Testing and Certification

TEST REPORT

PART 2: RF Exposure Compliance Test of SM-S721U

APPLICANT

Samsung Electronics. Co., Ltd.

REPORT NO.

HCT-SR-2407-FC011-R2

DATE OF ISSUE

Aug. 19, 2024

Tested by Jin nyeong Choi	(signature)
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TEST REPORT

PART 2 RF Exposure Compliance Test for certification

REPORT NO.
HCT-SR-2407-FC011-R2

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FCC ID
A3LSMS721U

Applicant	SAMSUNG Electronics Co., Ltd 129, Samsung-ro, Yeongtong-gu, Suwon-Si, Gyeonggi-do, 16677, Korea
Product Name Model Name Additional Model Name	Mobile Phone SM-S721U SM-S721U1
Date of Test	Jul. 08, 2024 ~ Jul. 18, 2024
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. 23, 2024	Initial Release
1	Jul. 26, 2024	Added TC#18 Decoupled case
2	Aug. 19, 2024	Revised Section 4, 5 and 11 Detailed Description Added

Notice

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 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).

CONTENTS

1. RF Exposure Limits

1.1 RF Exposure Limits for Frequencies < 6 GHz

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

NOTES:

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

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

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

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be mad fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e.as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

1.2 Interim Guidance for Time Averaging

Per October 2018 TCB Workshop Notes, the below time-averaging windows can be used for assessing time-averaged exposures for devices that are capable of actively monitoring and adjusting power output over time to comply with exposure limits.

Interim Guidance	Frequency (GHz)	Maximum Averaging Time (sec)
SAR	< 3	100
	3 – 6	60
MPE	6 - 10	30
	10 - 16	14
	16 – 24	8
	24 – 42	4
	42 – 95	2

Note:
S.LSI's TAS algorithm applies an overall average time of 60 seconds for communication modes below 6 GHz frequency, 4 seonds 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-S721U
Additional Model Name	SM-S721U1
Equipment Type	Mobile Phone
FCC ID	A3LSMS721U
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 7	Voice / Data	2 502.5 MHz ~ 2 567.5 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 14	Voice / Data	790.5 MHz ~ 795.5 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 FDD Band 30	Voice / Data	2 307.5 MHz ~ 2 312.5 MHz
LTE TDD Band 38	Voice / Data	2 572.5 MHz ~ 2 617.5 MHz
LTE TDD Band 41	Voice / Data	2 498.5 MHz ~ 2 687.5 MHz
LTE TDD Band 48	Voice / Data	3 552.5 MHz ~ 3 697.5 MHz
LTE FDD Band 66 (AWS)	Voice / Data	1 710.7 MHz ~ 1 779.3 MHz
LTE FDD Band 71	Voice / Data	665.5 MHz ~ 695.5 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 n7	Voice / Data	2 502.5 MHz ~ 2 567.5 MHz
NR FDD Band n12	Voice / Data	701.5 MHz ~ 713.5 MHz
NR FDD Band n25 (PCS)	Voice / Data	1 852.5 MHz ~ 1 912.5 MHz
NR FDD Band n26	Voice / Data	816.5 MHz ~ 846.5 MHz
NR FDD Band n30	Voice / Data	2 307.5 MHz ~ 2 312.5 MHz
NR TDD Band n38	Voice / Data	2 575 MHz ~ 2 615 MHz
NR TDD Band n41	Voice / Data	2 501.01 MHz ~ 2 685 MHz
NR TDD Band n48	Voice / Data	3 555 MHz ~ 3 695.01 MHz
NR FDD Band n66	Voice / Data	1 712.5 MHz ~ 1 777.5 MHz
NR FDD Band n70	Voice / Data	1 697.5 MHz ~ 1 707.5 MHz
NR FDD Band n71	Voice / Data	665.5 MHz ~ 695.5 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
NR TDD Band n78	Voice / Data	3 705 MHz ~ 3 795 MHz
NR TDD Band n78 DoD	Voice / Data	3 455.01 MHz ~ 3 544.98 MHz
NR Band n258	Data	24 250 MHz ~ 24 450 MHz; 24 750 MHz ~ 25 250 MHz
NR Band n260	Data	37 000 MHz ~ 40 000 MHz
NR Band n261	Data	27 500 MHz ~ 28 350 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 ~ 2 462 MHz
Bluetooth / LE 5.3	Data	2 402 MHz ~ 2 480 MHz
NFC	Data	13.56 MHz
WPC	Data	110 kHz ~ 148 kHz

<table>
<tr><td rowspan="4">Device Serial Numbers</td><th>Mode</th><th>Serial Number</th></tr>
<tr><td>2G/3G/4G 5G Sub 6 NR</td><td>XFD0475M</td></tr>
<tr><td>4G/5G mmWave</td><td>XFD0458M</td></tr>
<tr><td colspan="2">The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics are within operational tolerances expected for production units.</td></tr>
</table>

Measurement Results Summary Table (FR1)

TC#	Test Scenario	Tech	Band	Ant.	RSI	SAR Part 1 Measured SAR at Plimit (W/kg)	Part 2 Time averaged SAR at Plimit (W/kg)	Test Results
1	Time varying Tx power case 1	LTE	B66	A	0	0.676	0.626	Validated
2		SA/FR1	n66			0.721	0.668	Validated
3		WCDMA	B2			0.704	0.728	Validated
4		GSM	1900			0.389	0.394	Validated
5	Time varying Tx power case 2	LTE	B66	A	0	0.676	0.600	Validated
6		SA/FR1	n66			0.721	0.663	Validated
7		WCDMA	B2			0.704	0.689	Validated
8		GSM	1900			0.389	0.409	Validated
9	Change in call	LTE	B66	A	0	0.676	0.633	Validated
10	Modulation Change	LTE	B66	A	0	0.676	0.660	Validated
11	Re-selection in call	LTE	B66	A	0	0.676	0.663	Validated
		SA/FR1	n7	B		0.313		
12	Antenna/Band Switching	LTE	B66	A	0	0.676	0.662	Validated
			B41	B		0.241		
13	SAR exposure switch	LTE	B12	A	0	0.293	0.287	Validated
		NSA/FR1	n41	B		0.202		
14	Change in RSI	SA/FR1	n66	A	0	0.721	0.677	Validated
					1	0.115		
15	Intra-band ULCA	LTE	B66	A	0	0.676	0.766	
16	NSA antenna switching with Spatial TAS	LTE	B12	A	0	0.239	0.564	Validated
		NSA/FR1	n41	B		0.202		
		NSA/FR1	n77	F		0.464		Validated
17	Inter-band ULCA	SA/FR1	n71	A	0	0.203	0.203	Validated
			n41	B		0.202		

Note: RSI (1) – Reduced-RCV ON, RSI(0) – Reduced-non Head Mode ON

FCC SAR Limit [W/kg]: 1.6W/kg,1g

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

Measurement Results Summary Table (FR2)

Test Case #	Test Scenario	Tech	Band	Ant	RSI	Total Exposure Ratio Limit	Max averaged Total Exposure Ratio	Test Results
18	mmWave_Max_Tx_Power EN-DC	LTE	2	F	0	1.0	0.798	Validated
		FR2	258	M				
		LTE	2	F	0	1.0	0.684	Validated
		FR2	260	M				
		LTE	2	F	0	1.0	0.774	Validated
		FR2	261	M				
19	mmWave_Max Tx Power NR-DC	FR1	2	F	0	1.0	0.868	Validated
		FR2	261	M				
20	mmWave_Dominant Power_Switching EN-DC	LTE	2	F	0	1.0	0.744	Validated
		FR2	261	M				
21	mmWave_Dominant Power_Switching NR-DC	FR1	2	F	0	1.0	0.843	Validated
		FR2	261	M				
22	mmWave_UL_CA	LTE	2	F	0	1.0	0.945	Validated
		FR2	261	M				
23	mmWave_Module Beam_Change	LTE	2	F	0	1.0	0.707	Validated
		FR2	261	M				

Note : RSI (1) – Reduced-RCV ON, RSI(0) – Reduced-Hotspot Mode ON

Total exposure Limit :1.0

The computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. The TER is always under the FCC compliance limit of 1.

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 willbe 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.

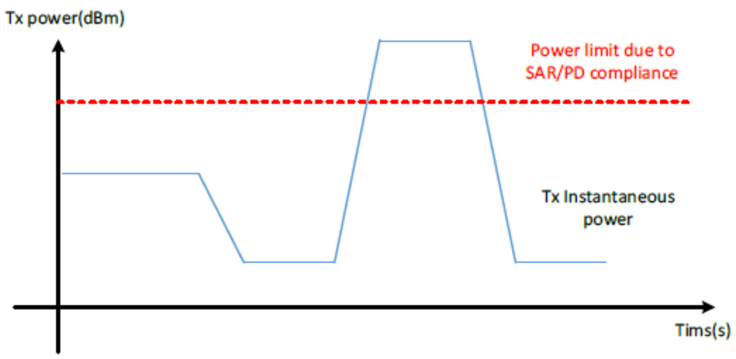


Figure 4.1-1 TAS algorithm concept

4.2 Algorithm operation and configurable parameters for each RAT

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 3.2-1shows 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.

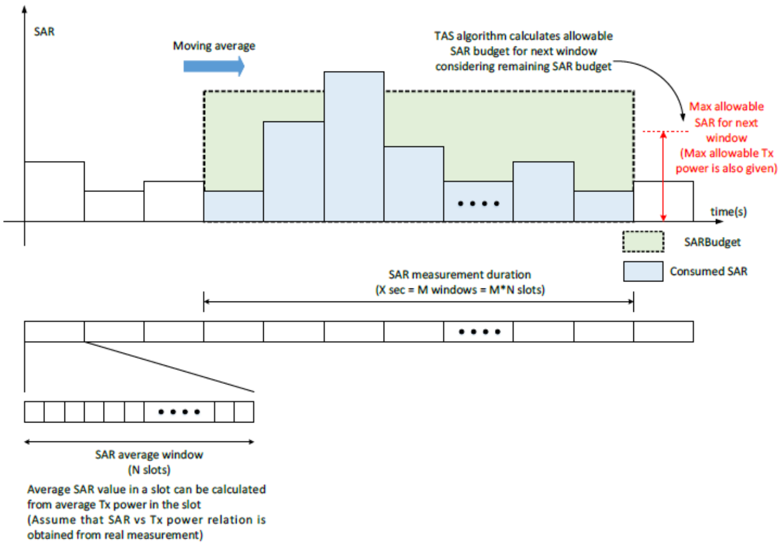


Figure 4.2-1 SAR measurement from Tx power using block-wise processing

LTE/FR1 and legacy transmitter should follow SAR requirements for sub6GHz. 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:

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

-For both sub-6 and mmWave transmissions:

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

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 6GHz and is defined as

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

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

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

In addition, SAR represents sub-6GHz average power, PD stands for power density of MPE regulation, L_{SAR} 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:

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

-For both sub-6 and mmWave transmissions:

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

$SAR_{WiFi,Norm}$ 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 is60 or 100 seconds depends on carrier frequency (whether higher or lower than 3GHz, respectively). On the other hand, 4 second scan 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 250msand 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 (Sub 6GHz)	Time window size 60 seconds
Time window size for PD (Above 6GHz)	Time window size 4 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.

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

For sub 6GHz and legacy modem, maximum Tx power($Pmax$)and allowable limit power ($Plimit$) has to be defined. In general cases, if $Pmax<Plimit$, 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 $Pmax+\delta<Plimit$. In this case, the δ 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.

$$SAR_{design_{target}} < SAR\_regulatory\_limit \times 10^{-total_{uncertainty_{SAR}}/10} \quad (5\text{-}2)$$

$$PD_{design_{target}} < PD\_regulatory\_limit \times 10^{-total_{uncertainty_{PD}}/10} \quad (5\text{-}3)$$

Table 5.1-2 Definitions for uncertainty and design target

Term	Description
SAR_regulatory_limit	1.6W/Kg at 1gSAR for head 1.6 W/Kg at 1gSAR for body (Hotspot) 4.0W/Kg at 10gSAR for extremity
Total_uncertainty_SAR	1.0 dB(considering Tx power variation, part to part deviation, etc.)
SAR_desing_target	SAR_design_target should beless than 1.27W/Kg Considering safety margin, 1.0 W/Kg is used as the value of SAR_design_target
PD_regulatory_limit	10 W/m^2 (averaged over $4cm^2$ area), 200 W/m^2 ($1cm^2$)
Total_uncertainty_SAR	2.3dB(considering Tx EIRP variation, part to part deviation, etc.)
PD_design_target	PD_design_target should be less than 5.89 W/m^2 and 118 W/m^2 according to equation (5.2.2) for $4cm^2$ and $1cm^2$ respectively. Considering safety margin, 5.9W/Kg and 118 W/m^2 is used as the value of SAR_design_target for $4cm^2$ and $1cm^2$ 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-6GHz, and FR2 technologies. Thus, we rely on conducted power measurements for sub-6GHz 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_desin_targets

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

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.

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

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 Plimit<Pmax).
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 Plimit 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 Plimit 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 <3GHz FR1 bands in addition to the previously supported 100s duration.

7. SAR Time Averageing 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 (Pmax) which is appied at least for 150s. The other level is set at the target power level plus 2dB(Plimi(dBm)+2dB) 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 Pmax and Plimit.

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 Plimit and Pmax as determined in SAR Char Report. Essentially, we need to pick this combination such that Plimit is less than Pmax 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 Plimit among all bands. The test is performed with DUT requested power at Pmax so that the Samsung S.LSI TAS feature enforces power restriction for longest duration. The call change is performed when the DUT is operating with restricted power. One such test is sufficient since behavior is not dependent on band/technology.

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 Plimit is less than Pmax for both states. However, to show the performance of the TAS algorithm in this document, the case of low Plimit 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 Plimit is less than Pmax for both states. However, to show the performance of the TAS algorithm in this document, the case of low Plimit 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 Plimit lower than Pmax in each case. The test is performed with both RATs connected in an EN-DC scenario. In the first portion of the test, DUT is requested to transmit at maximum power for NR and minimum power for LTE. In the second portion of the test, DUT is requested to transmit at maximum power for both NR and LTE. In the final portion of the test, DUT is requested to transmit at minimum power for NR and maximum power for LTE.

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 Plimit is less than Pmax.

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 Plimit lower than Pmax in each case. The test is performed with both RATs connected in an EN-DC scenario. In the first portion of the test, DUT is requested to transmit at maximum power for NR and minimum power for LTE. In the second portion of the test, DUT is requested to transmit at maximum power for both NR and LTE. In the final portion of the test, DUT is requested to 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 whena 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

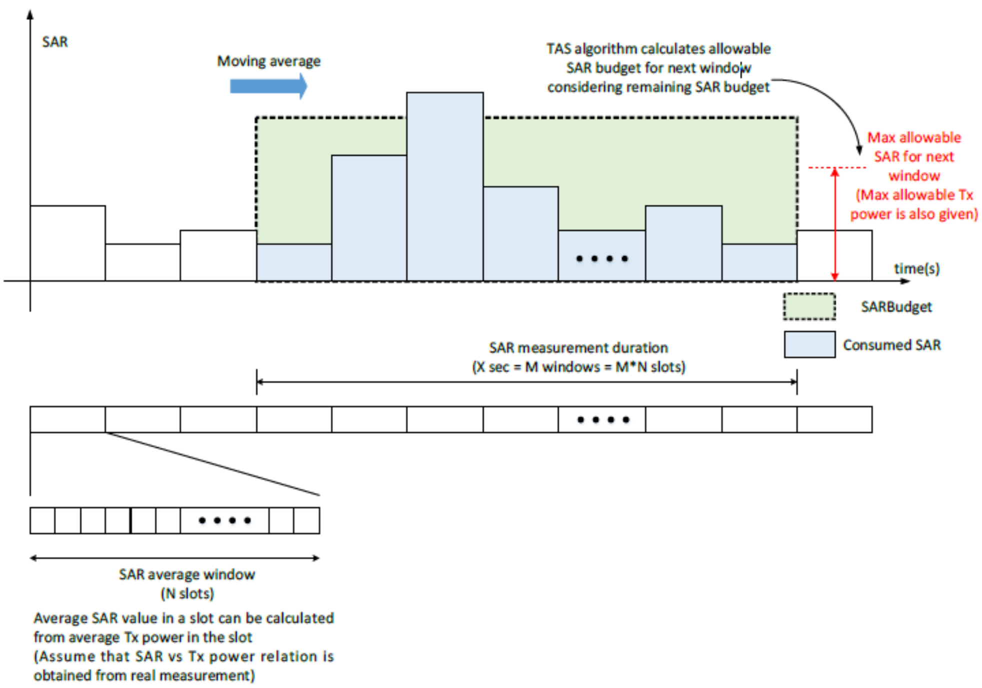


Figure 7.3-1 SAR measurement from Tx power using block-wise processing

3. Release connection.

4. After the completion of the test, prepare one plot with the following information:
    A. Instantaneous Tx power versus time measured in Step 2
    B. Requested Tx power versus time used in Step 2
    C. Time-averaged power over 100s using instantaneous values from Step 2
    D. Power level Plimit which is determined as meeting SAR target in Table 9.2.1(Pmax Plimit 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 Plimit 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 technology/band

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.

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

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

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$_design_target_2$,$T_{2,SAR}$ are defined for the second technology/band/antenna/ In this document, 60s is considered for all sub 6GHz including below 3GHz.

7.3.4 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) FCC1g 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.

7.3.4.1 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 Plimit which is determined as meeting SAR target.

7. 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 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.

7.3.5 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.

7.3.5.1 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.

7.3.6 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 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 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 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 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 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.

7.3.8.1 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.

7.3.8.2 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 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 inter-band change occurs.

7.3.9 Change in modulation change 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.

7.3.9.1 Test procedure for

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 below 0dBmfor 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. Continue the transmission for 150s.
4. Change the modulation from QPSK to 16QAM from call box and continued the transmission for another 150s.
5. Release LTE 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 limitof1.6 W/kg throughout the test duration. It is required to check if SAR calculation is accounting for modulation change. Current TAS algorithm software makes the UE estimate the exact amount of Tx power and average SAR even during modulation change event.

7.3.10 WCDMA time-varying Tx power

The test is to demonstrate that Samsung S.LSI TAS feature can properly handle the SAR exposure for WCDMA with varying requested power over time.

7.3.10.1 Test Procedure for WCDMA_Time_varying_Tx_power_Case1

1. Establish WCDMA connection of DUT with call box
2. Configure call box to set DUT Tx power to a low value of 0dBm for 100s.
3. Configure call box to send "ALL UP" power control commands and continue WCDMA transmission for 80s from DUT so that maximum power of Pmax is achieved.
4. Configure call box to set DUT Tx power to a lower value of Plimit(dBm)-3dB for 420s
5. Release WCDMA connection.

7.3.10.2 Test Procedure for WCDMA_Time_varying_Tx_power_Case2

1. Establish WCDMA connection of DUT with call box
2. Configure call box to set DUT Tx power to a low value of 0dBm for 100s.
3. Configure call box with requesting the DUT Tx power to be according to the sequence B generated and continue 2G transmission till the end of the test.
4. Release WCDMA connection

7.3.11 2G time-varying Tx power

The test is to demonstrate that Samsung S.LSI TAS feature can properly handle the SAR exposure for 2G with varying requested power over time.

7.3.11.1 Test Procedure for 2G_Time_varying_Tx_power_Case1

1. Establish 2G connection of DUT with call box
2. Configure call box to set DUT Tx power to a low value of 0dBm for 100s.
3. Configure call box to send "ALL UP" power control commands and continue 2G transmission for 500s from DUT so that maximum power of Pmax is achieved.
4. Release 2G connection.

7.3.11.2 Test Procedure for 2G_Time_varying_Tx_power_Case2

1. Establish 2G connection of DUT with call box
2. Configure call box to set DUT Tx power to a low value of 0dBm for 100s.
3. Configure call box with requesting the DUT Tx power to be according to the sequence B generated and continue 2G transmission till the end of the test.
4. Release 2G connection.

7.4 Spatial TAS

For the test cases with spatial TAS, we will consider 4 antennas (Ant A, B and F) 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 LTE 7, 12, 66, 41, 71 NR n41, n66
AG1	Ant F	NR n77

The coupling matrix considered during the tests is

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

8. PD Time Averageing 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.

8.3 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 $10W/m^2$ for $4cm^2$ 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 $10W/m^2$ for $4cm^2$ 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 $10W/m^2$ for $4cm^2$ 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 $10W/m^2$ for $4cm^2$ 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.

9. Test Configurations

Plim values in green indicate Plimit < Pmax			Plim values in grey indicate Plimt > Pmax			
Plimit corresponding to Head 0.8 W/kg (1g)/ Body 1.0 W/kg (1g) / Head 2W/Kg (10g) Body 2.5W/kg(10g) SAR_Design_target						Pmax
SAR Exposure Position			Head (RCV ON)	Body Phablet		Maximum Tune-up Output Power (Burst Average Power) [dBm]
Averaging volume			1g	1g	10g	
seperation Distance			0 mm	10 mm	0 mm	
Mode	Band	Antenna	RSI = 1	RSI =0		
GSM/GPRS/EDGE	850	A	32.3	26.9		28.5
GSM/GPRS/EDGE	1900	A	30.3	18.8		27.5
UMTS	2	A	36.3	20.0		23.5
UMTS	4	A	37.9	20.0		23.5
UMTS	5	A	31.6	29.2		24.5
LTE FDD	2 Lower	A	32.6	20.0		24.3
LTE FDD	2 Upper	F	17.5	20.0		22.5
LTE FDD	66(4) Lower	A	32.3	19.0		24.3
LTE FDD	66(4) Upper	F	17.5	19.0		22.5
LTE FDD	12	A	33.0	28.6		24.8
LTE FDD	13	A	31.8	28.2		24.8
LTE FDD	14	A	31.8	27.8		24.8
LTE FDD	5(26)	A	32.2	28.1		24.8
LTE FDD	30 Lower	A	38.1	20.0		23.0
LTE FDD	30 Upper	F	16.5	19.0		20.5
LTE FDD	71	A	33.0	27.3		24.8
LTE FDD	7	B	31.8	21.0		24.0
LTE FDD	7 Upper	F	16.0	19.0		22.5
LTE TDD PC3	41	B	34.0	20.0		24.0
LTE TDD PC2	41	B	32.6	20.4		26.0
LTE TDD PC3	41	F	14.5	18.0		20.0
LTE TDD PC2	41	F	14.9	17.4		23.0
LTE TDD	48	F	15.0	18.0		22.0
NR FDD	5	A	32.6	28.6		24.8
NR FDD	25 Lower	A	31.2	20.0		24.3
NR FDD	25 Upper	F	17.0	20.0		22.5
NR FDD	66 Lower	A	32.9	19.0		24.3
NR FDD	66 Upper	F	16.5	19.0		22.5
NR FDD	71	A	34.9	28.7		24.8
NR FDD	12	A	33.0	29.5		24.8
NR FDD	70	A	33.6	20.0		23.5
NR FDD	30	A	38.1	18.0		23.0
NR FDD	30 Upper	F	16.0	18.0		20.5
NR FDD	7	B	34.8	20.0		24.0
NR FDD	7 Upper	F	16.0	19.0		22.5
NR FDD	38	B	30.4	20.0		24.0
NR TDD	41 SRS0	B	19.5	20.0		26.0
NR TDD	41 SRS1	F	13.5	14.0		21.0
NR TDD	41 SRS2	D	14.0	14.0		21.0
NR TDD	41 SRS3	E	13.5	14.5		21.5
NR TDD	48 SRS0	F	15.0	17.0		22.0
NR TDD	48 SRS1	C	13.0	15.0		20.0
NR TDD	48 SRS2	D	14.5	16.5		21.0
NR TDD	48 SRS3	I	15.0	17.0		22.0
NR TDD	77 SRS0	F	15.0	17.0		26.0
NR TDD	77DoD SRS0	F	15.0	17.0		26.0
NR TDD	77 SRS1	C	14.0	16.0		23.5
NR TDD	77DoD SRS1	C	14.0	16.0		23.5
NR TDD	77 SRS2	D	14.0	16.0		23.5
NR TDD	77DoD SRS2	D	14.0	16.0		23.5
NR TDD	77 SRS3	I	15.0	17.0		25.0
NR TDD	77DoD SRS3	I	15.0	17.0		25.0

Note:
1. Radio SAR indicator (RSI) in the table above means the SAR test configuration of each mobile communication technology.
2. WLAN/BT mode are not controlled by The Samsung S.LSI proprietary TAS (Time Average SAR) algorithm.
2. Plimit and Tune up output power Pmax above table correspond to average power level accounting for duty cycle in the case of TDD Modulation schemes (GSM,LTE TDD,NR TDD)
3. Maximum tune up output Power Pmax is used to configure DUT during RF tune up procedure. The maximum allowed output power is equal to Tune up power +1 dB device design uncertainty.
4. Compared with the Plimit (Tune up Powers) declared in each RSI by the manufacturer and the Plimit (calculation) calculated by the SAR measurement of each RSI, the lower power is applied to the DUT as the Plimit at each RSI configurations.
5. when non-Head Mode (RSI=0) and Head Mode [RCV-ON, RSI=1] are triggered at the same time, RSI =1(RCV-ON) takes higher priority.

10. Test case list

10.1 Test case list for sub-6GHz transmissions

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

Table 10.1-1 Sub-6GHz 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 66
TC02		Time_Varying_Tx_Power_Case_1(NR)	NR Band n66
TC03		Time_Varying_Tx_Power_Case_1(WCDMA)	WCDMA B2
TC04		Time_Varying_Tx_Power_Case_1(2G)	GSM1900
TC05		Time_Varying_Tx_Power_Case_2(LTE)	LTE Band 66
TC06		Time_Varying_Tx_Power_Case_2(NR)	NR Band n66
TC07		Time_Varying_Tx_Power_Case_2(WCDMA)	WCDMA B2
TC08		Time_Varying_Tx_Power_Case_2(2G)	GSM1900
TC09	Change in call	LTE_Call_Disconnect_Reestablishment	LTE Band 66
TC10	Modulation Chage	LTE_Moudulation_Change	LTE Band 66
TC11	Re-selection in call	SA_FR1_to_LTE_RAT_Re-selection_Coupling_Case	NR Band n66, LTE Band 7
TC12	Antenna/Band switching	LTE_Antenna_Band_Swithcing	LTE Band 41, 66
TC13	SAR exposure switch	NSA_FR1_Dominant_Power_Switching	LTE Band 12, NR Band n41
TC14	Change in RSI	SA_FR1_RF_SAR_Index_Change	NR Band n66
TC15	Intra-band ULCA	LTE_Intra_Band_UL_CA	LTE Band 66
TC16	NSA antenna switching with Spatial TAS	NSA_Ant_switching_Spatial_TAS	LTE Band 12, NR Band n41, n77
TC17	Inter-band ULCA	SA_FR1_Inter_Band_UL_CA	NR Band n71, n41

10.2 Test case list for FR2 transmissions

To validate TAS algorithm in FR2 conditions, the chosen TC (Test Case) list is defined as in Table **10.2-1**

Table 10.2-1 FR2 TAS validation test case list

No.	Test Scenario	Test case	Test configuration
TC18	Time-varying Tx power transmission	mmWave_Max_Tx_Power EN-DC	LTE Band 2 / NR n258,260,261
TC19		mmWave_Max_Tx_Power NR-DC	NR Band n2 / NR n261
TC20	SAR Exposure Switch	mmWave_Dominant_Power_Switching EN-DC	LTE Band 2 / NR n261
TC21		mmWave_Dominant_Power_Switching NR-DC	NR Band n2 / NR n261
TC22	FR2 UL CA	mmWave_UL_CA	LTE Band 2 / NR n261
TC23	Change of beam	mmWave_Module_Beam_Change	LTE Band 2 / NR n261

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

11.1 Measurement set-up

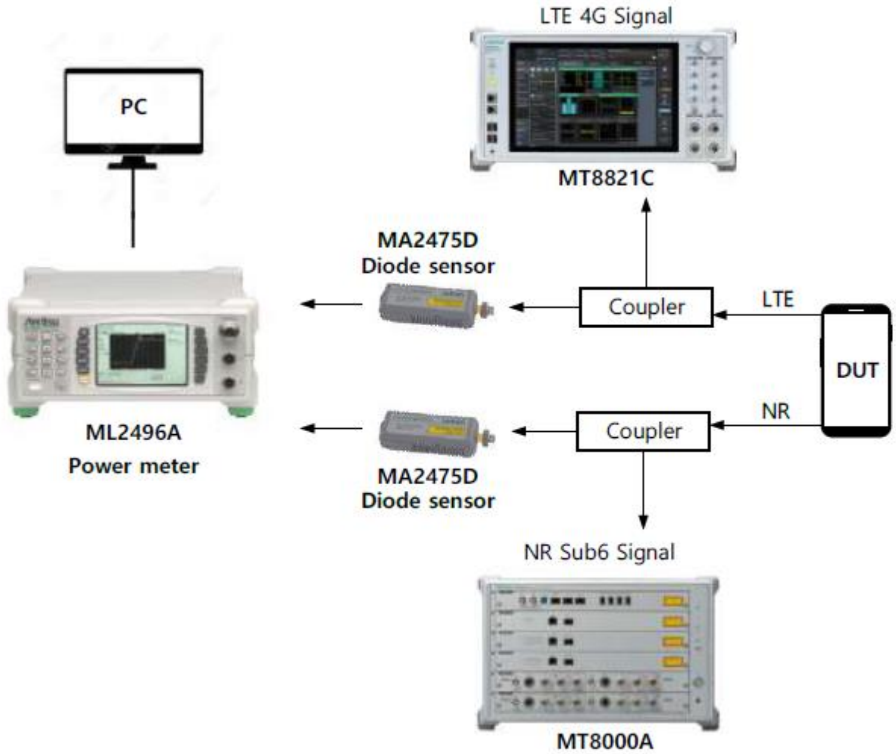


Figure 11.1-1 Test set-up for legacy and sub 6GHz

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.

11.2 *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	Ant.	RSI	RB/offset/BW	Mode	Configuration	SAR Part 1 Measured SAR at Plimit (W/kg)	Plimit setting (dBm)	Pmax setting (dBm)	measured Plimit (dBm)	measured Pmax (dBm)
1	Time varying Tx power case 1	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
2		SA/FR1	n66	A	0	1/1/40MHz	DFT-s QPSK	1g/10mm/Body	0.721	19	24.3	18.93	23.82
3		WCDMA	B2	A	0	-	RMC	1g/10mm/Body	0.704	20	23.5	19.98	23.02
4		GSM	1900	A	0	-	GPRS	1g/10mm/Body	0.389	19	22	19.03	22.05
5	Time varying Tx power case 2	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
6		SA/FR1	n66	A	0	1/1/40MHz	DFT-s QPSK	1g/10mm/Body	0.721	19	24.3	18.93	23.82
7		WCDMA	B2	A	0	-	RMC	1g/10mm/Body	0.704	20	23.5	19.98	23.02
8		GSM	1900	A	0	-	GPRS	1g/10mm/Body	0.389	19	22	19.03	22.05
9	Change in Call	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
10	Modulation Change	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
11	Re-selection in call	SA/FR1	n66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	18.93	24.01
		LTE	B7	B		1/1/40MHz	DFT-s QPSK	1g/10mm/Body	0.313	21	24	20.97	24.01
12	Antenna/Band switching	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
			B41	B		1/0/20MHz	QPSK	1g/10mm/Body	0.241	20	22	19.89	22.03
13	SAR exposure switch	LTE	B12	A	0	1/0/10MHz	QPSK	1g/10mm/Body	0.293	24.8	24.8	24.42	24.42
		NSA/FR1	n41	B		1/1/100MHz	DFT-s QPSK	1g/10mm/Body	0.202	20	26	20.53	25.59
14	Change in RSI	SA FR1	n66	A	0	1/1/40MHz	DFT-s QPSK	1g/10mm/Body	0.721	19	24.3	18.93	23.82
					1	1/1/40MHz	DFT-s QPSK	1g/10mm/Head	0.115	24.3	24.3	23.82	23.82
15	Intra-band ULCA	LTE	B66	A	0	1/0/20MHz	QPSK	1g/10mm/Body	0.676	19	24.3	19.02	24.01
16	NSA antenna switching with Spatial TAS	LTE	B12	A	0	1/0/10MHz	QPSK	1g/10mm/Body	0.239	24.8	24.8	24.42	24.42
		NSA/FR1	n41	B		1/1/100MHz	DFT-s QPSK		0.202	20	26	20.53	25.59
		NSA/FR1	n77	F		1/1/100MHz			0.464	17	26	17.01	25.89
17	Inter-band ULCA	SA FR1	n71	A	0	1/0/20MHz	DFT-s QPSK	1g/10mm/Body	0.203	24.8	24.8	24.51	24.51
			n41	B		1/1/20MHz			0.202	20	26	20.53	25.59

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)

FR2 Test configurations are listed on Table 11.2.2

TC#	Test scenario	Tech	Band	Antenna	RSI	RB/offset/BW	Mode	Plimit setting (dBm)	measured Plimit (dBm)
18	Time varying Tx Transmission EN-DC (EN-DC Evaluation of the coupled Antenna Group)	LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n258	M	0	1/1/100MHz	DFT-s QPSK	13.5	
18		LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n260	M	0	1/1/100MHz	DFT-s QPSK	14.5	
18		LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
18	Time varying Tx Transmission EN-DC EN-DC Evaluation of the decoupled Antenna Group	LTE	B2	A	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
19	Time varying Tx Transmission NR-DC	NR FR1	n2	F	0	1/1/40MHz	DFT-s QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
20	SAR Exposure Switch EN-DC	LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
21	SAR Exposure Switch NR-DC	NR FR1	n2	F	0	1/1/40MHz	DFT-s QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
22	FR2 ULCA	LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	
23	Change of Beam	LTE	B2	F	0	1/0/20MHz	QPSK	20.0	20.31
		NR FR2	n261	M	0	1/1/100MHz	DFT-s QPSK	13.3	

Table 11.2.2

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 #01and #02in Table 11.1-1 by generating the test sequence A or B given in Appendix.

TC01: Time_Varying_Tx_Power_Case_1 [LTE B66]

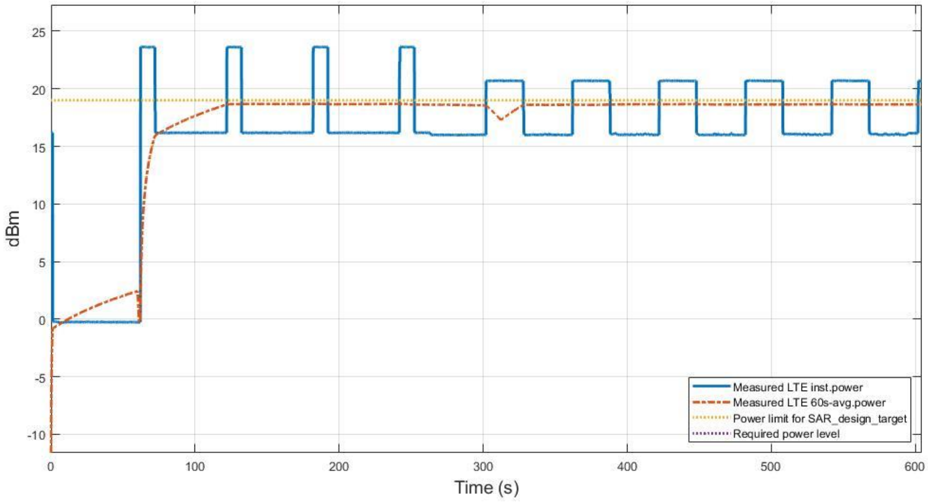


Figure 11.3-1 Time average conducted power of LTE B66 in TC01

In this test, measured 1g SAR would be 0.676 W/kg at 19.0 dBm. Figure 11.3-1 shows the instantaneous and time-averaged Tx power with test sequence A for LTE B66 with Plimit 19.0 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.

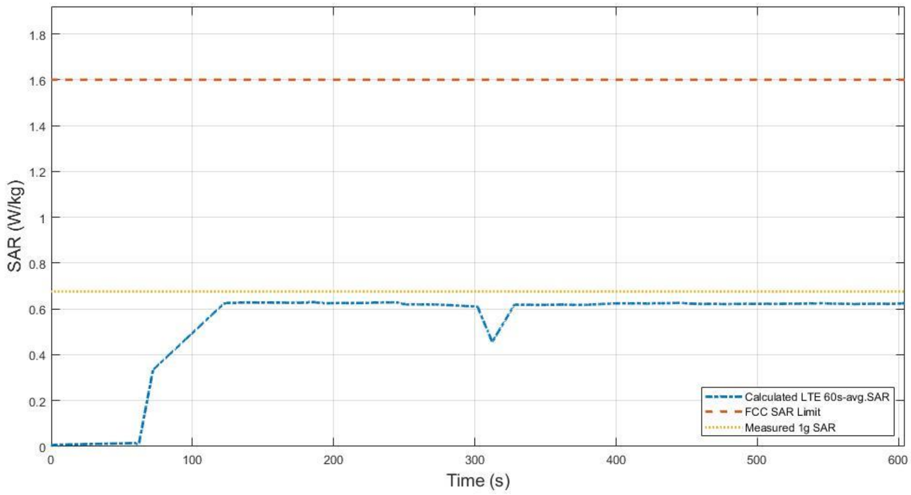


Figure 11.3-2 Total time-averaged SAR in TC01

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.626 W/kg
Device uncertainty	1 dB

TC02: Time_Varying_Tx_Power_Case_1 [NR n66]

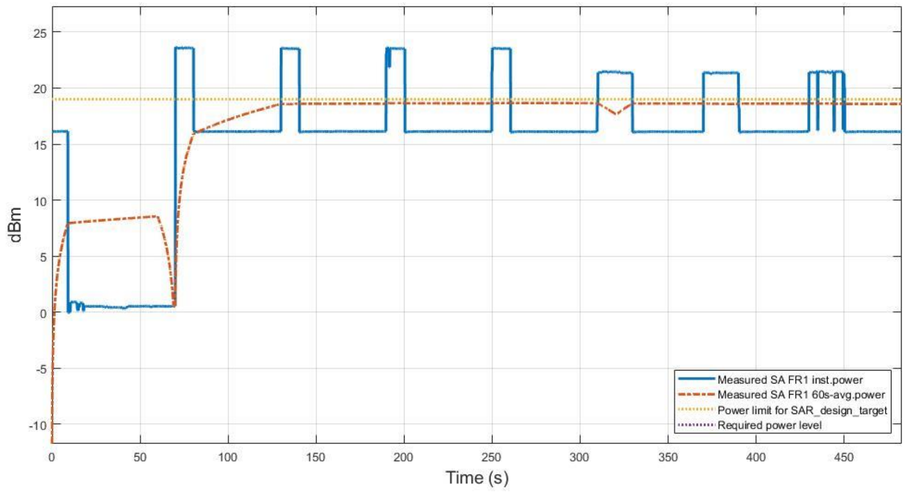


Figure 11.3-3 Time average conducted power of NR n66 in TC02

In this test, measured 1g SAR would be 0.721 W/kg at 19.0 dBm. Figure 11.3-3 shows the instantaneous and time-averaged Tx power with test sequence A for NR n66 with Plimit 19.0 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.

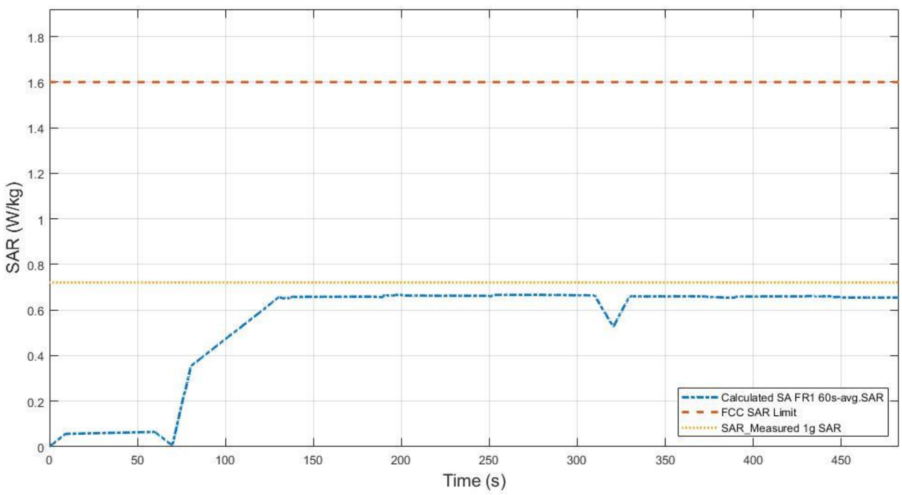


Figure 11.3-4 Total time-averaged SAR in TC02

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.668 W/kg
Device uncertainty	1 dB

TC03: Time_Varying_Tx_Power_Case_1 [WCDMA B2]

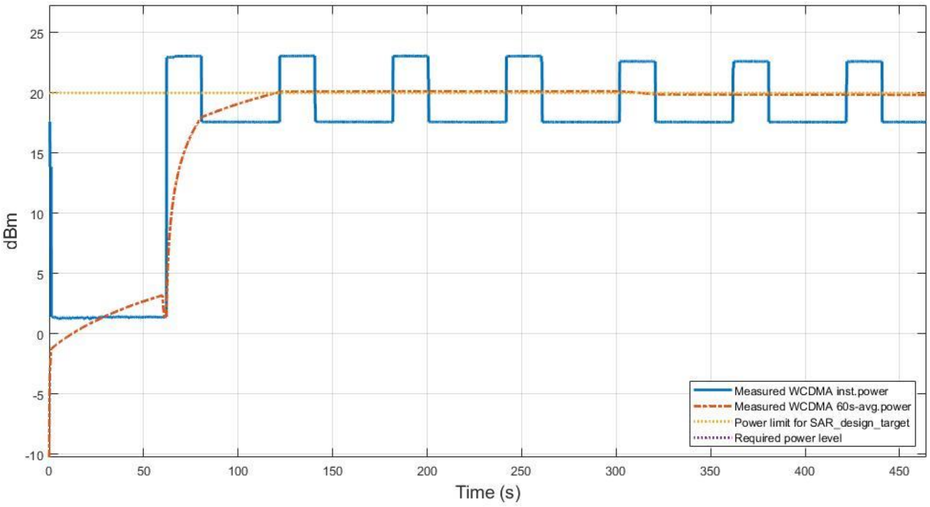


Figure 11.3-5 Time-average conducted power of WCDMA B2 in TC03
In this test, measured 1g SAR would be 0.704 W/kg at 20.0 dBm. Figure 11.3-5 shows the instantaneous and time-averaged Tx power with test sequence A for WCDMA B2 with Plimit 19.0 dBm. In addition, Figure 11.3-5 shows that the moving-average 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.

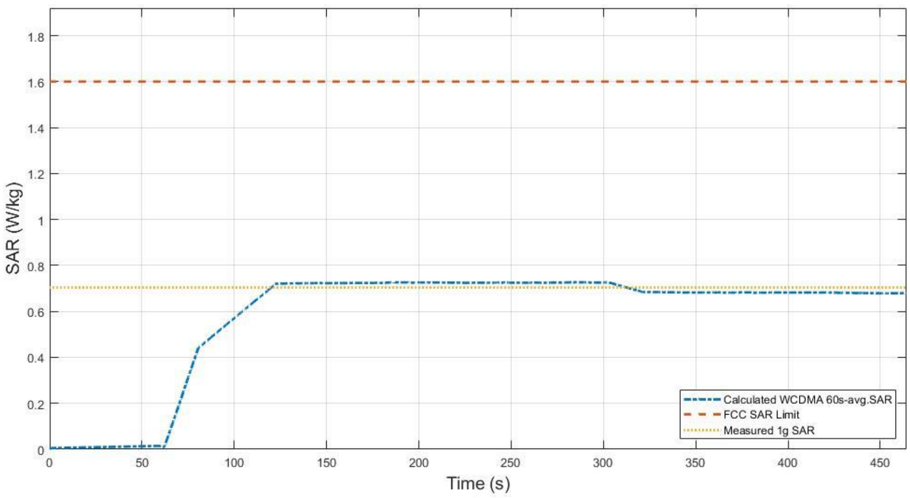


Figure 11.3-6 Total time-averaged SAR in TC03

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.728 W/kg
Device uncertainty	1 dB

TC04: Time_Varying_Tx_Power_Case_1 [GSM1900]

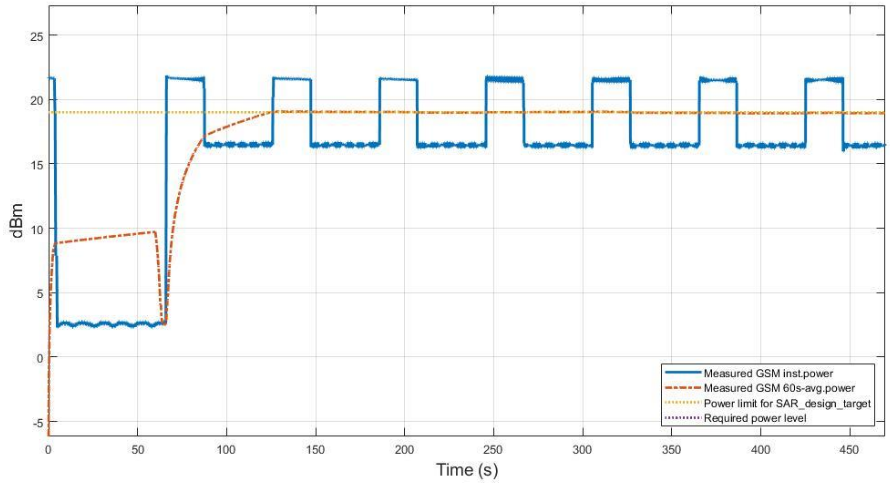


Figure 11.3-7 Time-average conducted power of GSM1900 in TC04

In this test, measured 1g SAR would be 0.389 W/kg at 19.0 dBm. Figure 11.3-7 shows the instantaneous and time-averaged Tx power with test sequence A for GSM1900 with Plimit 19.0 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.

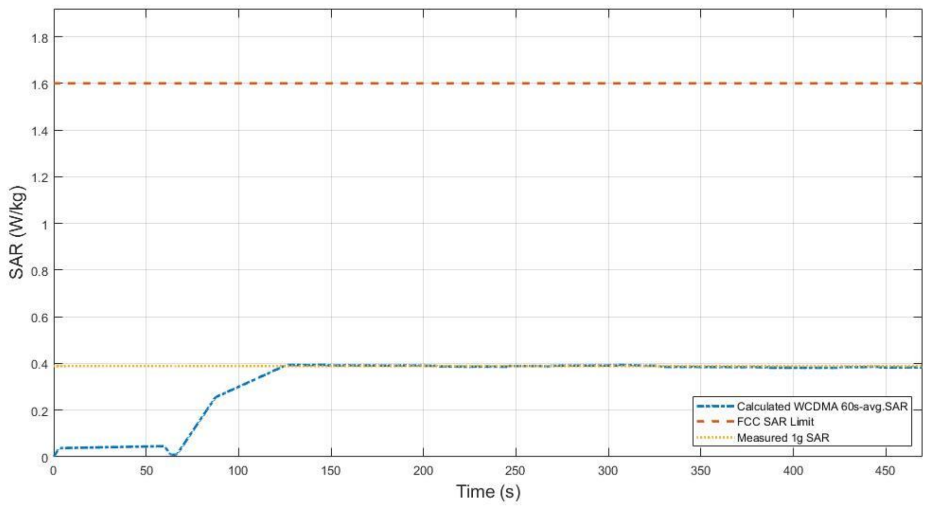


Figure 11.3-8 Total time-averaged SAR in TC04

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.394 W/kg
Device uncertainty	1 dB

TC05: Time_Varying_Tx_Power_Case_2 [LTE B66]

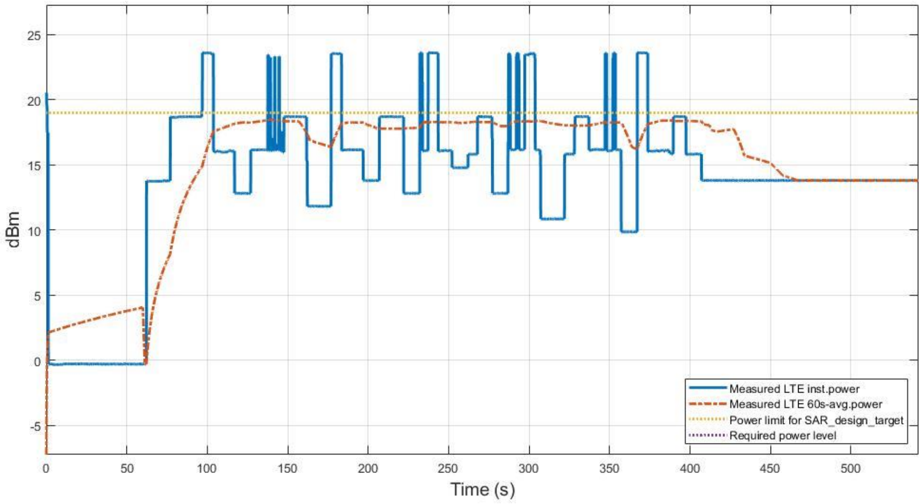


Figure 11.3-9 Conducted Tx power of LTE B66 in TC05

In this test, measured 1g SAR would be 0.676 W/kg at 19.0 dBm. Figure 11.3-9 shows the instantaneous and time-averaged Tx power with test sequence A for LTE B66 with Plimit 19.0 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.

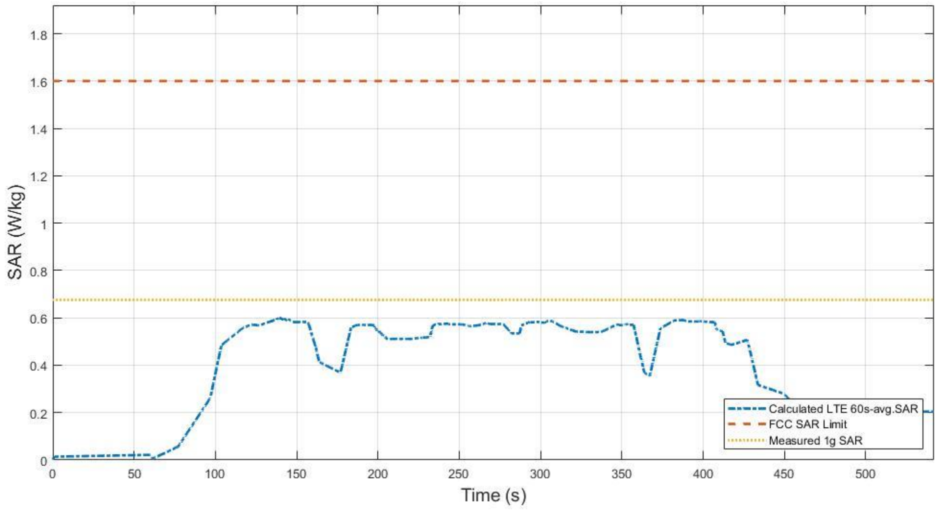


Figure 11.3-10 Total time-averaged SAR in TC05

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.600 W/kg
Device uncertainty	1 dB

TC06: Time_Varying_Tx_Power_Case_2 [NR n66]

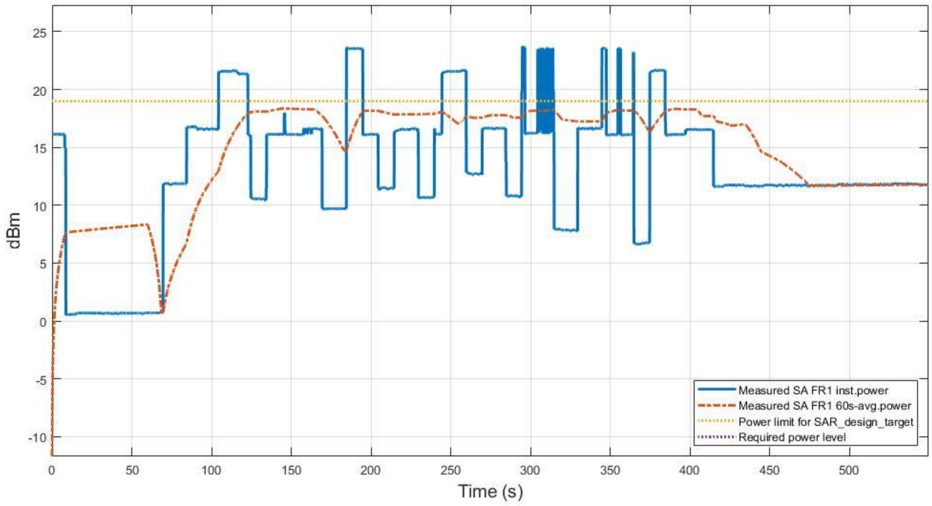


Figure 11.3-11 Conducted Tx power of NR n66 in TC06

In this test, measured 1g SAR would be 0.721 W/kg at 19.0 dBm. Figure 11.3-11 shows the instantaneous and time-averaged Tx power with test sequence A for NR n66 with Plimit 19.0 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.

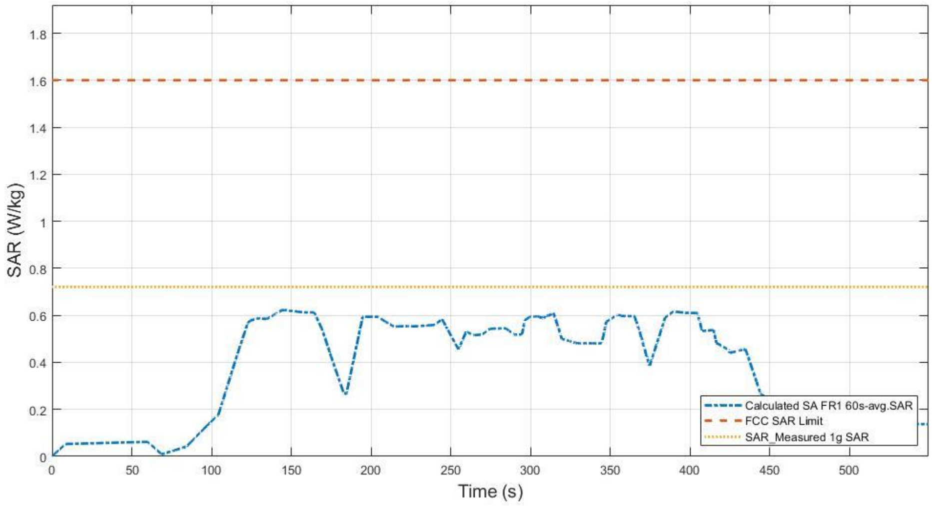


Figure 11.3-12 Total time-averaged SAR in TC06

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.663W/kg
Device uncertainty	1 dB

TC07: Time_Varying_Tx_Power_Case_2 [WCDMA B2]

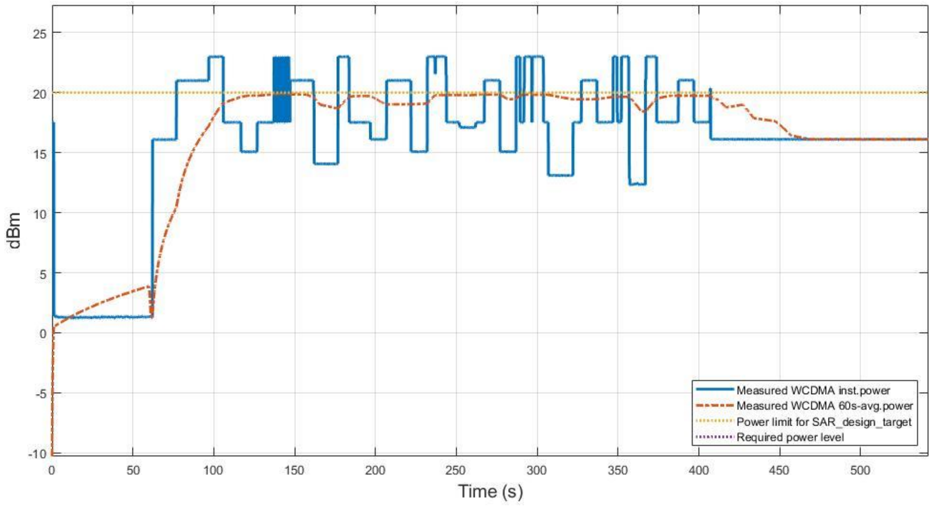


Figure 11.3-13 Conducted Tx power for WCDMA B2 in TC07

In this test, measured 1g SAR would be 0.704 W/kg at 20.0 dBm. Figure 11.3-13 shows the instantaneous and time-averaged Tx power with test sequence A for WCDMA B2 with Plimit 19.0 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.

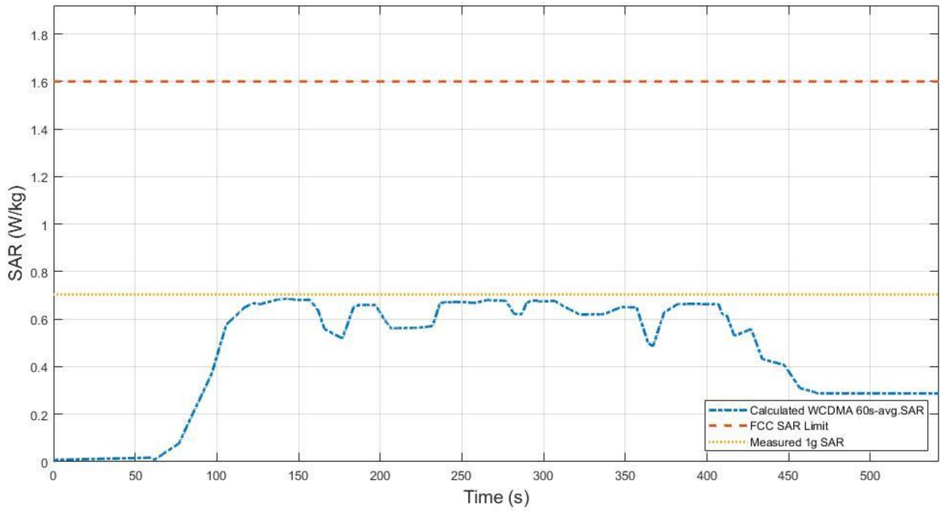


Figure 11.3-14 Total time-averaged SAR in TC07

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.689 W/kg
Device uncertainty	1 dB

TC08: Time_Varying_Tx_Power_Case_2 [GSM1900]

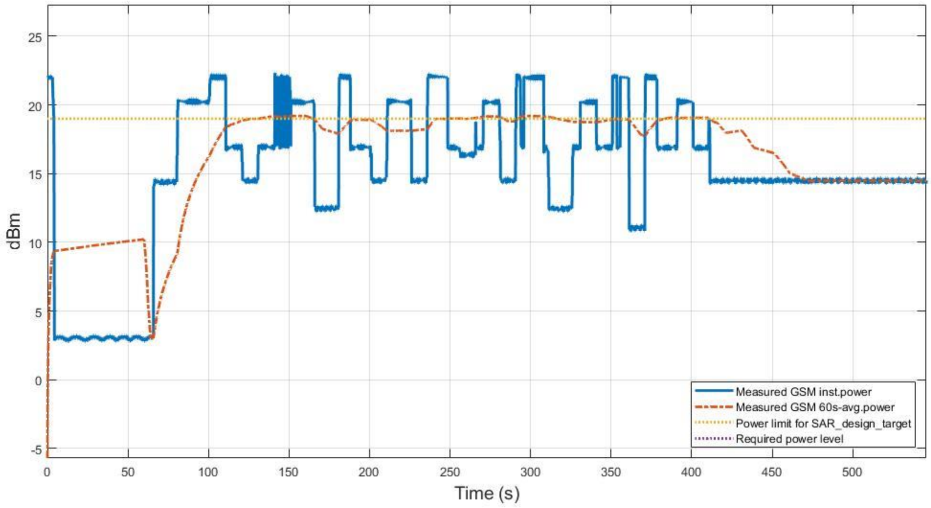


Figure 11.3-15 Conducted Tx power for GSM1900 in TC08

In this test, measured 1g SAR would be 0.389 W/kg at 19.0 dBm. Figure 11.3-15 shows the instantaneous and time-averaged Tx power with test sequence A for GSM1900 with Plimit 19.0 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.

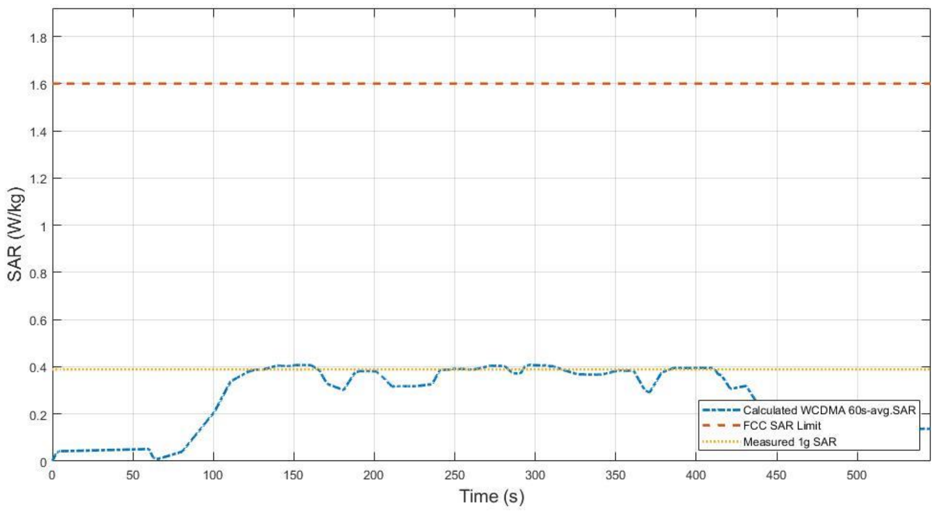


Figure 11.3-16 Total time-averaged SAR in TC08

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.409 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

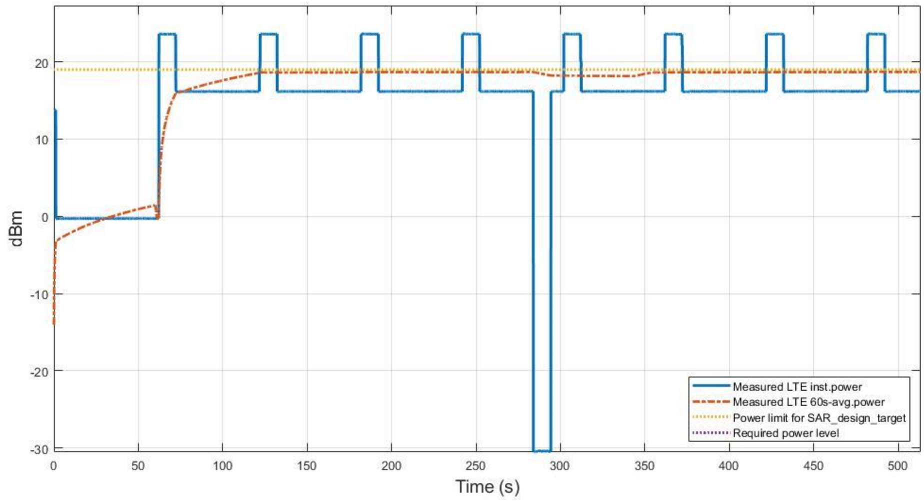


Figure 11.4-1 Conducted Tx power in Call_Disconnect_Reestablishment LTE Band 66 case TC09

In this test, Measured 1g SAR would be 0.676 W/kg at 19.0 dBm. Figure 11.4-1 shows the instantaneous and time-averaged Tx power for this test. The call disconnected around 220s 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.

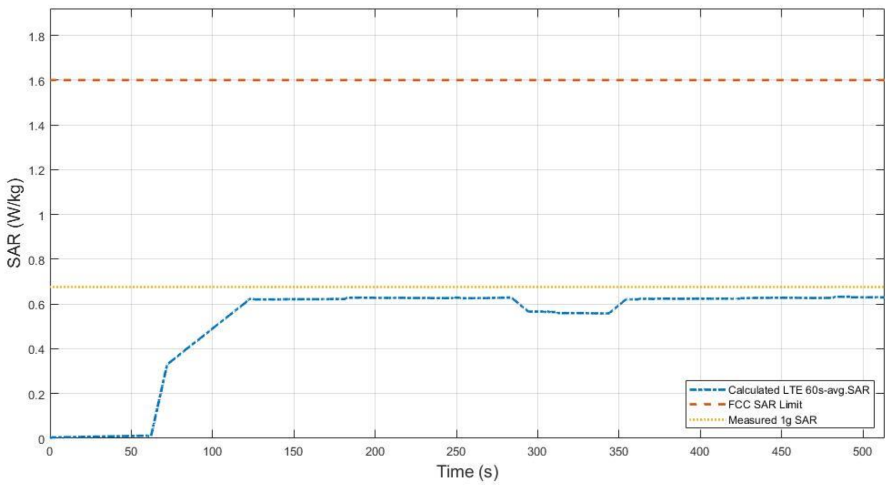


Figure 11.4-2 Total time-averaged SAR in TC09

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (blue curve)	0.633 W/kg
Device uncertainty	1 dB

11.5 Modulation Change test result

The test results in this section are obtained following the procedure in Section 7.3.9. The test cases correspond to TC#10 in Table 11.2.1.

TC10: LTE_Modulation_Change

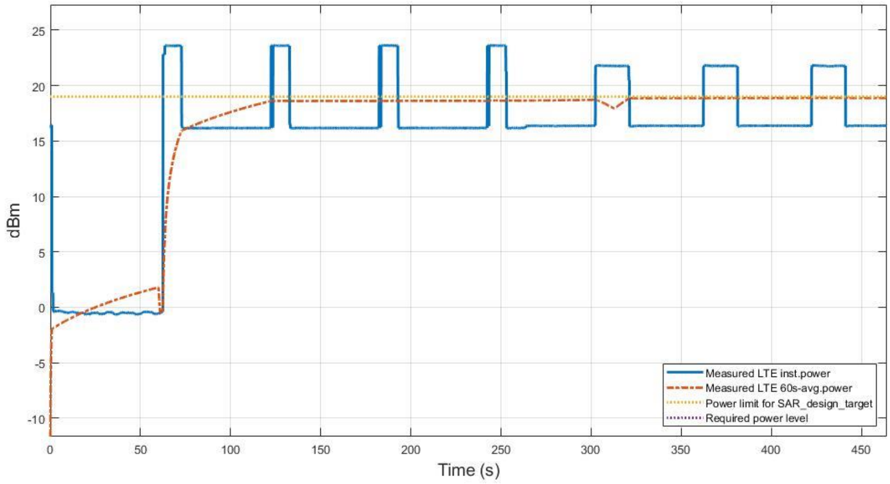


Figure 11.5-1 Conducted Tx power for SAR Modulation Change in test TC10

In this test, Measured 1g SAR would be 0.676 W/kg at 19.0 dBm. Figure 11.5-1 shows the instantaneous and time-averaged Tx power with Plimit 19.0 dBm. The nominal maximum power is set at 24.3dBm and a switch of modulation is happening from QPSK to 16QAM at 260s where an increase in the MPR value from 0dB to 1dB happens. The measured power meter reading is 23dBm at maximum output power. Figure 11.5-1 shows that the moving-average Tx power is around the targeted Plimit value but it is acceptable result due to uncertainty. Also Figure 11.5-2 shows the calculated time-averaged 1gSAR for this test demonstrating that exposure is well below the FCC limit of 1.6W/kg.

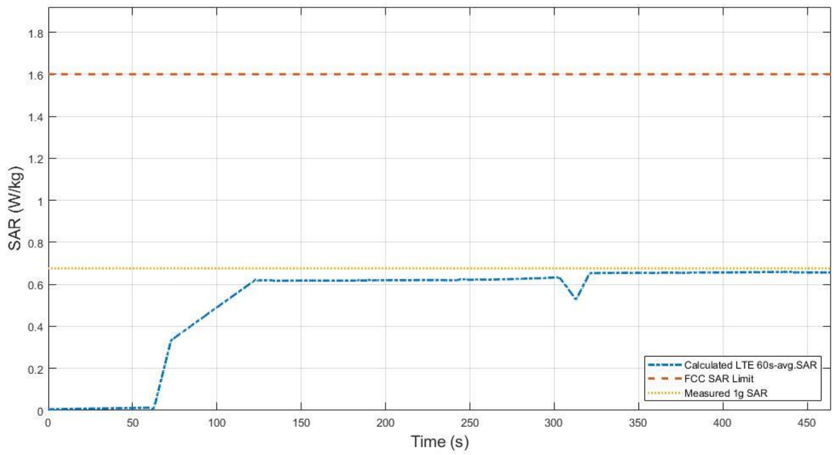


Figure 11.5-2 Total time-averaged SAR in TC10

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (yellow curve)	0.660 W/kg
Device uncertainty	1 dB

11.6 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.

TC11: FR1 to LTE IRAT Re-selection

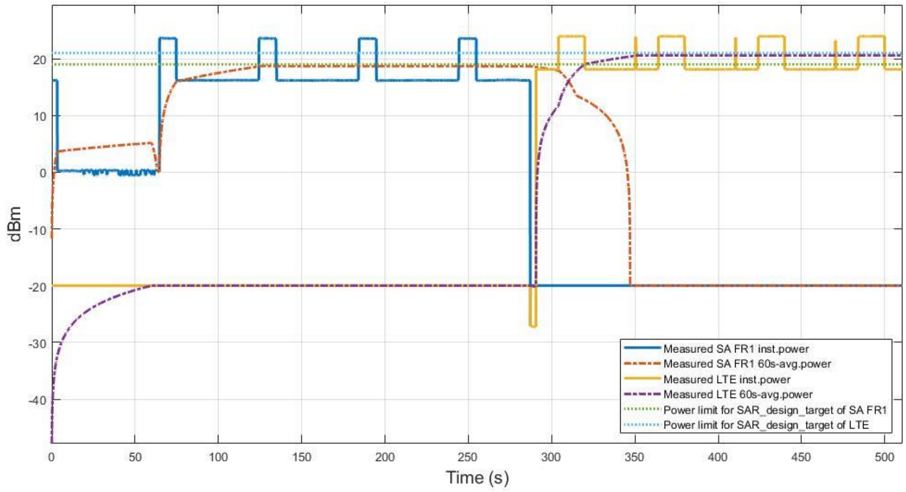


Figure 11.6-1 Conducted Tx power for SAR IRAT re-selection in test TC11 [n66 to LTE B7]

In this test, measured 1g SAR would be 0.721W/kg at 19.0dBm for NR n66 and 0.313 W/kg at 21.0dBm for LTE B7. Figure 11.6-1 shows the instantaneous and time-averaged conducted Tx power for both LTE Band 7 and NR n66 for the duration of the test. Around time stamp of ~220s, a RAT re-selection from NR n66 to LTE B7 was executed, resulting in reduction of time-averaged power of NR n66 and simultaneous increase in time-averaged power of LTE B7. Here, LTE can use back-off power just after re-selection. Since there is a correlation between n66 and B7, TAS algorithm needs to consider the SAR value used in n66 for B7. Figure 11.6-2 shows the time-averaged 1gSAR value for each of LTE B7 and NR n66, 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.

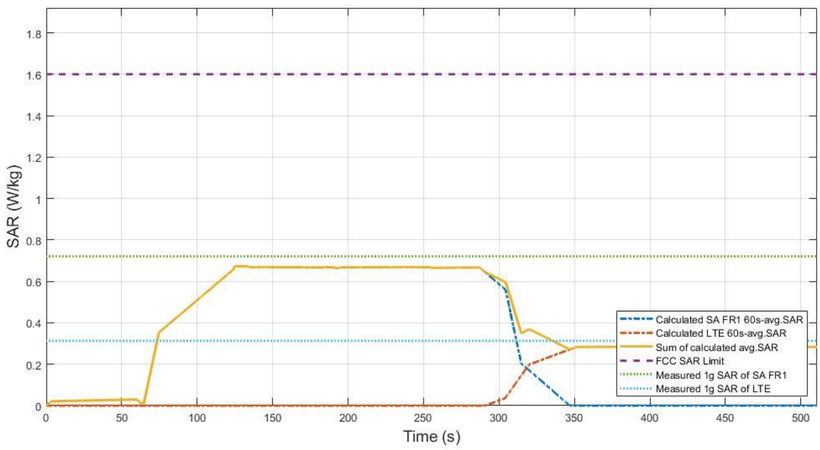


Figure 11.6-2 Conducted Tx power for SAR IRAT re-selection in test TC11

FCC 1gSAR limit	1.6 W/kg
Max 100s-time average 1gSAR (yellow curve)	0.663 W/kg
Device uncertainty	1 dB

11.7 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#12 in Table 11.2.1.

TC12: LTE_Antenna_Band_Switching

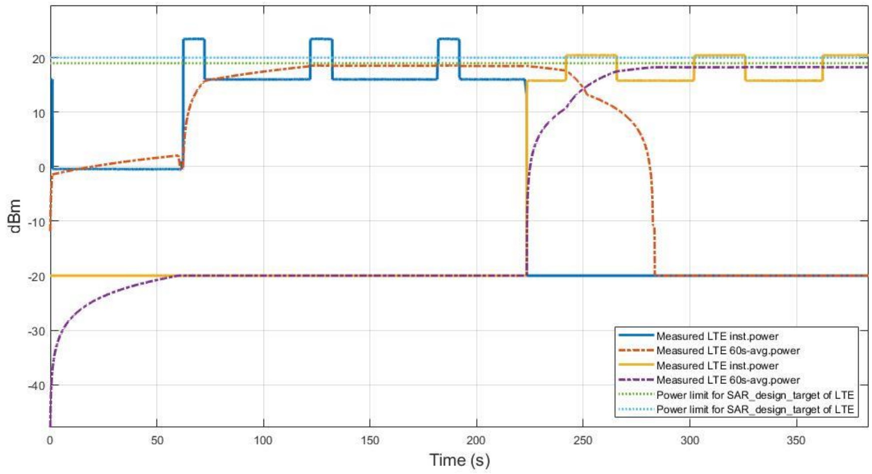


Figure 11.7-1 Conducted Tx power for antenna switching in test TC12

In this test, measured 1g SAR 0.676 W/kg at 19.0dBm for LTE B66 and 0.241 W/kg at 20.0dBm for LTE B41. Figure 11.7-1 shows the instantaneous and time-averaged conducted Tx power for both LTE B66 and LTE B41 for the duration of the test. Around time stamp of ~210s, a band change from LTE B66 to B41 was executed, resulting in reduction of time-averaged power of LTE B66 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 B66 and B41, TAS algorithm needs to consider the SAR value used in B66 for B41. Figure 11.7-2 shows the time-averaged 1gSAR value for each of LTE B66 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.

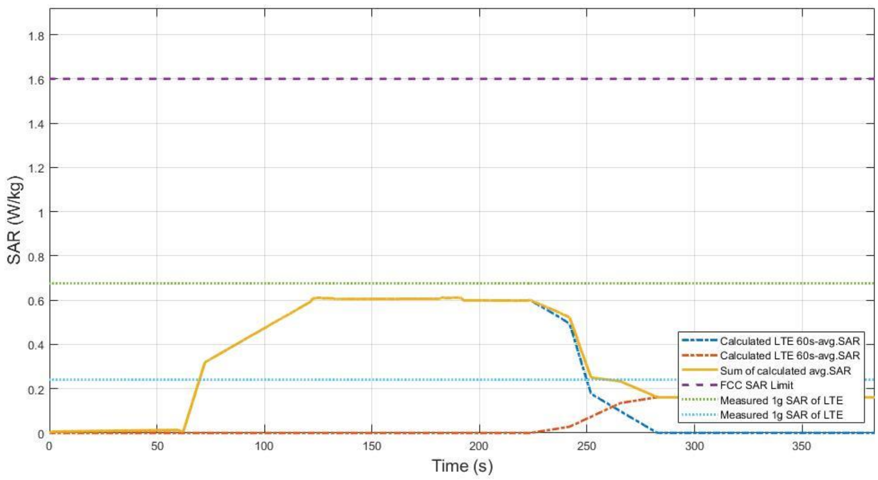


Figure 11.7-2 Total time-averaged SAR in TC12

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (yellow curve)	0.662 W/kg
Device uncertainty	1 dB

11.8 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#13 in Table 11.2.1.

TC13: NSA_FR1_Dominant_Power_Switching

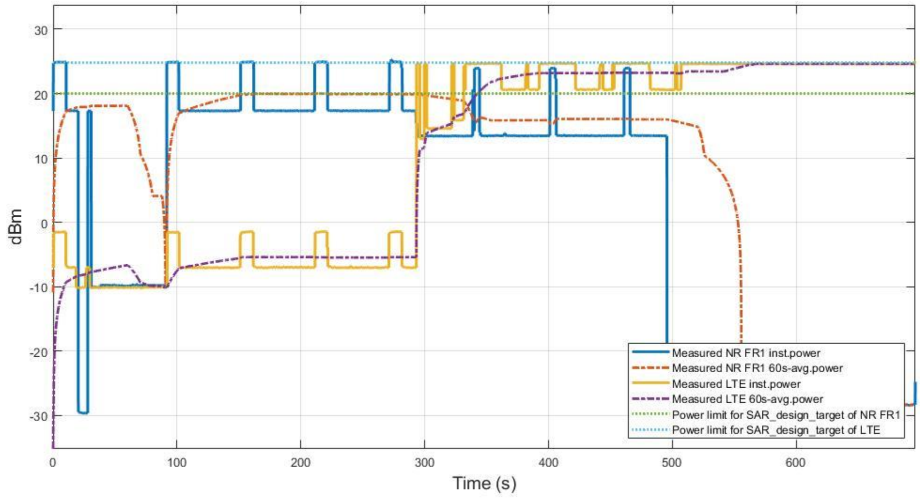


Figure 11.8-1 Conducted Transmitted power for LTE B12 and NR n41 in test TC13

In this test, measured 1g SAR would be 0.293W/kg at 24.8dBm for LTE B12 and 0.202W/kg at 20.0dBm for NR n41. 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 n41 versus time. When both LTE and FR1 operate in around 200s, averaged Tx power for NR is decreased and averaged Tx power of LTE is increased by taking the SAR budget. After 200s, 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.

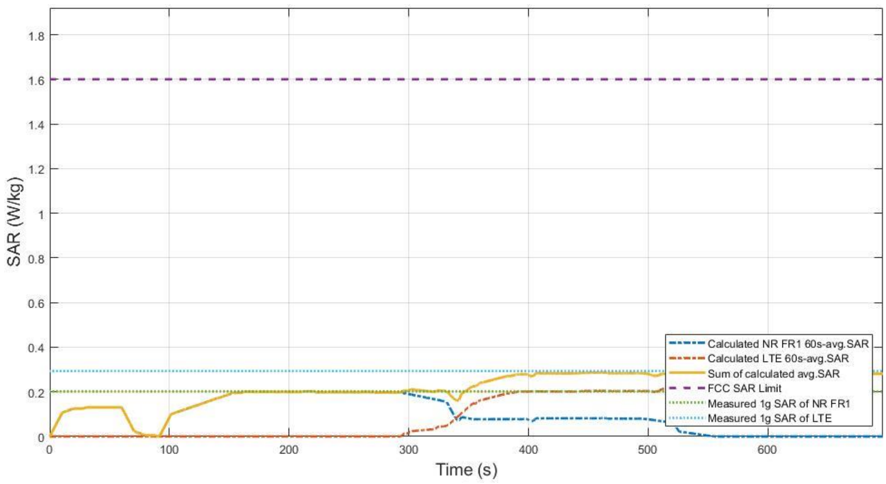


Figure 11.8-2 Total time-averaged SAR FR1 n41 and LTE B12 in TC13

FCC 1gSAR limit	1.6 W/kg
Max 60s-time average 1gSAR (yellow curve)	0.287 W/kg
Device uncertainty	1 dB

11.9 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#14 in Table 11.2.1.

TC14: SA_FR1_RF_SAR_Index_Change

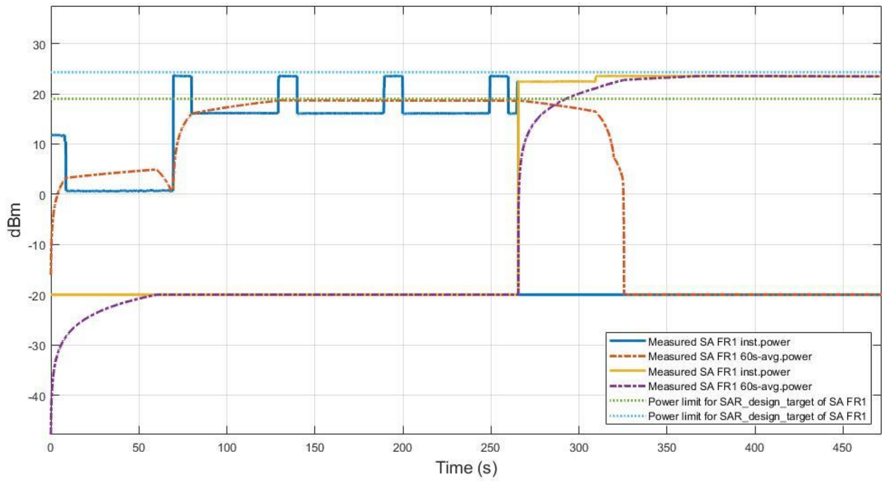


Figure 11.9-1 Conducted Tx power for SAR RSI change in test TC14

In this test, measured 1g SAR would be 0.721W/kg at 19.0dBm (RSI 1) and 0.115W/kg at 24.3dBm (RSI 0). Figure 11.9-1 shows the instantaneous and time-averaged conducted Tx power for both NR n66 for the duration of the test. Around time stamp of ~220s, the RSI value is changed from low RSI with Plimit of 19.0dBm to high RSI with Plimit of 24.3 dBm, resulting in reduction of target time-averaged power of NR n66. 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 11.9-2shows 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.

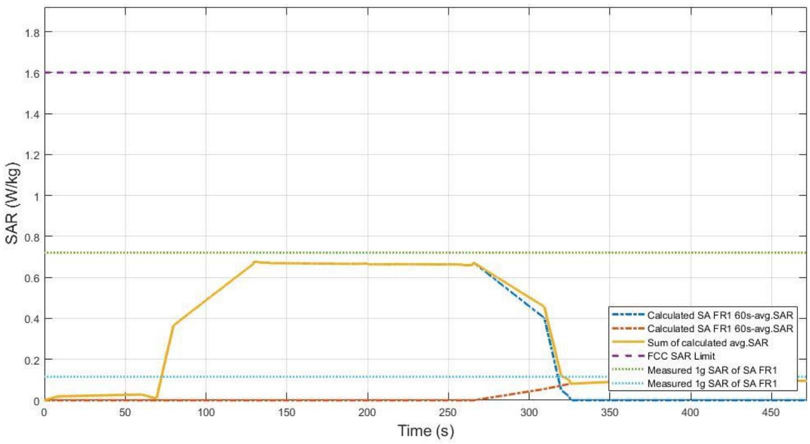


Figure 11.9-2 Total time-averaged SAR in TC14

FCC 1gSAR limit	1.6 W/kg
Sum of calculated average SAR (yellow curve)	0.677 W/kg
Device uncertainty	1 dB

11.10 Intra-band ULCA

The test results in this section are obtained following the procedure in Section 7.3.8. The test cases correspond to TC#15 in Table 11.2.1.

TC15: LTE_Intra_Band_ULCA

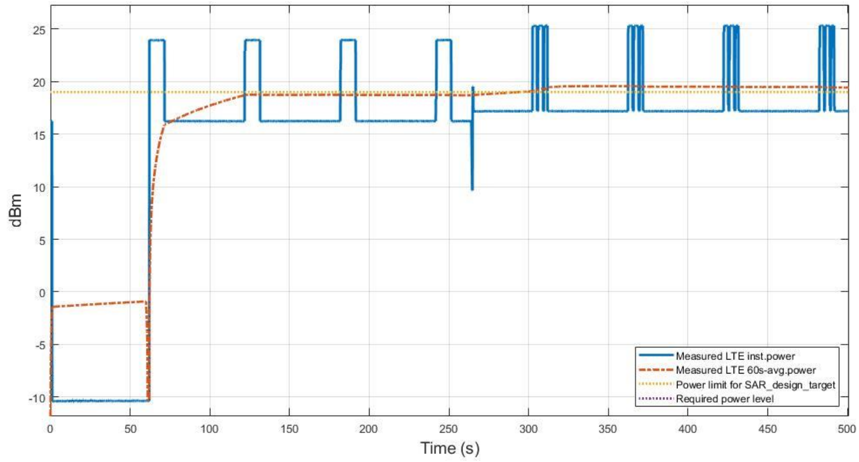


Figure 11.10-1 Conducted Tx power for LTE B66 intra-band ULCA in test TC15

In this test, measured 1g SAR would be 0.676W/kg at 19.0dBm. Figure 11.10-1 shows the conducted Tx power plot with calculated time-averaged power based on the measured instantaneous Tx power with 1gSAR FCC Limit value. After 60s seconds from the start a single CC is transmitted. Next after 150s from a single CC transmission, an intra-band CA is configured (CA_66C) where a new CC is added and the transmission is continued for another 150s. As shown in Figure 11.10-1, the total power of the two CC is kept almost the same as inthe single CC transmission. Average power assures the compliance of the average power of the transmitted signal which is around 19.0dBm and consequently the average SAR in Figure 11.10-2 is around 1W/kg which is below the FCC limit of 1.6W/kg.

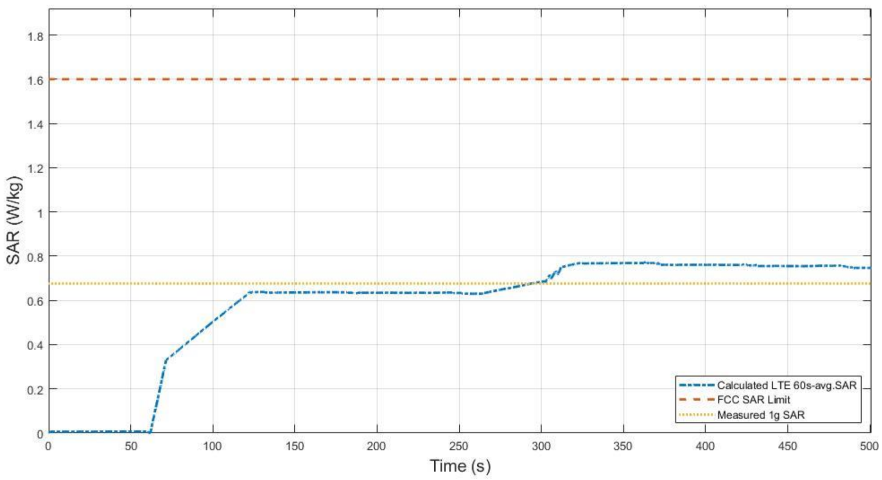


Figure 11.10-2 Total time-averaged SAR in TC15

FCC 1gSAR limit	1.6 W/kg
Sum of calculated average SAR (yellow curve)	0.766 W/kg
Device uncertainty	1 dB

11.11 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#16 in Table 11.2.1.

TC16: NSA_Ant_switching_Spatial_TAS

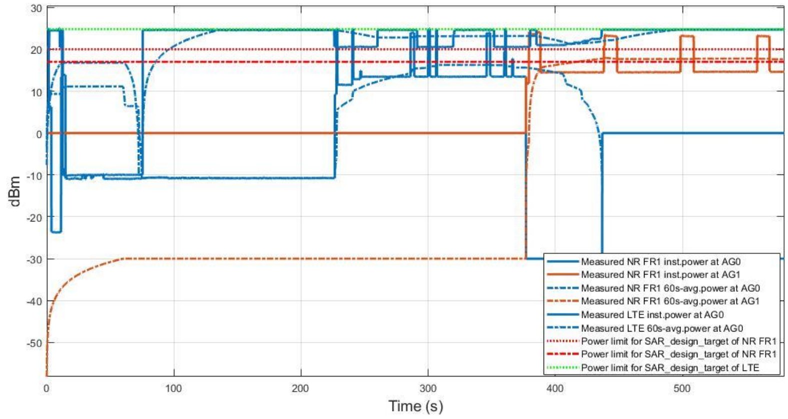


Figure 11.11-1 Conducted Transmitted power for LTE B12(AG0) and NR n41(AG0), n77(AG1) in Test TC16

In this test, measured 1g SAR would be 0.239W/kg at 24.8dBm for LTE B12, 0.202W/kg at 20.0dBm and 0.464W/kg at 17.0dBm for NR n41 and n77. The setting value and measured values are described in Table 11.11-1. Figure 11.11-1 shows the instantaneous and time-averaged Tx power for both LTE B12 and NR n77 versus time. When both LTE and FR1 operate in around 260s, 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 11.11-2, total average SAR is less than 1W/Kg which is below the FCC limit of 1.6W/Kg.

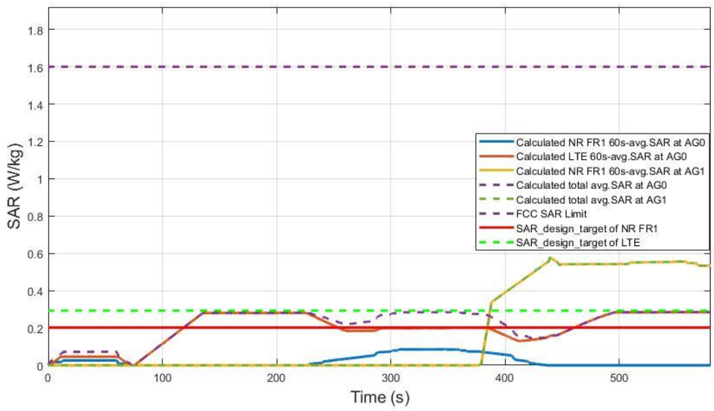


Figure 11.11-2 Total time-averaged SAR in TC16

FCC 1gSAR limit	1.6 W/kg
Sum of calculated average SAR (purple curve)	0.564
Device uncertainty	1 dB

11.12 Inter-band ULCA test reults

The test results in this section are obtained following the procedure in Section 7.3.8. The test cases correspond to TC#17 in Table 11.2.1.

TC17: NR_Inter_Band_UL_CA

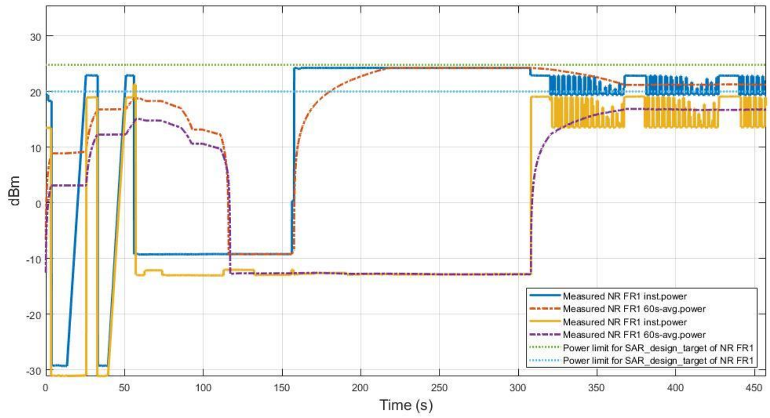


Figure 11.12-1 Conducted Tx power in NR inter-band ULCA in test TC 17

In this test, measured 1g SAR would be 0.203W/kg at 24.8dBm for NR n71 and 0.202W/kg at 20.0dBm for NR n41. Figure 11.12-1 shows the instantaneous and time-averaged conducted Tx power for both NR n71 and NR n41 for the duration of the test. The setting value and measured values are described in Table 11.12-1. After a 70s from the start a single CC is transmitted. Next after 150s from a single CC transmission, ULCA mode is configured where a new CC is added and the transmission is continued for another 150s. Here, the Back-off power is decreased from Plimit -3dB to more high back-off in coupling case. Because each CC share the same SAR budget. Here, in NR ULCA mode, ther is high priority in PCC. So more power is allocated to PCC and SCC just take the remaining SAR and power. Average power assures the compliance of the average power of the transmitted signal which is below 24.8dBm and 20.0dBm in a single CC and ULCA mode. Also the average SAR in Figure 11.12-2 is around 1.0W/kg which is below the FCC limit of 1.6W/kg.

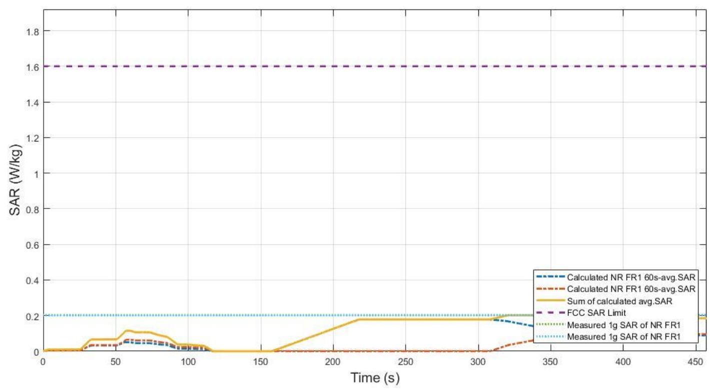


Figure 11.12-2 Total time-averaged SAR in TC17

FCC 1gSAR limit	1.6 W/kg
Sum of calculated average SAR (purple curve)	0.203
Device uncertainty	1 dB

12. FR2 Radiated Power Test Results for TAS validation

12.1 Measurement setup

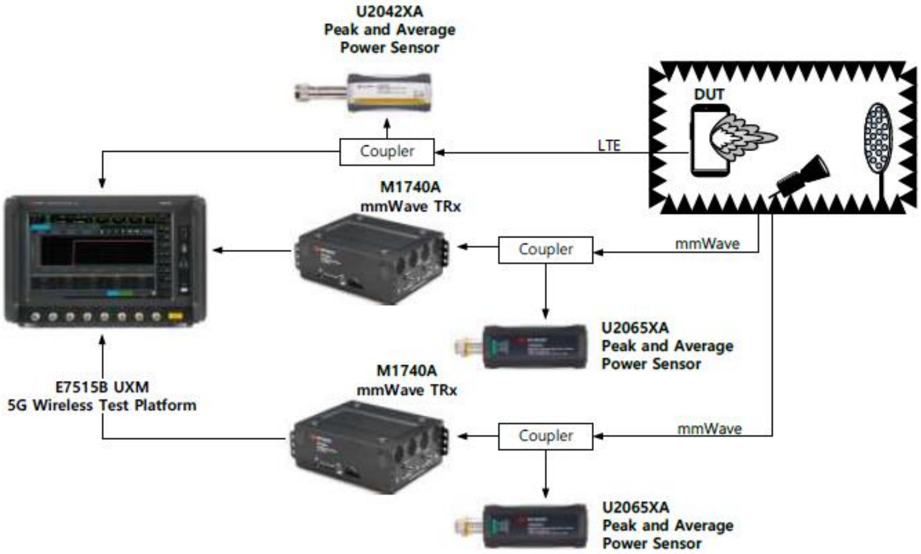


Figure 12.1-1 Test set-up for mmWave

In mmWave technology, we are not able to measure conducted power at antenna, so only radiated power in the form of EIRP (equivalent isotropically radiated power) will be measured in an anechoic chamber. The test setup is illustrated in Figure 12.1-1. LTE/FR1 technology will also be active and this connection can be done via a connected port of the DUT. A power sensor can be coupled to the LTE/FR1 transmission. There is a concept of two orthogonal polarization measurements (horizontal and vertical) in mmWave, and so two additional power sensors are needed to measure both. There are remote radio-heads required to performance up/down-conversion of the mmWave signal from/to the call box. The Keysight UXM call box is capable of establishing both LTE/FR1 and FR2 connections. The coupled power sensors in mmWave uplink will be logged along with the LTE/FR1 power simultaneously for post-processing on the PC. The LTE/FR1 power is then mapped to SAR, while the mmWave power readings will be mapped to PD using the characterization data.

The direction of DUT is set to see the worst case corresponding to module and beam showing the highest PD in characterization. By validation in this conservative worst PD case, all other cases can be regarded as to be validated as well.

In summary, PD test has to be executed as following procedure

1. Measure conduction sub 6GHz Tx power corresponds to SAR regulation and measure Tx EIRP corresponds to PD regulation. For mmWave, E-field PD measurement TE is used instead of EIRP measurements.
2. Set sub 6GHz and mmWave 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 and EIRP value using mmWave power meter.
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.

12.2 Time-varying Tx power measurement results

The results in this section were obtained following the procedure in Section 8.3.1 and corresponds to the test case TC18,TC19 in Table 10.2.1.

TC18: mmWave_Max_Tx_Power_EN-DC

AG0 : n258[M] + LTE B2 [Ant F] [EN-DC Evaluation of the coupled Antenna Group [0]]

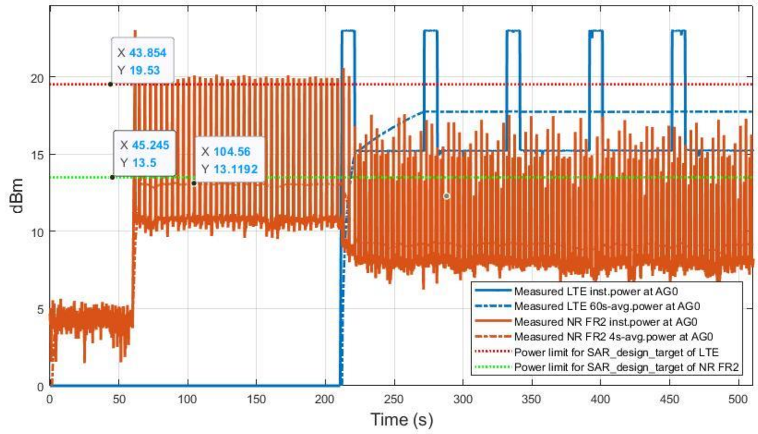


Figure 12.2-1 Conducted power of LTE B2 and radiated EIRP of FR2 n258 in TC18 EN-DC

Figure 12.2-1 shows the instantaneous and time-averaged conducted power for LTE and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design target is 1.0W/Kg, and the Plimit value of FR2 is 13.5dBm when PD_design_target is 5.89W/m2.

When LTE is operated, FR2 power would be decreased to maintain TER value. After the average power of LTE is saturated as target power, the average power of FR2 is not decreased any more. As a result, although LTE is turned on, the TER value doesn't increase or decrease. Figure 12.2-2 shows the computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

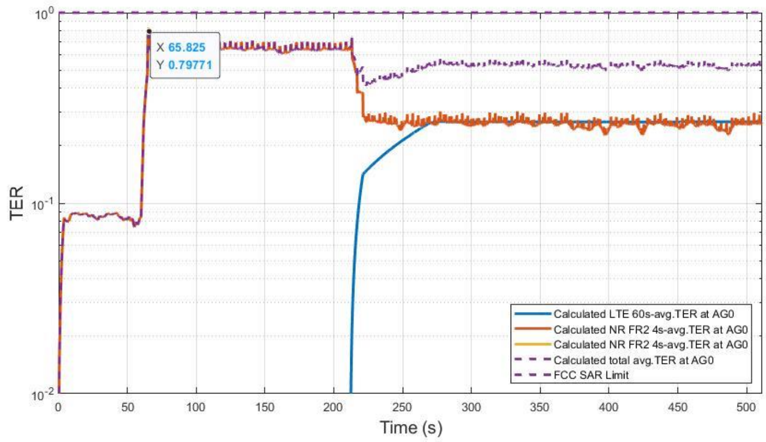


Figure 12.2-2 Total normalized time-average RF exposure in TC18 EN-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.798
Validated	

AG0 : n260[M] + LTE B2 [Ant F] [EN-DC Evaluation of the coupled Antenna Group [0]]

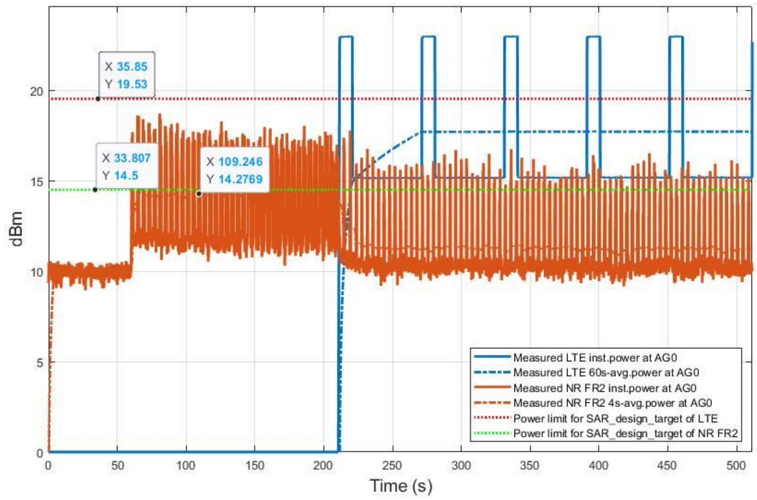


Figure 12.2-3 Conducted power of LTE B2 and radiated EIRP of FR2 n260 in TC18 EN-DC

Figure 12.2-3 shows the instantaneous and time-averaged conducted power for LTE and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design target is 1.0W/Kg, and the Plimit value of FR2 is 14.5dBm when PD_design_target is 5.89W/m2. When LTE is operated, FR2 power would be decreased to maintain TER value. After the average power of LTE is saturated as target power, the average power of FR2 is not decreased any more. As a result, although LTE is turned on, the TER value doesn't increase or decrease. Figure 12.2-4 shows the computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

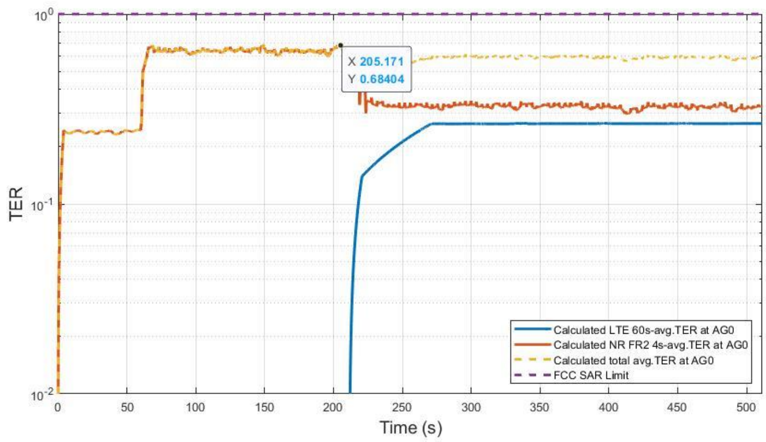


Figure 12.2-4 Total normalized time-average RF exposure in TC18 EN-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.684
Validated	

AG0 : n261[M] + LTE B2 [Ant F] [EN-DC Evaluation of the coupled Antenna Group [0]]

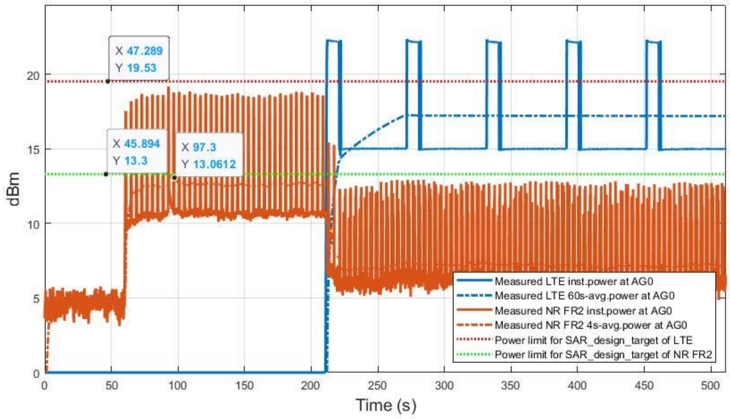


Figure 12.2-5 Conducted power of LTE B2 and radiated EIRP of FR2 n261 in TC18 EN-DC

Figure 12.2-5 shows the instantaneous and time-averaged conducted power for LTE and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. When LTE is operated, FR2 power would be decreased to maintain TER value. After the average power of LTE is saturated as target power, the average power of FR2 is not decreased any more. As a result, although LTE is turned on, the TER value doesn't increase or decrease. Figure 12.2-6 shows the computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

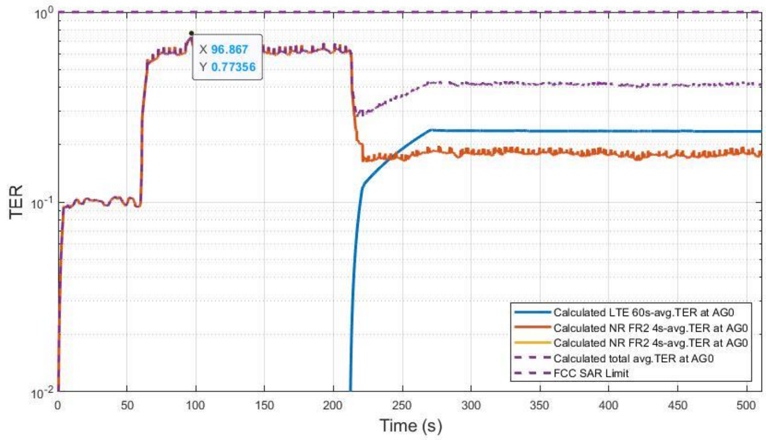


Figure 12.2-6 Total normalized time-average RF exposure in TC18 EN-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.774
Validated	

[EN-DC evaluation between decoupled Antenna Groups [AG0 and AG1]

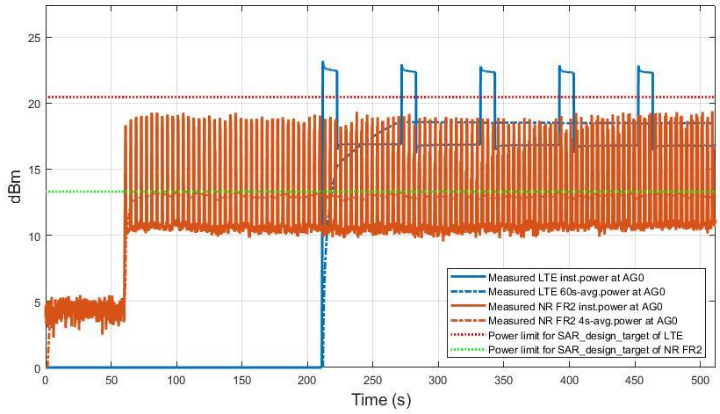
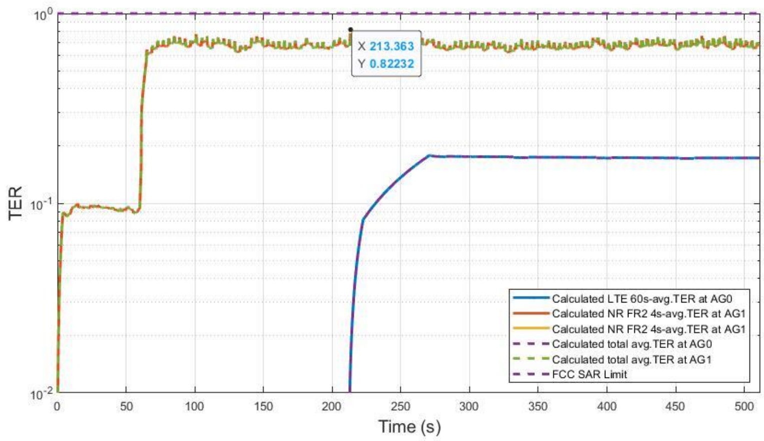


Figure 12.2-6-1 Conducted power of LTE B2 and radiated EIRP of FR2 n261 in TC18 EN-DC

Figure 12.2-6-1 shows the instantaneous and time-averaged conducted power for LTE [AG1]and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. When LTE is operated, FR2 power would be decreased to maintain TER value. After the average power of LTE is saturated as target power, the average power of FR2 is not decreased any more. As a result, although LTE is turned on, the TER value doesn't increase or decrease. Figure 12.2-6-1 shows the computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.



FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.822
Validated	

Figure 12.2-6-2 Total normalized time-average RF exposure in TC18 EN-DC_AG0 between AG1

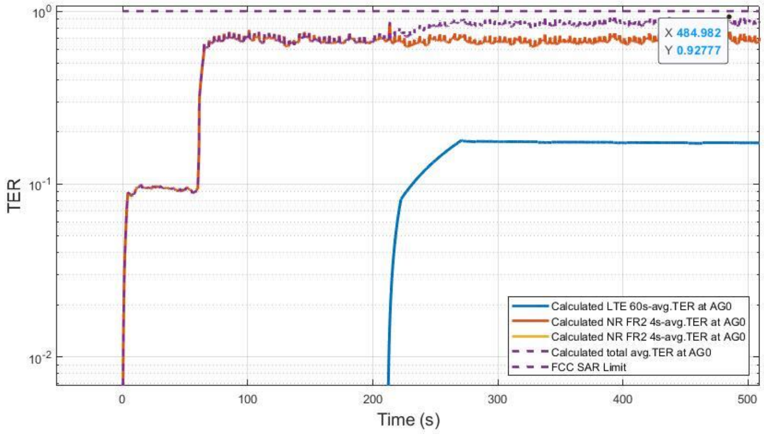


Figure 12.2-6-3 Total normalized time-average RF exposure in TC18 EN-DC for SUM =AG0 +AG1

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.928
Validated	

The top antenna group 0 and the bottom antenna group 1 are physically far enough apart that there is no influence between the antenna groups, and even if the 5G FR2 of AG0 on the top and the LTE B2 of AG1 on the bottom are transmitted simultaneously, the output is controlled by Samsung S.LSI TAS algorithm to ensure that the FCC's simultaneous radiation standard of TER 1 is not exceeded.

In addition, the TER does not exceed 1 even when the output power of AG0 [FR2] and AG1 [LTE] is summed up, so the simultaneous transmission TAS evaluation result of FR2 and WWAN always satisfies the FCC TER.

TC19: mmWave_Max_Tx_Power_NR-DC

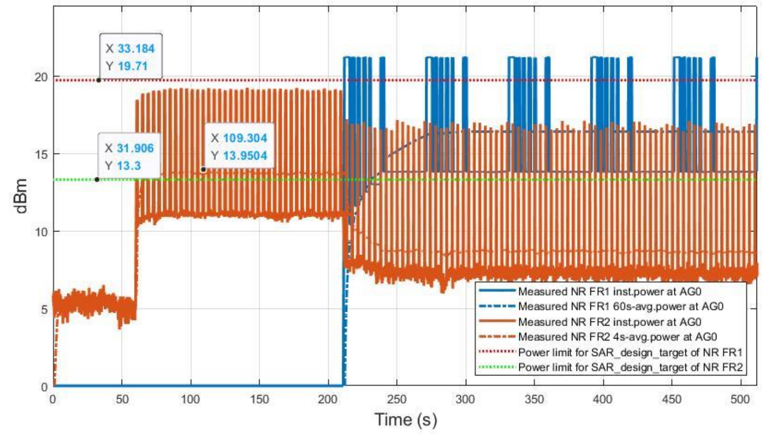


Figure 12.2-7 Conducted power of FR1 n2 and radiated EIRP of FR2 n261 in TC19 NR-DC

Figure 12.2-7 shows the instantaneous and time-averaged conducted power for FR1 and radiated power for NR FR2. In this test, we assumed that Plimit value for FR1 is 20dBm when SAR_design target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. When FR1 is operated, FR2 power would be decreased to maintain TER value. After the average power of FR1 is saturated as target power, the average power of FR2 is not decreased any more. As a result, although FR1 is turned on, the TER value doesn't increase or decrease. Figure 12.2-8 shows the computed normalized and time-averaged SAR and PD values for FR1 and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

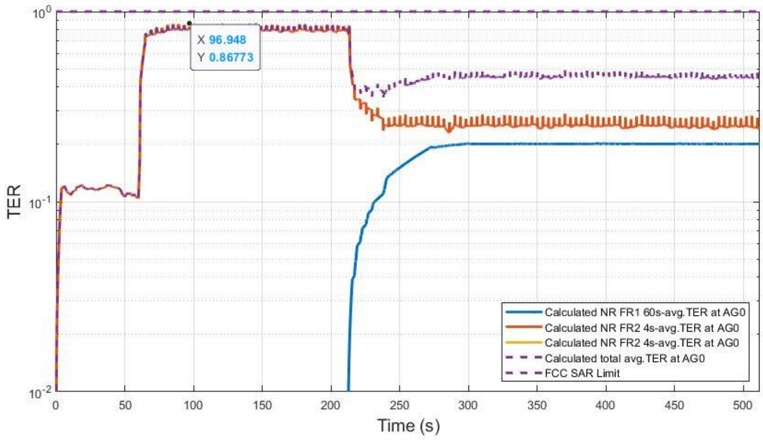


Figure 12.2-8 Total normalized time-average RF exposure in TC19 NR-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.868
Validated	

12.3 SAR vs PD Exposure Switch measurement results

The results in this section were obtained following the procedure in Section 8.3.2 and corresponds to the test case TC20,TC21 in Table 10.2.1.

TC20: mmWave_Dominant_Power_Switching _EN-DC

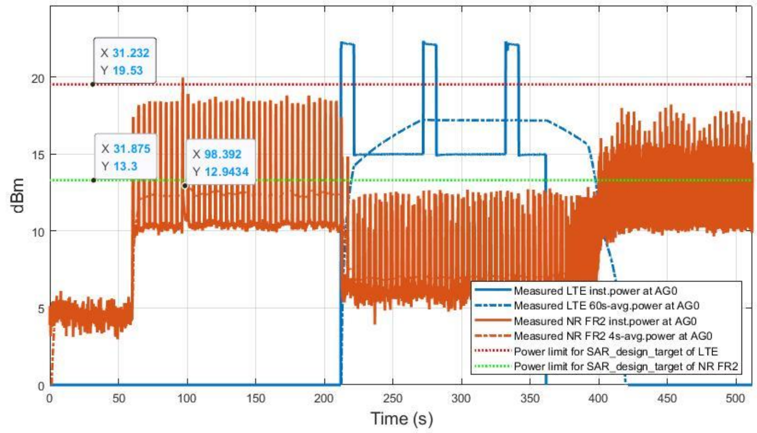


Figure 12.3-1 Conducted power of LTE B2 and radiated EIRP of FR2 n261 in TC20 EN-DC

Figure 12.3-1 shows the instantaneous and time-averaged conducted power for LTE and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design_target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. When LTE is operated, FR2 power would be decreased to maintain TER value. After the average power of LTE is saturated as target power, the average power of FR2 is not decreased any more. After LTE is turned off, the average power of FR2 is increased to restore the original target power. As a result, whether LTE is turned on or not, the TER value dramatically doesn't increase or decrease. Figure 12.3-2 shows the computed normalized and time-averaged SAR and PD values for LTE and NR FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

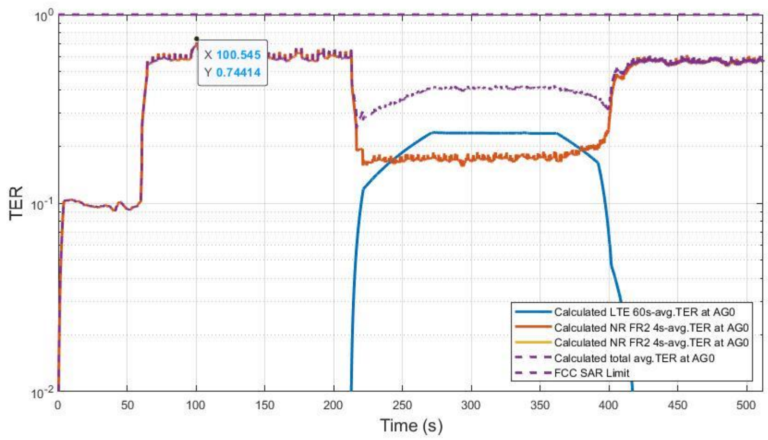


Figure 12.3-2 Total normalized time-average RF exposure in TC20 EN-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.744
Validated	

TC21: mmWave_Dominant_Power_Switching _NR-DC

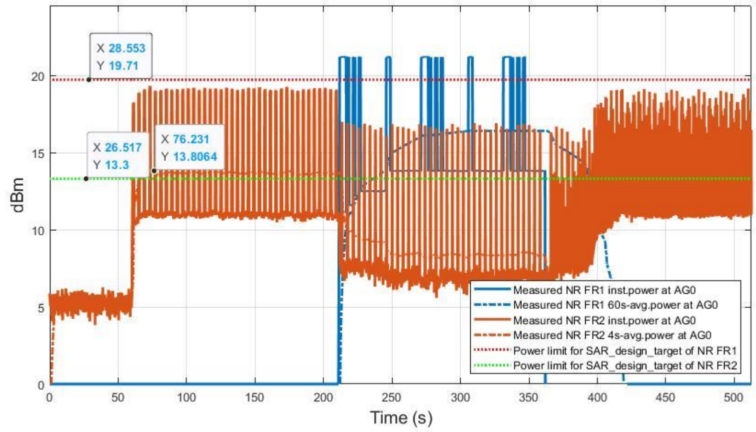


Figure 12.3-3 Conducted power of FR1 n2 and radiated EIRP of FR2 n261 in TC21 NR-DC

Figure 12.3-3 shows the instantaneous and time-averaged conducted power for FR1 and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design_target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. When FR1 is operated, FR2 power would be decreased to maintain TER value. After the average power of FR1 is saturated as target power, the average power of FR2 is not decreased any more. After LTE is turned off, the average power of FR2 is increased to restore the original target power. As a result, whether FR1 is turned on or not, the TER value dramatically doesn't increase or decrease. Figure 12.3-4 shows the computed normalized and time-averaged SAR and PD values for FR1 and FR2, respectively, as well as their sum which is the TER value. We can see that the TER is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

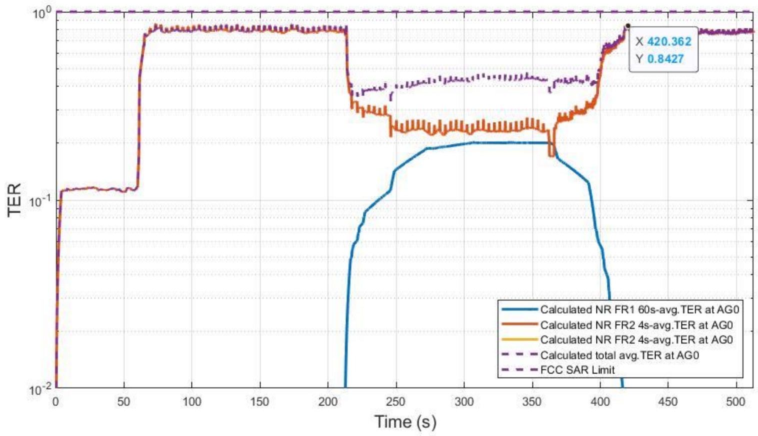


Figure 12.3-4 Total normalized time-average RF exposure in TC21 NR-DC

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.843
Validated	

12.4 FR2 Uplink CA measurement results

The results in this section were obtained following the procedure in Section 8.3.3 and corresponds to the test case TC22 in Table 10.2.1.

TC22: mmWave_UL_CA

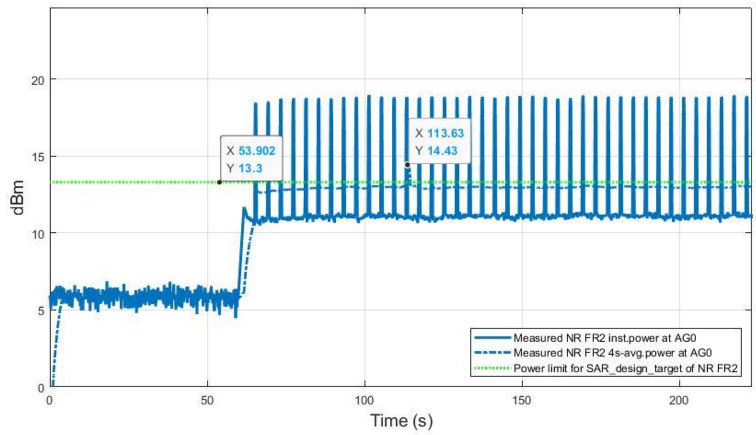


Figure 12.4-1 Radiated EIRP of FR2 n261 in TC22

Figure 12.4-1 shows the instantaneous and time-averaged conducted power for LTE and radiated power for NR FR2. In this test, we assumed that Plimit value for LTE is 20dBm when SAR_design_target is 1.0W/Kg, and the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. Upon start up LTE and FR2 are all down. After a 60s from the start FR2 cell 1 is all up, FR2 cell 2 is all down. Next after 50s, the FR2 Cell 1,2 are all up, and continues for more than 100s. Figure 12.4-2 is always under the FCC compliance limit of 1, thus validating the TAS feature in this test case.

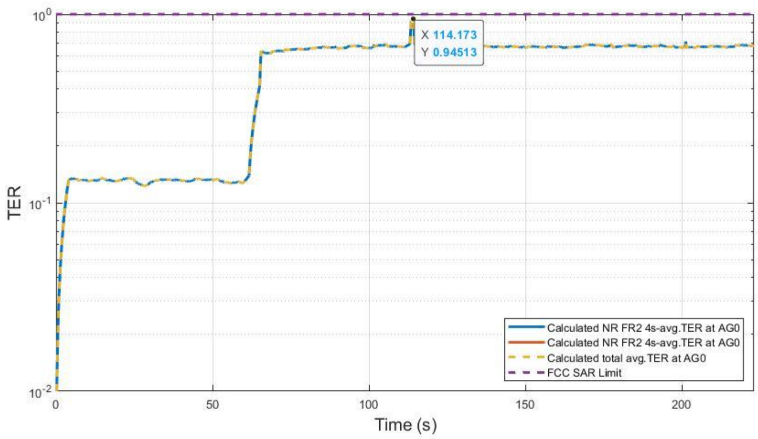


Figure 12.4-2 Total normalized time-average RF exposure in TC22

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.945
Validated	

12.5 FR2 Beam change measurement results

The results in this section were obtained following the procedure in Section 8.3.4 and corresponds to the test case TC23 in Table 10.2.1.

TC23: mmWave_Module_Beam_Change

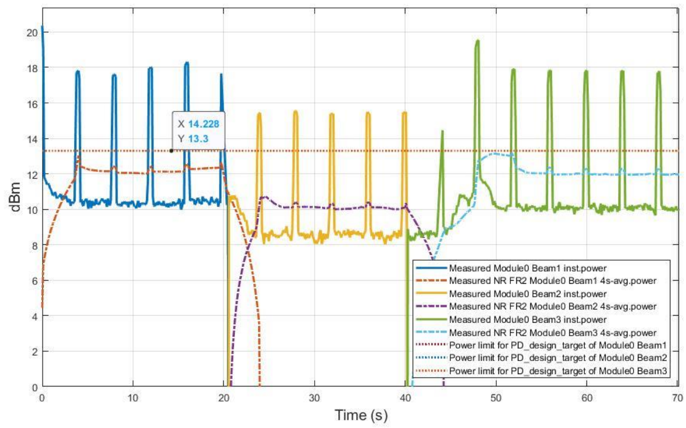


Figure 12.5-1 Radiated EIRP of FR2 n261 in TC23

Figure 12.5-1 shows the instantaneous time-averaged radiated power for NR FR2. We don't show the LTE transmit power, since it would be at the lowest level and doesn't meaningfully contribute to the TER. In this test, we assumed the Plimit value of FR2 is 13.3dBm when PD_design_target is 5.89W/m2. Figure 12.5-2 shows the computed time-averaged PD for each Module/beam setting as well as the total sum. When beam or module of FR2 would be changed, the sum of each beam/module is not higher than the target power limit. As a result, whether beam/module is changed or not, the TER value dramatically doesn't increase.

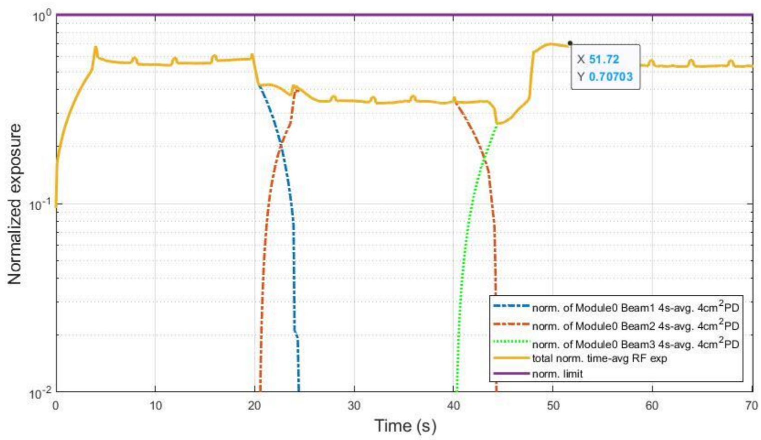


Figure 12.5-2 Total normalized time-average RF exposure in TC23

FCC requirement for total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.707
Validated	

13. Conclusions

Samsung Time-Averaging SAR (TAS) feature employed in Samsung Mobile Phone (FCC A3LSMS721U) 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	11/28/2023	Annual	11/28/2024
Narda	Directional Coupler / 4216-10	01489	11/28/2023	Annual	11/28/2024
HP	Power Divider/11636B	50659	05/21/2024	Annual	05/21/2025
HP	Power Divider/11636B	58698	01/15/2024	Annual	01/15/2025
RFCOREA	2Way Spliter	473842	12/13/2023	Annual	12/13/2024
Anritsu	Radio Communication Analyzer / MT8821C	6262044720	11/28/2023	Annual	11/28/2024
Anritsu	Radio Communication Analyzer / MT8821C	6262116770	08/02/2023	Annual	08/02/2024
Anritsu	Radio Communication Test Station / MT8000A	6262036812	11/28/2023	Annual	11/28/2024
Anritsu	Power Meter / ML2496A	2041001	11/28/2023	Annual	11/28/2024
Anritsu	Power Sensor / MA2475D	1911225	11/28/2023	Annual	11/28/2024
Anritsu	Power Sensor / MA2475D	1911226	11/28/2023	Annual	11/28/2024
-	CATR System Control PC	-	N/A	N/A	N/A
Keysight	5G Compact Antenna Test Range Chamber	230 #27	N/A	N/A	N/A
Keysight	Power Sensor / U2065XA	MY60000018	01/17/2024	Annual	01/17/2025
Keysight	Power Sensor / U2065XA	MY60000014	01/17/2024	Annual	01/17/2025
Keysight	Power Sensor / U2042XA	MY60050004	01/17/2024	Annual	01/17/2025
Keysight	UXM 5G Wireless Test Platform / E7515B	MY60102101	04/25/2024	Annual	04/25/2025
Keysight	mmWave Transceiver / M1740A	MY59292349	09/25/2023	Annual	09/25/2024
Keysight	mmWave Transceiver / M1740A	MY59292403	09/25/2023	Annual	09/25/2024
Keysight	5G Common Interface Unit / E7770A	MY58290875	N/A	N/A	N/A
Mini Circuits	Directional Coupler / ZCDC10-V245+	913911	11/28/2023	Annual	11/28/2024
Mini Circuits	Directional Coupler / ZCDC10-V245+	913901	11/28/2023	Annual	11/28/2024
Narda	Directional Coupler / 4216-10	01652	06/25/2024	Annual	06/25/2025

15. References

The following documents contain reference in this technical document.

[1] [OEM][Samsung+S.LSI_S5400]+Time+average+SAR+algorithm+(FCC)_v1.1

Appendix A. Test sequence

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

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

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

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