.3-19 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-20 shows the calculated time-averaged 1g SAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



**Figure 11.3-20 Total time-averaged SAR in WTC01**

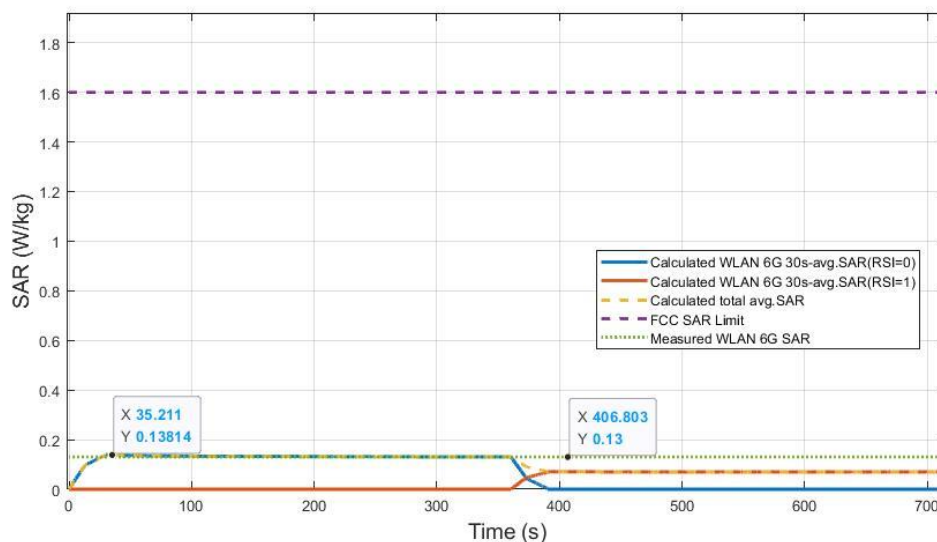
|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.493 W/kg |
| Device uncertainty                      | 1 dB       |

## WTC03: Tx Power of WLAN TAS (Bluetooth off) [WLAN 6GHz]



**Figure 11.3-21 Conducted Tx power for WLAN 6GHz in WTC03**

In this test, measured 1g SAR would be 0.130W/kg at 8.0dBm for WLAN 6GHz[RSI=0] and 0.070 W/kg at 8.0dBm for WLAN 6GHz[RSI=1]. Figure 11.3-21 shows the instantaneous and time-averaged conducted Tx power for WLAN 6GHz for the duration of the test. In addition, Figure 11.3-21 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.3-22 shows the calculated time-averaged 1g SAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.



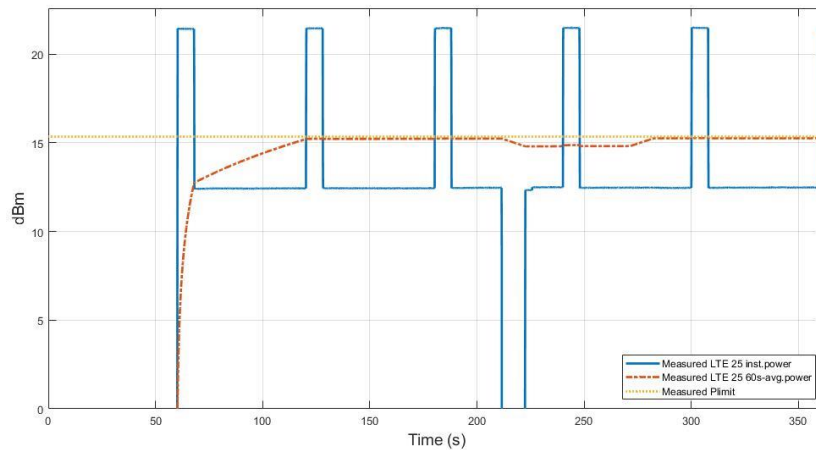
**Figure 11.3-22 Total time-averaged SAR in WTC01**

|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.138 W/kg |
| Device uncertainty                      | 1 dB       |

## 11.4 Change in call test results

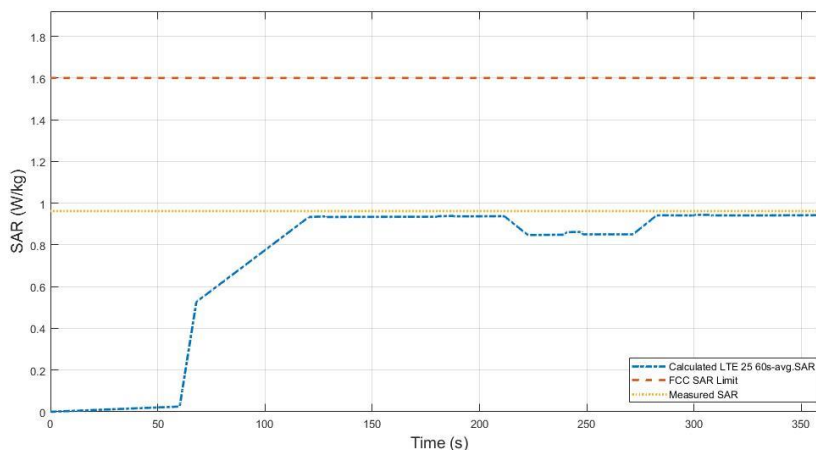
The test results in this section are obtained following the procedure in Section 7.3.2. The test case corresponds to TC#9 in Table 11.2.1.

### TC09: LTE\_Call\_Disconnect\_Reestablishment



**Figure 11.4-1 Conducted Tx power in Call\_Disconnect\_Reestablishment LTE Band 25 case TC09**

In this test, Measured 1g SAR would be 0.962 W/kg at 15.0 dBm. Figure 11.4-1 shows the instantaneous and time-averaged Tx power for this test. The call disconnected around 210s and resumed after 10s. It is confirmed for time-average Tx power that the FCC limit was not exceeded, and observed averaging power is around power limit with an uncertainty. Figure 11.4-2 shows the 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.



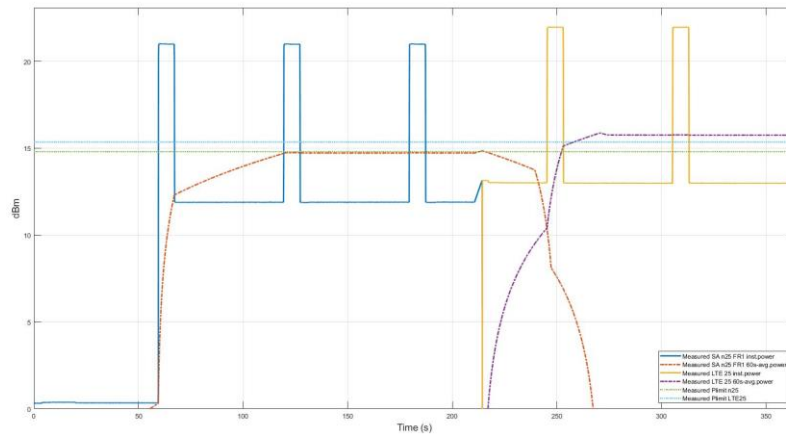
**Figure 11.4-2 Total time-averaged SAR in TC09**

|                                         |            |
|-----------------------------------------|------------|
| FCC 1gSAR limit                         | 1.6 W/kg   |
| Max 60s-time average 1gSAR (blue curve) | 0.946 W/kg |
| Device uncertainty                      | 1 dB       |

## 11.5 Re-selection in call test results

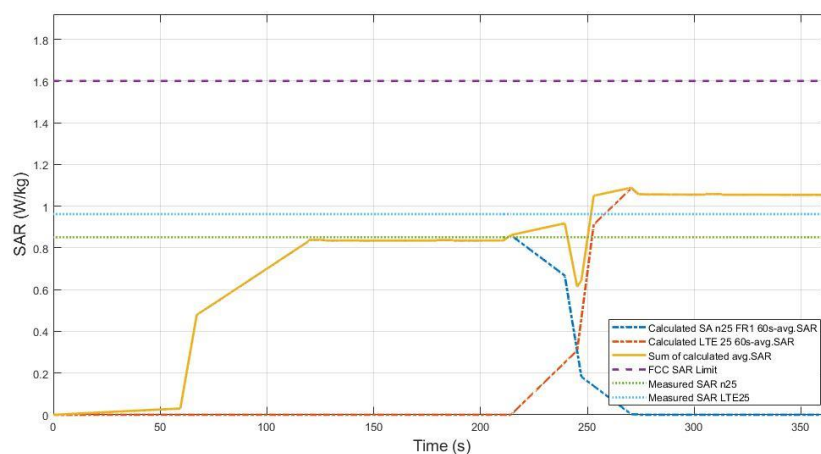
The test results in this section are obtained following the procedure in Section 7.3.4. The test cases correspond to TC#11 in Table 11.2.1.

### TC10: FR1 to LTE IRAT Re-selection



**Figure 11.5-1 Conducted Tx power for SAR IRAT re-selection in test TC10 [n25 to LTE B25]**

In this test, measured 1g SAR would be 0.851W/kg at 14.0dBm for NR n25 and 0.962 W/kg at 15.0dBm for LTE B25. Figure 11.6-1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band 25 and NR n7 for the duration of the test. Around time stamp of ~210s, a RAT re-selection from NR n25 to LTE B25 was executed, resulting in reduction of time-averaged power of NR n25 and simultaneous increase in time-averaged power of LTE B25. Here, LTE can use back-off power just after re-selection. Since there is a correlation between n25 and B25, TAS algorithm needs to consider the SAR value used in n25 for B25. Figure 11.6-2 shows the time-averaged 1gSAR value for each of LTE B25 and NR n25, as well as the total SAR value. It can be confirmed that the total 1gSAR is always under the total FCC limit of 1.6W/Kg even in coupling case.



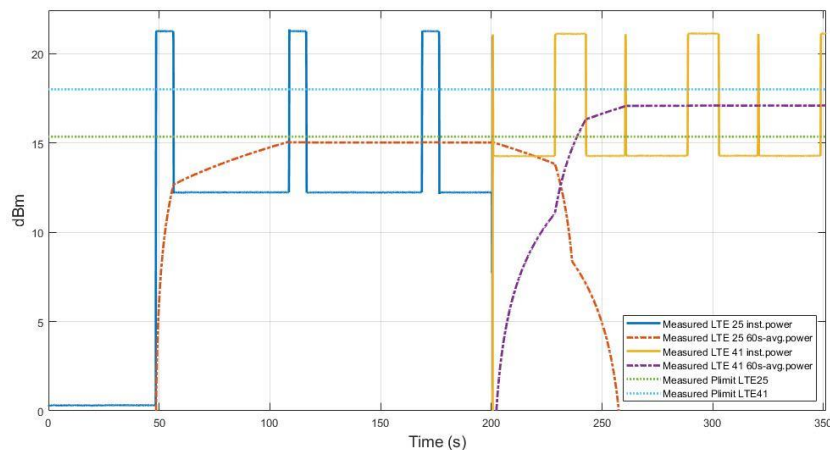
**Figure 11.5-2 Conducted Tx power for SAR IRAT re-selection in test TC10**

|                                            |            |
|--------------------------------------------|------------|
| FCC 1gSAR limit                            | 1.6 W/kg   |
| Max 100s-time average 1gSAR (yellow curve) | 1.089 W/kg |
| Device uncertainty                         | 1 dB       |

## 11.6 Antenna/Band switching test results

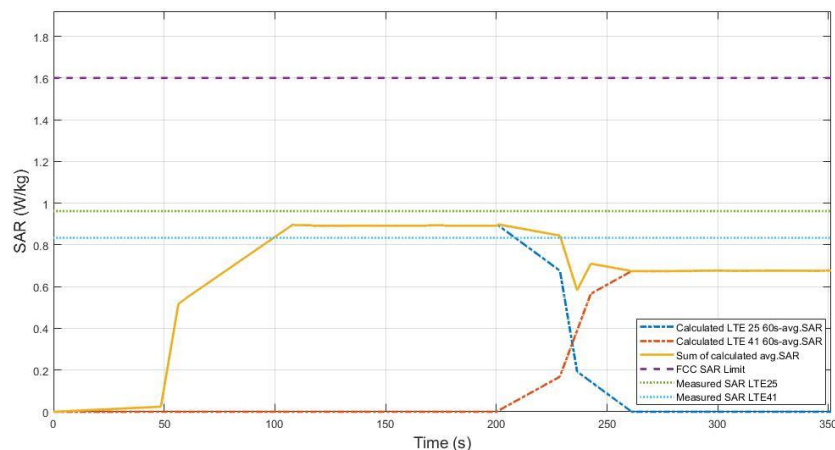
The test results in this section are obtained following the procedure in Section 7.3.4 The test cases correspond to TC#11 in Table 11.2.1.

### TC11: LTE\_Antenna\_Band\_Switching



**Figure 11.6-1 Conducted Tx power for antenna switching in test TC11**

In this test, measured 1g SAR 0.962 W/kg at 15.0dBm for LTE B25 and 0.834 W/kg at 18.0dBm for LTE B41. Figure 11.7-1 shows the instantaneous and time-averaged conducted Tx power for both LTE B25 and LTE B41 for the duration of the test. Around time stamp of ~210s, a band change from LTE B25 to B41 was executed, resulting in reduction of time-averaged power of LTE B25 and simultaneous increase in time-averaged power of LTE B41. Here, LTE can use back-off power just after re-selection. Since there is a correlation between B25 and B41, TAS algorithm needs to consider the SAR value used in B25 for B41. Figure 11.7-2 shows the time-averaged 1gSAR value for each of LTE B25 and LTE B41, as well as the total SAR value. It can be confirmed that the total 1gSAR is always under the total FCC limit of 1.6W/Kg even in coupling case.



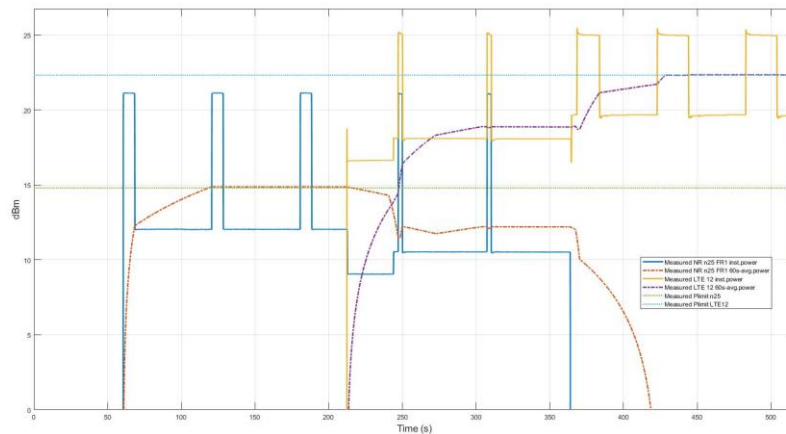
**Figure 11.6-2 Total time-averaged SAR in TC11**

|                                           |            |
|-------------------------------------------|------------|
| FCC 1gSAR limit                           | 1.6 W/kg   |
| Max 60s-time average 1gSAR (yellow curve) | 0.900 W/kg |
| Device uncertainty                        | 1 dB       |

## 11.7 SAR exposure switching test results

The test results in this section are obtained following the procedure in Section 7.3.6. The test cases correspond to TC#12 in Table 11.2.1.

TC12: NSA\_FR1\_Dominant\_Power\_Switching

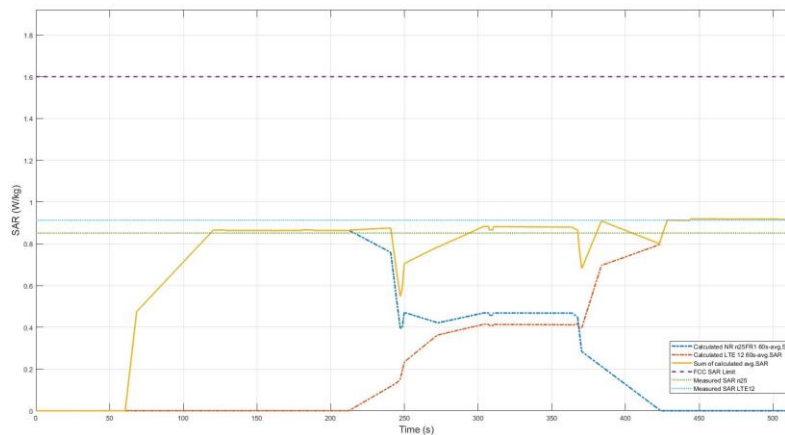


**Figure 11.7-1 Conducted Transmitted power for LTE B12 and NR n25 in test TC12**

In this test, measured 1g SAR would be 0.913 W/kg at 22.0dBm for LTE B12 and 0.851W/kg at 14.0dBm for NR n25. The setting value and measured values are described in Table 11.2-1.

Figure 11.8-1 shows the instantaneous and time-averaged Tx power for both LTE B12 and NR n25 versus time. When both LTE and FR1 operate in around 210s, averaged Tx power for NR is decreased and averaged Tx power of LTE is increased by taking the SAR budget. After 150s, NR doesn't use transmitted power and LTE takes the all SAR budget.

As shown in Figure 11.8-2, total average SAR is less than 1W/Kg which is below the FCC limit of 1.6W/Kg.



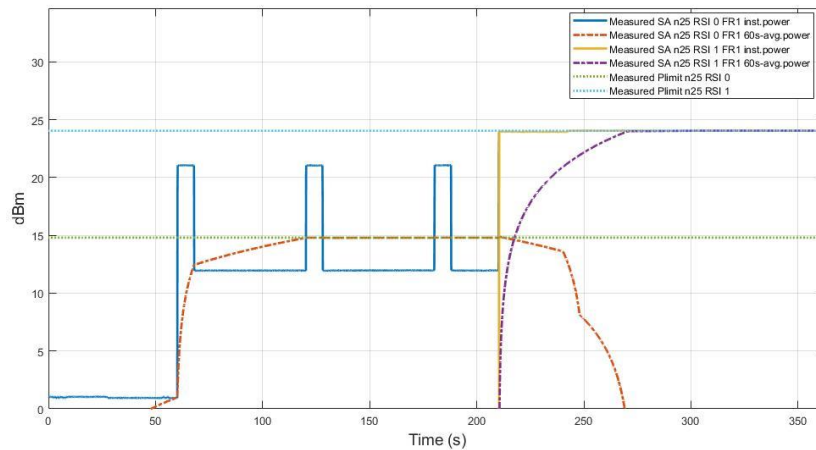
**Figure 11.7-2 Total time-averaged SAR FR1 n25 and LTE B12 in TC12**

|                                           |            |
|-------------------------------------------|------------|
| FCC 1gSAR limit                           | 1.6 W/kg   |
| Max 60s-time average 1gSAR (yellow curve) | 0.920 W/kg |
| Device uncertainty                        | 1 dB       |

## 11.8 Change in RSI

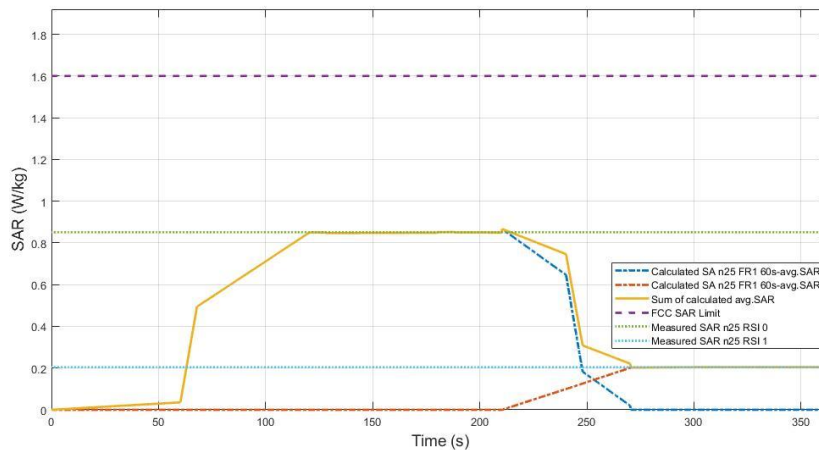
The test results in this section are obtained following the procedure in Section 7.3.5. The test cases correspond to TC#13 in Table 11.2.1.

### TC13: SA\_FR1\_RF\_SAR\_Index\_Change



**Figure 11.8-1 Conducted Tx power for SAR RSI change in test TC13**

In this test, measured 1g SAR would be 0.851W/kg at 14.0dBm (RSI 0) and 0.204W/kg at 24.0dBm (RSI 1). Figure 11.9-1 shows the instantaneous and time-averaged conducted Tx power for both NR25 for the duration of the test. Around time stamp of ~210s, the RSI value is changed from low RSI with Plimit of 14.0dBm to high RSI with Plimit of 24.0 dBm, resulting in reduction of target time-averaged power of NR25. It can be seen that Plimit value of high RSI is lower than that of low RSI, so in high RSI region, more Tx power is limited compared to low RSI region. Figure 11.9-2 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 always under the total FCC limit of 1.6W/Kg.



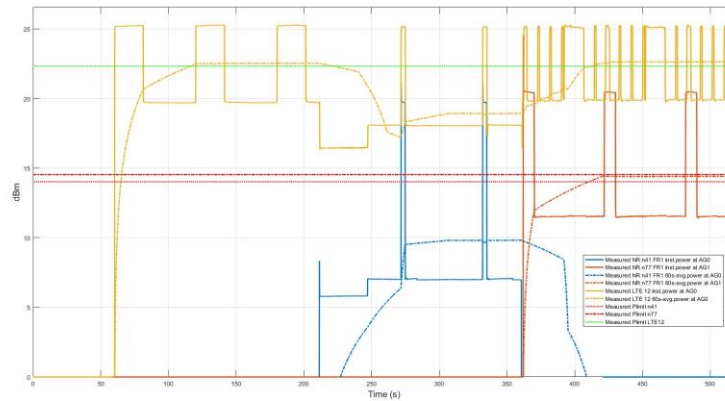
**Figure 11.8-2 Total time-averaged SAR in TC13**

|                                              |            |
|----------------------------------------------|------------|
| FCC 1gSAR limit                              | 1.6 W/kg   |
| Sum of calculated average SAR (yellow curve) | 0.867 W/kg |
| Device uncertainty                           | 1 dB       |

## 11.9 NSA antenna switching with Spatial TAS

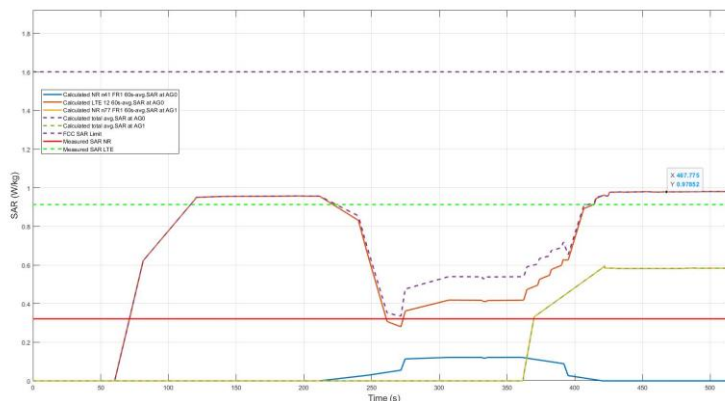
The test results in this section are obtained following the procedure in Section 7.3.7. The test cases correspond to TC#14 in Table 11.2.1.

### TC14: NSA\_Ant\_switching\_Spatial\_TAS



**Figure 11.9-1 Conducted Transmitted power for LTE B12(AG0) and NR n41(AG0), n77(AG1) in Test TC14**

In this test, measured 1g SAR would be 0.913 W/kg at 22.0dBm for LTE B12, 0.321W/kg at 14.0dBm and 0.601W/kg at 14.5dBm for NR n41 and n77. The setting value and measured values are described in Table 11.11-1. Figure 11.9-1 shows the instantaneous and time-averaged Tx power for both LTE B12 and NR n41 versus time. After connection establishment for both RATs, all RATs are set to low power for 60s. Next, a transmission starts with LTE requesting maximum power while FR1 is not transmitting on any antenna. After ~150s, FR1 starts transmission on band n41(AG0) which yields which is coupled to the LTE B12(AG0). Since both antennas are coupled, the SAR budget is split among both RATs and the average power of each RAT is reduced. After ~150s, a band change happened for n41(AG0) to n77(AG1) which yields to switching the antenna to another one. FR1 starts transmission by requesting max power. (which is operating on an uncoupled antenna with LTE B12). As shown in Figure 11.9-2, total average SAR is less than 1W/Kg which is below the FCC limit of 1.6W/Kg.



**Figure 11.9-2 Total time-averaged SAR in TC14**

|                                              |            |
|----------------------------------------------|------------|
| FCC 1gSAR limit                              | 1.6 W/kg   |
| Sum of calculated average SAR (purple curve) | 0.978 W/kg |
| Device uncertainty                           | 1 dB       |

### 11.10 C-TAS: Tech Switch test results

The test results in this section are obtained following the procedure in Section 10.3  
The test cases correspond to C-TC#01, #02 in Table 10.3.1.

#### C-TC01: Tech switch compliance Test [LTE Band 66/WLAN 5GHz/Bluetooth]

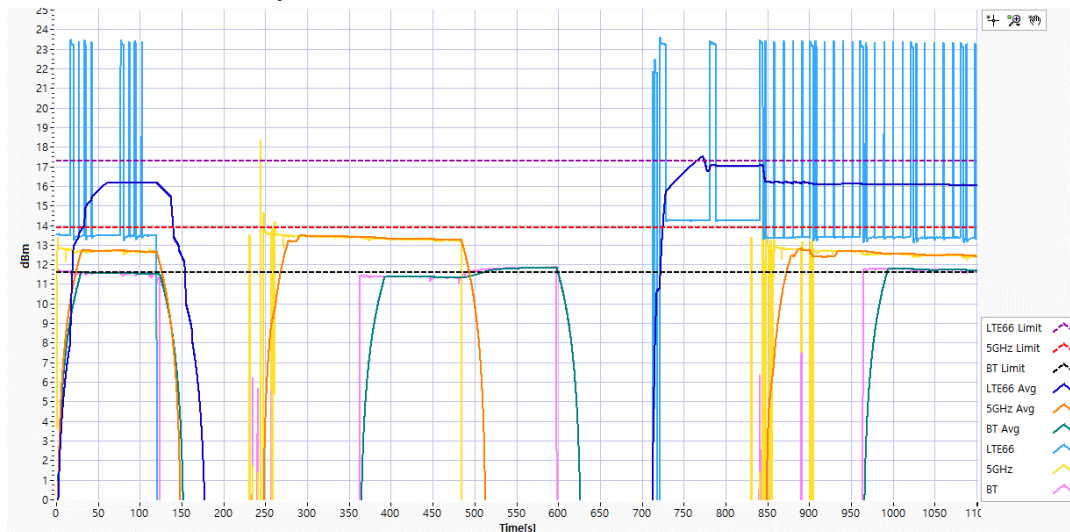


Figure 11.10-1 Conducted Tx power in LTE /WLAN 5G/Bluetooth in test C-TC 01

In this test, measured 1g SAR would be 0.605 W/kg at 17.30 dBm for LTE and 0.409 W/kg at 13.87dBm for WLAN 5G[RSI=1], 0.116 W/kg at 11.60dBm for Bluetooth. Figure 11.10-1 shows the instantaneous and time-averaged conducted Tx power for LTE B25, WLAN 5G for the duration of the test. In addition, Figure 11.10-1 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty It is proved that WWAN Mode, controlled by TAS Manager, reduces the time-averaged output power in the simultaneous transmission condition of WLAN Mode and BT Mode.

Also Figure 11.10-2 shows the calculated time-averaged 1g SAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.

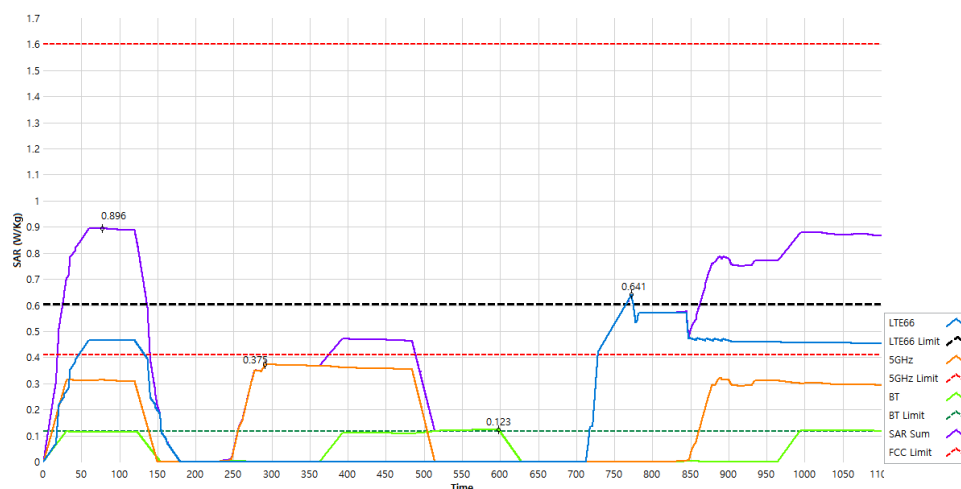


Figure 11.10-2 Time-averaged SAR in C-TC01

Combined-TAS (C-TAS), a TAS manager algorithm, can control WWAN TAS algorithm and WLAN TAS algorithm within a predefined SAR budget

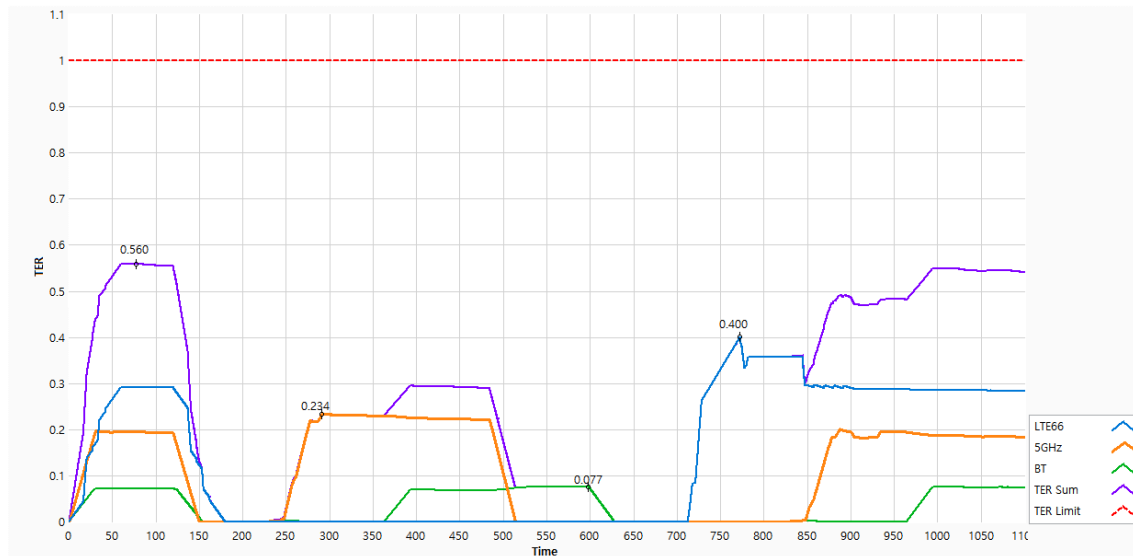


Figure 11.10-3 Total Exposure Ratio in C-TC01

Combined-TAS (C-TAS), a TAS manager algorithm, controls the time-averaged output power of each modem so that the TER (Total Exposure Ratio) is always less than 1 under the condition of simultaneous transmission. of WWAN mode and WLAN/BT modes

|                               |         |
|-------------------------------|---------|
| FCC 1g SAR Limit              | 1.6W/kg |
| Sum of calculated average SAR | 0.896   |
| Total Exposure Ratio          | 0.560   |
| Device uncertainty            | 1 dB    |

### C-TC02: Tech switch compliance Test [NR Band n77/WLAN 5GHz/Bluetooth]

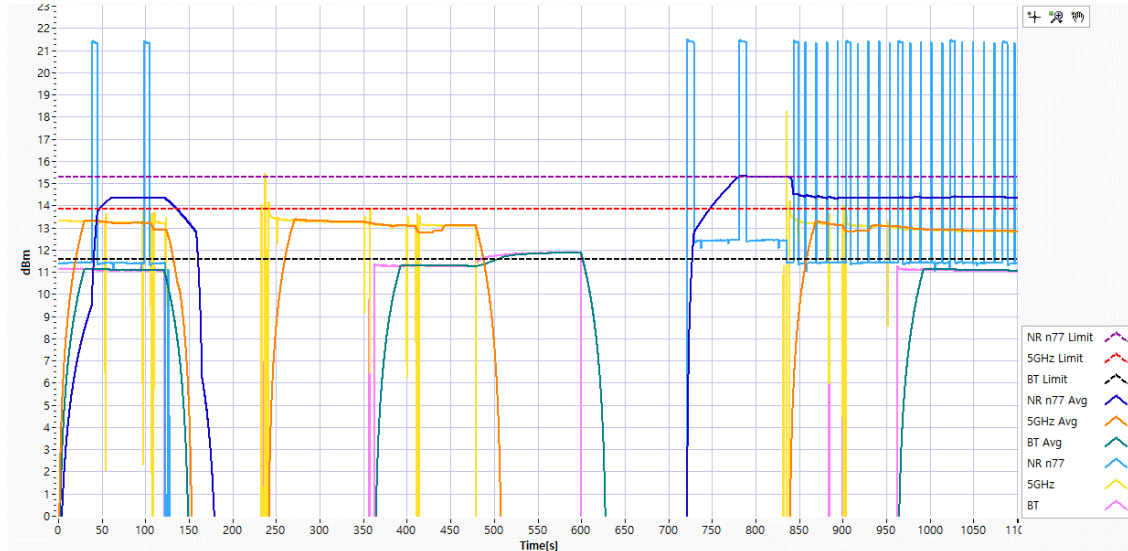


Figure 11.10-4 Conducted Tx power in NR/WLAN 5G/Bluetooth in test C-TC02

In this test, measured 1g SAR would be 0.601 W/kg at 15.31 dBm for LTE and 0.409 W/kg at 13.87 dBm for WLAN 5G[RSI=1], 0.116 W/kg at 11.60 dBm for Bluetooth. Figure 11.10-4 shows the instantaneous and time-averaged conducted Tx power for n77, WLAN 5G for the duration of the test. In addition, Figure 11.10-4 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. It is proved that WWAN Mode, controlled by TAS Manager, reduces the time-averaged output power in the simultaneous transmission condition of WLAN Mode and BT Mode.

Also Figure 11.10-5 shows the calculated time-averaged 1g SAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.

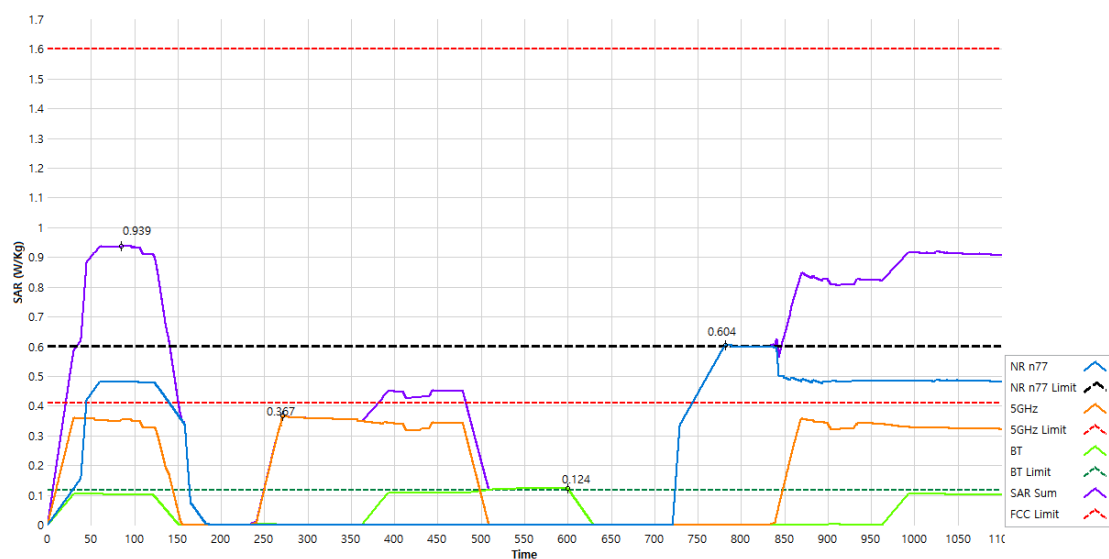


Figure 11.10-5 Time-averaged SAR in C-TC02

Combined-TAS (C-TAS), a TAS manager algorithm, can control WWAN TAS algorithm and WLAN TAS algorithm within a predefined SAR budget

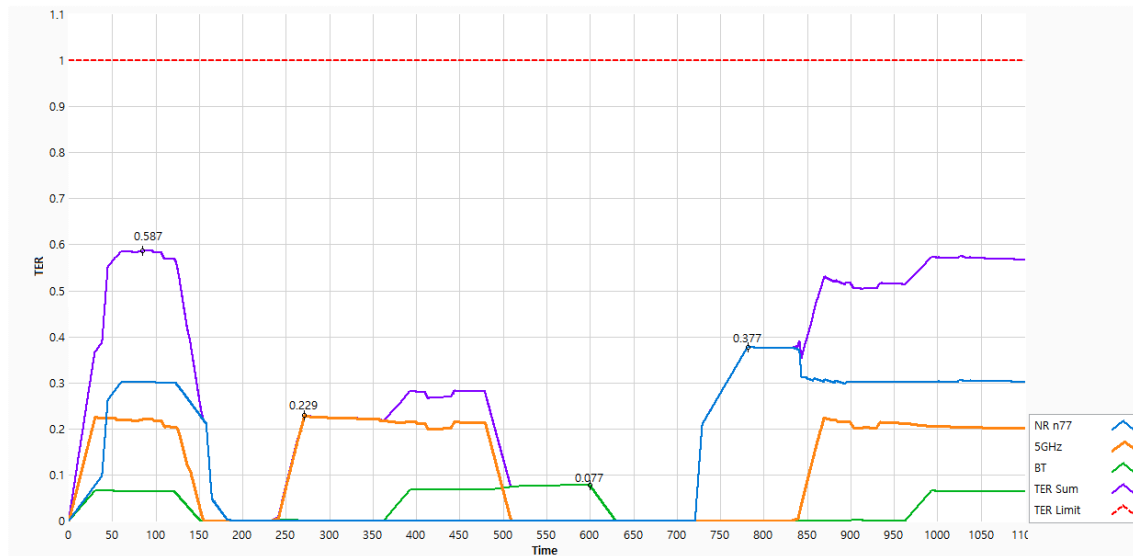


Figure 11.10-6 Total Exposure Ratio in C-TC02

Combined-TAS (C-TAS), a TAS manager algorithm, controls the time-averaged output power of each modem so that the TER (Total Exposure Ratio) is always less than 1 under the condition of simultaneous transmission. of WWAN mode and WLAN/BT modes

|                               |            |
|-------------------------------|------------|
| FCC 1gSAR limit               | 1.6 W/kg   |
| Sum of calculated average SAR | 0.939 W/kg |
| Total Exposure Ratio          | 0.587      |
| Device uncertainty            | 1 dB       |

## 12. Conclusions

Samsung Time-Averaging SAR (TAS) feature employed in Samsung Mobile Phone (FCC A3LSMS731B) 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 and the TER value does not exceed 1.0 for all the transmission scenarios.

## 14. Equipment List

| Manufacturer                | Type / Model                               | S/N        | Calib. Date | Calib. Interval | Calib. Due |
|-----------------------------|--------------------------------------------|------------|-------------|-----------------|------------|
| Narda                       | Directional Coupler / 4216-10              | 01490      | 11/22/2024  | Annual          | 11/22/2025 |
| Narda                       | Directional Coupler / 4216-10              | 01489      | 11/22/2024  | Annual          | 11/22/2025 |
| Narda                       | Directional Coupler / 4216-10              | 01653      | 06/24/2025  | Annual          | 06/24/2026 |
| HP                          | Power Divider/11636B                       | 58698      | 01/13/2025  | Annual          | 01/13/2026 |
| RFCOREA                     | 2Way Splitter                              | 473842     | 12/09/2024  | Annual          | 12/09/2025 |
| Anritsu                     | Radio Communication Analyzer / MT8821C     | 6262044720 | 11/27/2024  | Annual          | 11/27/2025 |
| Anritsu                     | Radio Communication Analyzer / MT8821C     | 6262116770 | 07/29/2024  | Annual          | 07/29/2025 |
| Anritsu                     | Radio Communication Test Station / MT8000A | 6262036812 | 11/27/2024  | Annual          | 11/27/2025 |
| R&S                         | Radio Communication Tester / CMX500        | 100325     | 10/14/2024  | Annual          | 10/14/2025 |
| R&S                         | Power Sensor/NRP8S                         | 114588     | 01/22/2025  | Annual          | 01/22/2026 |
| R&S                         | Power Sensor/NRP8S                         | 114589     | 01/22/2025  | Annual          | 01/22/2026 |
| R&S                         | Power Sensor/NRP8S                         | 103308     | 01/07/2025  | Annual          | 01/07/2026 |
| R&S                         | Power Sensor/NRP8S                         | 101618     | 01/07/2025  | Annual          | 01/07/2026 |
| MICRO LAB                   | LP Filter / LA-15N                         | 10453      | 09/11/2024  | Annual          | 09/11/2025 |
| MICRO LAB                   | LP Filter / LA-30N                         | -          | 09/11/2024  | Annual          | 09/11/2025 |
| R&S                         | Wireless Communication Test Set CMW500     | 167918     | 03/18/2025  | Annual          | 03/18/2026 |
| Wainwright Instruments GmbH | High Pass Filter                           | 61         | 02/19/2025  | Annual          | 02/19/2026 |

## 15. References

The following documents contain reference in this technical document.

- [1] [OEM][2024-09-30] Samsung S.LSI TAS report\_v.3.3
- [2] [Samsung S.LSI\_S5E8835] Time-averaged SAR algorithm for Wi-Fi and BT (Customer)\_v.1.0
- [3] [OEM][2025-04-29] S.LSI Cellular-Connectivity combined TAS\_v1.1.1

## Appendix A. Test sequence

### 1.1 Test sequence is generated based on below parameters of the DUT:

1. Measured maximum power (Pmax)
2. Measured Tx power (Plimit) to satisfy SAR Compliance
3. Setup time to make SAR Remaining be full
4. Do test according to test sequence

### 1.2 Test Sequence A waveform:

Based on the parameters above, the test sequence A is generated with one or two 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

### 1.3 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 1.3.1

**Table 1.3.1 Table of test sequence B**

| Time duration (second) | Power level (dB) |
|------------------------|------------------|
| 15                     | Plimit – 5       |
| 20                     | Plimit           |
| 20                     | Plimit + 5       |
| 10                     | Plimit – 6       |
| 20                     | Pmax             |
| 15                     | Plimit           |
| 15                     | Plimit -7        |
| 20                     | Pmax             |
| 10                     | Plimit-5         |
| 15                     | Plimit           |
| 10                     | Plimit-6         |
| 20                     | Plimit + 5       |
| 10                     | Plimit – 4       |
| 15                     | Plimit           |
| 10                     | Plimit – 6       |
| 20                     | Pmax             |
| 15                     | Plimit-8         |
| 15                     | Plimit           |
| 20                     | Pmax             |
| 10                     | Plimit – 9       |
| 20                     | Plimit + 5       |
| 20                     | Plimit           |
| 15                     | Plimit – 5       |

## Appendix B. TAS Test setup Photo

Please refer to test setup photo file no as follows

| Report NO.          |
|---------------------|
| HCT-SR-2507-FC011-P |