



TIME-AVERAGED SAR VALIDATION REPORT

Applicant Name:
Apple, Inc.
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Test Site/Location:
Element, Morgan Hill, CA, USA
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1C2504170041-04.BCG (Rev 1)

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APPLICANT: APPLE INC.

DUT Type: Tablet Device
Application Type: Certification
FCC Rule Part(s): CFR §2.1093
Model: A3361
Additional Model: A3362
Device Serial Numbers: Pre-Production Samples [F123D, 9R7C6, C6VGX, QVHDX, Y2RJ6]

Note: This revised Test Report supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.



RJ Ortanez
Executive Vice President



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1. DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
UMTS 850	Data	826.4 - 846.6 MHz
UMTS 1750	Data	1712.4 - 1752.6 MHz
UMTS 1900	Data	1852.4 - 1907.6 MHz
LTE Band 71	Data	665.5 - 695.5 MHz
LTE Band 12	Data	699.7 - 715.3 MHz
LTE Band 17	Data	706.5 - 713.5 MHz
LTE Band 13	Data	779.5 - 784.5 MHz
LTE Band 14	Data	790.5 - 795.5 MHz
LTE Band 26 (Cell)	Data	814.7 - 848.3 MHz
LTE Band 5 (Cell)	Data	824.7 - 848.3 MHz
LTE Band 66 (AWS)	Data	1710.7 - 1779.3 MHz
LTE Band 4 (AWS)	Data	1710.7 - 1754.3 MHz
LTE Band 25 (PCS)	Data	1850.7 - 1914.3 MHz
LTE Band 2 (PCS)	Data	1850.7 - 1909.3 MHz
LTE Band 30	Data	2307.5 - 2312.5 MHz
LTE Band 7	Data	2502.5 - 2567.5 MHz
LTE Band 41	Data	2498.5 - 2687.5 MHz
LTE Band 48	Data	3552.5 - 3697.5 MHz
NR Band n71	Data	665.5 - 695.5 MHz
NR Band n12	Data	701.5 - 713.5 MHz
NR Band n14	Data	790.5 - 795.5 MHz
NR Band n26 (Cell)	Data	816.5 - 846.5 MHz
NR Band n5 (Cell)	Data	826.5 - 846.5 MHz
NR Band n70	Data	1697.5 - 1707.5 MHz
NR Band n66 (AWS)	Data	1712.5 - 1777.5 MHz
NR Band n25 (PCS)	Data	1852.5 - 1912.5 MHz
NR Band n2 (PCS)	Data	1852.5 - 1907.5 MHz
NR Band n30	Data	2307.5 - 2312.5 MHz
NR Band n7	Data	2502.5 - 2567.5 MHz
NR Band n41	Data	2501.01 - 2685.0 MHz
NR Band n48	Data	3555.0 - 3694.98 MHz
NR Band n77 DoD	Data	3455.01 - 3544.98 MHz
NR Band n77	Data	3705.0 - 3975.0 MHz
2.4 GHz WLAN	Voice/Data	2412 - 2472 MHz
5 GHz WIFI	Voice/Data	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz
6 GHz WIFI	Voice/Data	U-NII-5: 5935 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz
Bluetooth	Data	2402 - 2480 MHz
802.15.4	Data	2405 - 2475 MHz
NB UNII-1	Data	5162 - 5245 MHz
NB UNII-3	Data	5733 - 5844 MHz
NB UNII-5	Data	6106 - 6420 MHz
WPT	N/A	13.56 MHz

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1.2 Key Parameter Description

Operating parameters	Description
P_{limit}	The maximum possible time-averaged power for all device operating states where TAS is supported.
$P_{limit,nom}$	The target time-averaged power, excluding total device uncertainty.
P_{max}	The maximum possible instantaneous power for all device operating states where TAS is supported.
$SAR_{Design\ Target}$	The maximum Spatial Peak averaged-SAR value, corresponding to $P_{limit,nom}$.
$SAR_{Design\ Limit}$	The maximum Spatial Peak averaged-SAR value, corresponding to P_{limit} .

$P_{limit,nom}$, P_{limit} , and P_{max} values are defined for all antennas, technologies, bands, and operating state combinations supporting TAS on the DUT. The $P_{limit,nom}$ value is defined to ensure the RF exposure is never greater than $SAR_{Design\ Limit}$.

1.3 Time-Averaging Algorithm for RF Exposure Compliance

This DUT supports time-averaging with dynamic budgeting for Cellular technologies to control and manage transmitting power, in real time. Consumed SAR from active radios is tracked and stored for the duration of the applicable regulatory averaging window. Rolling time-averaged SAR values are calculated from the consumed SAR reported from active radios. The time-averaged SAR is always maintained less than the applicable $SAR_{Design\ Limit}$. Only Cellular technologies implement this dynamic budgeting method. Connectivity technologies (WLAN, BT, NB UNII, 802.15.4) implement an independent TAS algorithm for power and budget control.

The purpose of this document is to demonstrate the validity of the Cellular TAS and Budget Sharing feature.

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The tables below define the following parameters (SAR_{target}, SAR Design_{limit}, Plimit_{nom} and Pmax_{nom} values) for TAS operations.

1.3.1 SAR_{design_target} Calculations

Table 1-1
Antenna 1

SAR _{design_target} Calculations			
Mode/Band	1g SAR [W/kg]		
	SAR _{design_target}	SAR _{Design_limit}	SAR _{regulatory_limit}
UMTS 850	1.06	1.2 W/kg	1.6 W/kg
UMTS 1750	0.97		
UMTS 1900	1.02		
LTE Band 71	1.02		
LTE Band 12	0.99		
LTE Band 17	0.99		
LTE Band 13	1.04		
LTE Band 14	1.06		
LTE Band 26	1.06		
LTE Band 5	1.06		
LTE Band 5 ULCA	1.06		
LTE Band 4	0.97		
LTE Band 66	0.97		
LTE Band 2	1.02		
LTE Band 25	1.02		
LTE Band 30	1.04		
LTE Band 7	0.99		
LTE Band 7 ULCA	0.99		
LTE Band 41 (PC3) - [Ch. 39750 - 40620]	0.97		
LTE Band 41 (PC3) ULCA - [Ch. 39750 - 40620]	0.97		
LTE Band 41 (PC2) - [Ch. 39750 - 40620]	0.97		
LTE Band 41 (PC2) ULCA - [Ch. 39750 - 40620]	0.97		
LTE Band 41 (PC3) - [Ch. 41055 - 41490]	0.95		
LTE Band 41 (PC3) ULCA - [Ch. 41055 - 41490]	0.95		
LTE Band 41 (PC2) - [Ch. 41055 - 41490]	0.95		
LTE Band 41 (PC2) ULCA - [Ch. 41055 - 41490]	0.95		
LTE Band 48	0.86		
LTE Band 48 ULCA	0.86		
NR Band n71	0.99		
NR Band n12	0.99		
NR Band n14	1.04		
NR Band n26	1.06		
NR Band n5	1.04		
NR Band n70	0.97		
NR Band n66	0.95		
NR Band n2	1.02		
NR Band n25	1.02		
NR Band n30	1.04		
NR Band n7	0.97		
NR Band n41 (PC3) - [Ch. 518598]	0.84		
NR Band n41 (PC2) - [Ch. 518598]	0.84		
NR Band n41 (PC3) - [Ch. 528000]	0.84		
NR Band n41 (PC2) - [Ch. 528000]	0.84		
NR Band n48	0.83		
NR Band n77 DoD (PC3) - [Ch. 633334]	0.97		
NR Band n77 DoD (PC2) - [Ch. 633334]	0.97		
NR Band n77 (PC3) - [Ch. 650000]	0.91		
NR Band n77 (PC2) - [Ch. 650000]	0.91		
NR Band n77 (PC3) - [Ch. 662000]	0.93		
NR Band n77 (PC2) - [Ch. 662000]	0.93		

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Table 1-2
Antenna 2b

SAR_design_target Calculations			
Mode/Band	1g SAR [W/kg]		
	SAR_design_target	SAR_Design_limit	SAR_regulatory_limit
UMTS 1750	0.99	1.2 W/kg	1.6 W/kg
UMTS 1900	1.02		
LTE Band 4	0.99		
LTE Band 66	0.99		
LTE Band 2	1.02		
LTE Band 25	1.02		
LTE Band 30	0.95		
LTE Band 7	0.99		
LTE Band 7 ULCA	0.99		
LTE Band 41 (PC3) - [Ch. 39750 - 40620]	0.99		
LTE Band 41 (PC3) ULCA - [Ch. 39750 - 40620]	0.99		
LTE Band 41 (PC2) - [Ch. 39750 - 40620]	0.99		
LTE Band 41 (PC2) ULCA - [Ch. 39750 - 40620]	0.99		
LTE Band 41 (PC3) - [Ch. 41055 - 41490]	0.99		
LTE Band 41 (PC3) ULCA - [Ch. 41055 - 41490]	0.99		
LTE Band 41 (PC2) - [Ch. 41055 - 41490]	0.99		
LTE Band 41 (PC2) ULCA - [Ch. 41055 - 41490]	0.99		
LTE Band 48	0.99		
LTE Band 48 ULCA	0.99		
NR Band n70	0.99		
NR Band n66	0.95		
NR Band n2	0.99		
NR Band n25	0.99		
NR Band n30	0.95		
NR Band n7	0.97		
NR Band n41 (PC3) - [Ch. 518598]	0.84		
NR Band n41 (PC2) - [Ch. 518598]	0.84		
NR Band n41 (PC3) - [Ch. 528000]	0.81		
NR Band n41 (PC2) - [Ch. 528000]	0.81		
NR Band n48	0.86		
NR Band n77 DoD (PC3) - [Ch. 633334]	0.95		
NR Band n77 DoD (PC2) - [Ch. 633334]	0.95		
NR Band n77 (PC3) - [Ch. 650000]	0.95		
NR Band n77 (PC2) - [Ch. 650000]	0.95		
NR Band n77 (PC3) - [Ch. 662000]	0.88		
NR Band n77 (PC2) - [Ch. 662000]	0.88		

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Table 1-3
Antenna 3

SAR_design_target Calculations			
Mode/Band	1g SAR [W/kg]		
	SAR_design_target	SAR_Design_limit	SAR_regulatory_limit
UMTS 850	1.04	1.2 W/kg	1.6 W/kg
UMTS 1750	1.02		
UMTS 1900	1.02		
LTE Band 71	0.99		
LTE Band 12	0.99		
LTE Band 17	0.99		
LTE Band 13	1.02		
LTE Band 14	0.99		
LTE Band 26	1.04		
LTE Band 5	1.04		
LTE Band 5 ULCA	1.04		
LTE Band 4	1.02		
LTE Band 66	1.02		
LTE Band 2	1.02		
LTE Band 25	1.02		
LTE Band 30	0.97		
LTE Band 7	0.91		
LTE Band 7 ULCA	0.91		
LTE Band 41 (PC3) - [Ch. 39750 - 40620]	0.93		
LTE Band 41 (PC3) ULCA - [Ch. 39750 - 40620]	0.93		
LTE Band 41 (PC2) - [Ch. 39750 - 40620]	0.93		
LTE Band 41 (PC2) ULCA - [Ch. 39750 - 40620]	0.93		
LTE Band 41 (PC3) - [Ch. 41055 - 41490]	0.97		
LTE Band 41 (PC3) ULCA - [Ch. 41055 - 41490]	0.97		
LTE Band 41 (PC2) - [Ch. 41055 - 41490]	0.97		
LTE Band 41 (PC2) ULCA - [Ch. 41055 - 41490]	0.97		
LTE Band 48	0.93		
LTE Band 48 ULCA	0.93		
NR Band n71	0.97		
NR Band n12	0.99		
NR Band n14	1.02		
NR Band n26	1.02		
NR Band n5	0.99		
NR Band n70	1.02		
NR Band n66	0.97		
NR Band n2	0.99		
NR Band n25	0.99		
NR Band n30	0.97		
NR Band n7	0.88		
NR Band n41 (PC3) - [Ch. 518598]	0.91		
NR Band n41 (PC2) - [Ch. 518598]	0.91		
NR Band n41 (PC3) - [Ch. 528000]	0.86		
NR Band n41 (PC2) - [Ch. 528000]	0.86		
NR Band n48	0.84		
NR Band n77 DoD (PC3) - [Ch. 633334]	0.86		
NR Band n77 DoD (PC2) - [Ch. 633334]	0.86		
NR Band n77 (PC3) - [Ch. 650000]	0.91		
NR Band n77 (PC2) - [Ch. 650000]	0.91		
NR Band n77 (PC3) - [Ch. 662000]	0.88		
NR Band n77 (PC2) - [Ch. 662000]	0.88		

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Table 1-4
Antenna 4b

SAR_design_target Calculations			
Mode/Band	1g SAR [W/kg]		
	SAR_design_target	SAR_Design_limit	SAR_regulatory_limit
UMTS 1750	1.02	1.2 W/kg	1.6 W/kg
UMTS 1900	1.02		
LTE Band 4	1.02		
LTE Band 66	1.02		
LTE Band 2	1.02		
LTE Band 25	1.02		
LTE Band 30	0.99		
LTE Band 7	0.95		
LTE Band 7 ULCA	0.95		
LTE Band 41 (PC3) - [Ch. 39750 - 40620]	0.95		
LTE Band 41 (PC3) ULCA - [Ch. 39750 - 40620]	0.95		
LTE Band 41 (PC2) - [Ch. 39750 - 40620]	0.95		
LTE Band 41 (PC2) ULCA - [Ch. 39750 - 40620]	0.95		
LTE Band 41 (PC3) - [Ch. 41055 - 41490]	1.02		
LTE Band 41 (PC3) ULCA - [Ch. 41055 - 41490]	1.02		
LTE Band 41 (PC2) - [Ch. 41055 - 41490]	1.02		
LTE Band 41 (PC2) ULCA - [Ch. 41055 - 41490]	1.02		
LTE Band 48	0.97		
LTE Band 48 ULCA	0.97		
NR Band n70	0.97		
NR Band n66	0.99		
NR Band n2	0.99		
NR Band n25	0.99		
NR Band n30	0.99		
NR Band n7	0.95		
NR Band n41 (PC3) - [Ch. 518598]	0.86		
NR Band n41 (PC2) - [Ch. 518598]	0.86		
NR Band n41 (PC3) - [Ch. 528000]	0.84		
NR Band n41 (PC2) - [Ch. 528000]	0.84		
NR Band n48	0.83		
NR Band n77 DoD (PC3) - [Ch. 633334]	0.97		
NR Band n77 DoD (PC2) - [Ch. 633334]	0.97		
NR Band n77 (PC3) - [Ch. 650000]	0.97		
NR Band n77 (PC2) - [Ch. 650000]	0.97		
NR Band n77 (PC3) - [Ch. 662000]	0.97		
NR Band n77 (PC2) - [Ch. 662000]	0.97		

1.4 Bibliography

Report Type	Report Serial Number
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2. RF EXPOSURE LIMITS

2.1 Uncontrolled Environment

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

2.2 Controlled Environment

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

RF Exposure Limits for Frequencies Below 6 GHz

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

HUMAN EXPOSURE LIMITS		
	UNCONTROLLED ENVIRONMENT <i>General Population</i> (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT <i>Occupational</i> (W/kg) or (mW/g)
Peak Spatial Average SAR Head	1.6	8.0
Whole Body SAR	0.08	0.4
Peak Spatial Average SAR Hands, Feet, Ankle, Wrists, etc.	4.0	20

1. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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2.3 Time Averaging Windows for FCC Compliance

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

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

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3. VALIDATION TEST CASES

To validate the time averaging feature and demonstrate the compliance in Tx varying transmission conditions, the following transmission scenarios are covered in the TAS test:

- 1) Time-varying Tx power transmission: To prove that the algorithm accounts for Tx power variations in time accurately.
- 2) Antenna switching scenarios: To prove that the algorithm functions correctly during transitions in antenna.
- 3) Change in band: To prove that the algorithm functions correctly during transitions in bands.
- 4) Change in technology: To prove that the algorithm functions correctly during transitions in technology.
- 5) TDD/FDD Switch: To prove that the algorithm functions correctly during transitions between frequency division duplexing (FDD) and time division duplexing (TDD) configurations.
- 6) Call drop: To prove that the algorithm accounts for history of past Tx power transmissions accurately.
- 7) Linearity Validation: To validate linearity with TAS operation turned off.

The RF exposure is proportional to the Tx power for a SAR-characterized wireless device. Thus, feature validation in TAS can be effectively performed through conducted (for $f < 6\text{GHz}$) power measurement. Therefore, the compliance demonstration under dynamic transmission conditions and feature validation are done in conducted/radiated power measurement setup for transmission scenario 1 through 7.

Conducted power measurements will be used to validate all TAS test cases. In addition, single point SAR measurements will be performed to validate linearity.

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4. FCC MEASUREMENT PROCEDURES

This chapter provides the test plan and test procedure for validating Cellular TAS algorithm for sub-6 transmission. The 100 seconds time window for operating $f < 3\text{GHz}$ is used as an example to detail the test procedures in this chapter. The same test plan and test procedures described in this chapter apply to 100 seconds time window for operating $f \leq 3\text{GHz}$. The same test plan and test procedures described in this chapter apply to 60 seconds time window for operating $f \geq 3\text{GHz}$.

4.1 Test Configuration and Procedure for Test Case 1: Time-varying Tx power transmission via Conducted Power Measurements

Test Case 1a – Test Sequence A: Tx power is requested to be at P_{max} for a period of time (duration dependent on configuration being tested), followed by $0.5 \times P_{limit}$ for a period of time (duration dependent on configuration being tested).

Test Case 1b – Test Sequence B: Tx power is requested to be at 1mW (0dBm) for a period of time (duration dependent on configuration being tested), then at P_{max} for a period of time (duration dependent on configuration being tested).

Test Case 1c- Pseudo-Random Validation Sequence: Tx power is requested to vary with time. A unique pseudo-random sequence with 150 independent power requests according to RSS-102.SAR.MEAS is obtained based on the following formula:

$$P_{req} = P_{max,nom} \left(\frac{P_{limit,nom}}{P_{max,nom}} \right)^x$$

- P_{req} is the requested power in watts.
- x is a random value drawn from the Weibull distribution with shape and scale parameters of 2.0 and 0.8 respectively.
- The corresponding request durations are given by:

$$T_{req} = 2(1 + 2y)$$
- P_{req} is the duration of the power request in seconds.
- y is a uniform distributed random value between 0 and 1.

The details for generating test sequences A.B and Pseudo-random are described and listed in Appendix E.

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4.1.1 Configuration

Conducted power measurements shall be performed for at least one band per technology. The P_{limit} value associated with the chosen band should be several dB lower than the corresponding value of P_{max} . Whenever possible, the same band should not be repeated for different technologies. FDD, TDD, ENDC, and ULCA configurations shall be treated as separate technologies.

4.1.2 Procedure

Step 1: Measure P_{max} , measure P_{limit} for all the RATs and selected bands.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Callbox requests the EUT's Tx power according to time-varying test cases.

Step 5: Convert the measured conducted TX power from Step 4 into rolling time-averaged power (P_{avg}) for the n th step using equation 1a.

$$P_{avg}(n) = \frac{1}{M} \sum_{m=0}^{M-1} P_{meas}[n-m] \quad (1a)$$

Where 'M' is the total number of reporting periods per time-averaging window and 'm' is the index of the time-averaging window. The TAS algorithm is validated when P_{avg} is maintained less than or equal to P_{limit} .

In test cases where P_{limit} is not constant, the equation 1b below is used to calculate the normalized, rolling time-averaged power (P_{avg}).

$$P_{avg}(n) = \frac{1}{M} \sum_{m=0}^{M-1} \frac{P_{meas}[n-m]}{P_{limit}[n-m]} \quad (1b)$$

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW

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B. Make one time-averaged validation perspective plot containing

1. Rolling power average P_{avg} in mW
2. Power limit P_{limit} in mW

Step 7: repeat steps 2~6 for time varying test case 2 and pseudo-random test case.

The validation criteria are, at all times, the calculated rolling power average P_{avg} does not exceed P_{limit} .

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4.2 Test Configuration and Procedure for Test Case 2: Antenna Switching via Conducted Power Measurements

4.2.1 Configuration

When different P_{max} and P_{limit} values are associated with each transmitting antenna, consideration shall be given to the combinations of antennas and operating state(s) for which the P_{limit} values are several dB below the corresponding P_{max} values. Of these combinations, the performance of the TAS algorithm shall be validated when the EUT switches from the antenna with the highest P_{limit} value to that with the lowest.

Among RATs/bands supporting TX antenna switches, select the RAT/band with the highest P_{limit} difference between a pair of supported TX antennas.

A single test case covering antenna switch may be performed to display compliance.

4.2.2 Procedures

Step 1: Measure P_{max} measure P_{limit} for both selected antennas.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Request EUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, then request EUT's Tx power to be at maximum for at least one time window. Switch the radio link to second antenna selected. For the remaining time, continue callbox requesting EUT's TX power to be at maximum power at least one time window.

Step 5: Convert the measured conducted TX power from Step 4 into normalized rolling time-averaged power (P_{avg}) using equation 1b.

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW
- B. Make one time-averaged validation perspective plot containing
 1. Normalized total rolling power average P_{avg} in mW
 2. Normalized rolling power average P_{avg} in mW for each antenna/technology
 3. Normalized power limit P_{limit} in mW

The validation criteria are, at all times, the normalized total rolling power average P_{avg} does not exceed P_{limit} .

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4.3 Test Configuration and Procedure for Test Case 4: Change in Band via Conducted Power Measurements

4.3.1 Configuration

Conducted power measurements shall be performed to validate the TAS algorithm when the EUT switches between frequency bands with different P_{limit} values.

The TAS algorithm shall be validated for the following changes in frequency band:

- Among the frequency band configuration for which the P_{limit} values are several dB below the corresponding P_{max} values, changing from one frequency band to another with a lower P_{limit} value.
- If applicable, changing from an frequency for which the TAS algorithm is transparent $P_{limit} \geq P_{max}$, to one for which P_{limit} is several dB below P_{max} .

A single test case covering frequency band switch may be performed to display compliance.

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4.3.2 Procedure

Step 1: Measure P_{max} , measure P_{limit} for both selected bands.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Request EUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, then request EUT's Tx power to be at maximum for at least one time window. Switch the radio link to second selected band. For the remaining time, continue callbox requesting EUT's TX power to be at maximum power at least one time window.

Step 5: Convert the measured conducted TX power from Step 4 into normalized rolling time-averaged power (P_{avg}) using equation 1b.

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW
- B. Make one time-averaged validation perspective plot containing
 1. Normalized total rolling power average P_{avg} in mW
 2. Normalized rolling power average P_{avg} in mW for each antenna/technology
 3. Normalized power limit P_{limit} in mW

The validation criteria are, at all times, the normalized total rolling power average P_{avg} does not exceed P_{limit} .

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4.4 Test Configuration and Procedure for Test Case 5: Change in Technology via Conducted Power Measurements

4.4.1 Configuration

Conducted power measurements shall be performed to validate the TAS algorithm when the EUT switches between technologies with different P_{limit} values.

Among the technology configuration for which the P_{limit} values are several dB below the corresponding P_{max} values, changing from one technology to another with a lower P_{limit} value.

4.4.2 Procedures

Step 1: Measure P_{max} , measure P_{limit} for both selected technologies.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Request EUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, then request EUT's Tx power to be at maximum for at least one time window. Switch the radio link to second technology/band selected. For the remaining time, continue callbox requesting EUT's TX power to be at maximum power at least one time window.

Step 5: Convert the measured conducted TX power from Step 4 into normalized rolling time-averaged power (P_{avg}) using equation 1b.

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW
- B. Make one time-averaged validation perspective plot containing
 1. Normalized total rolling power average P_{avg} in mW
 2. Normalized rolling power average P_{avg} in mW for each antenna/technology
 3. Normalized power limit P_{limit} in mW

The validation criteria are, at all times, the normalized total rolling power average P_{avg} does not exceed P_{limit} .

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4.5 Test Configuration and Procedure for Test Case 6: TDD/FDD Switch Configurations via Conducted Power Measurements

4.5.1 Configuration

Conducted power measurements shall be performed to validate the TAS algorithm when the EUT switches between TDD and FDD configurations with different P_{limit} values, both of which should be several dB lower than the corresponding P_{max} values.

4.5.2 Procedure

Step 1: Measure P_{max} , measure P_{limit} for both selected technologies with TDD and FDD.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Request EUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, then request EUT's Tx power to be at maximum for at least one time window. Switch the radio link to second technology/band selected. For the remaining time, continue callbox requesting EUT's TX power to be at maximum power at least one time window.

Step 5: Convert the measured conducted TX power from Step 4 into normalized rolling time-averaged power (P_{avg}) using equation 1b.

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW
- B. Make one time-averaged validation perspective plot containing
 1. Normalized total rolling power average P_{avg} in mW
 2. Normalized rolling power average P_{avg} in mW for each antenna/technology
 3. Normalized power limit P_{limit} in mW

The validation criteria are, at all times, the normalized total rolling power average P_{avg} does not exceed P_{limit} .

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4.6 Test Configuration and Procedure for Test Case 8: Call Drop via Conducted Power Measurements

4.6.1 Configuration

Conducted power measurements shall be performed to validate the TAS algorithm during dropped connections to ensure the algorithm is able to account for previous connection states.

Only one test is required with one of the configurations for which P_{limit} is below P_{max} .

4.6.2 Procedure

Step 1: Measure P_{max} , measure P_{limit} for the selected technology.

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link with callbox in the selected RAT/band.

Step 4: Request EUT's Tx power at 0 dBm for at least one time window specified for the selected technology/band, then drop the call for ~10 seconds. Re-establish another call in the same radio configuration at first link. For the remaining time, continue callbox requesting EUT's Tx power to be at maximum power at least one time window.

Step 5: Convert the measured conducted TX power from Step 4 into rolling time-averaged power (P_{avg}) for the nth step using equation 1a.

Step 6: Plot results.

- A. Make one power perspective plot containing
 1. Requested power
 2. Measured instantaneous conducted TX power
 3. Power limit P_{limit} in mW
 4. Capable maximum TX power P_{max} in mW
- B. Make one time-averaged validation perspective plot containing
 1. Rolling power average P_{avg} in mW
 2. Power limit P_{limit} in mW

The validation criteria are, at all times, the calculated rolling power average P_{avg} does not exceed P_{limit} .

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4.7 Technology Specific Validations

4.7.1 ENDC

ENDC operation is validated by performing a single test sequence. A transition is initiated from cellular operation at all down bits/lower power configuration + NR requesting Pmax to cellular requesting Pmax + NR requesting Pmax to cellular requesting Pmax + NR at all down bits / lower power configuration. The configurations and operating states selected for single point SAR measurements shall match those selected for conducted power measurements and for SAR compliance assessment. This requirement facilitates the correlation of the single point SAR results with both the conducted power measurements and the SARtarget results in the RF exposure technical brief.

4.7.2 ULCA

ULCA operation is validated by performing a single test sequence. A transition is initiated from PCC at 0dBm + SCC at Pmax to PCC at Pmax + SCC at 0dBm to PCC at Pmax + SCC at Pmax."

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4.8 Test Configuration and Procedure for Test Case 1: Time-varying TX power transmission via Single Point SAR Measurements

4.8.1 Configuration

Single point SAR measurements shall be performed to validate the TAS algorithm; however, compared with the requirements for conducted power measurements, fewer test cases are required:

- Single point SAR measurements need be performed only for changes in requested power.
- To account for linearity, single point SAR measurements shall be performed on each antenna for at least one frequency. If possible, each antenna should be validated using a different frequency.
- Single point SAR measurements shall be performed only for configurations involving a single transmitter.

The configurations and operating states selected for single point SAR measurements shall match those selected for conducted power measurements and for SAR compliance assessment. This requirement facilitates the correlation of the single point SAR results with both the conducted power measurements and the SAR_{target} results in the RF exposure technical brief.

4.8.2 Procedure

Step 1: Perform area scan with DUT set to transmit at a fixed output of P_{limit} , and callbox set to request maximum power for all RATs and selected bands. Measure $pointSAR$ at peak location of the area scan. This $pointSAR$ value corresponds to $pointSAR$ at the measured P_{limit}

Step 2: Apply TAS on EUT to initialize time-averaging behavior.

Step 3: Establish radio link in selected radio configuration.

Step 4: Measure and record $pointSAR$ versus time at peak location of the area scan. Configure callbox to request the DUT's Tx power accordingly to pre-defined test sequences.

Step 5: Convert the measured SAR into time-averaged SAR.

Convert the instantaneous measured SAR from Step 4 into 1gSAR value. Perform the running time average to 1gSAR to determine time-averaged value versus time as follows,

$$1gSAR \text{ or } 10gSAR(t) = \frac{pointSAR(t)}{PointSAR_P_{limit}} * SAR_{target,nom} \quad (2a)$$

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Step 6: Plot results.

- A. Make one SAR perspective plot containing
1. Calculated time-averaged 1gSAR or 10gSAR
 2. $SAR_{target,nom}$ and SAR_{target}
($SAR_{target} = SAR_{target,nom} \times 10^{1dB \text{ uncertainty}/10}$)
 3. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
 4. Maximum time-averaged 1gSAR or 10gSAR value
 5. Measured instantaneous single point SAR

Step 7: Repeat steps 2~6 with the pre-defined test sequence 2

Step 8: Repeat steps 2~6 with the pre-defined pseudo-random test sequence

Step 9: Repeat steps 2~6 for all the selected technologies and bands

The validation criteria are, at all times, the calculated time-averaged 1gSAR or 10gSAR versus time shall not exceed SAR_{target}

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5 DYNAMIC BUDGET VALIDATION

This DUT supports dynamic budget sharing for Cellular technologies. The SAR budget for cellular technologies is allocated dynamically over time considering usage statistics and consumed SAR from all active radios. The device total exposure ratio (TER) is always maintained less than 1.

To validate the dynamic budgeting algorithm, the following configurations are applicable:

- 1) Cellular standalone -> Cellular + WLAN -> WLAN standalone
 - a) Pmax will be requested for this test scenario in all operating conditions. The test time for each connection will be sufficient to allow steady state to be reached.
- 2) Sub-6GHz Cellular standalone -> Sub-6GHz Cellular + FR2
 - a) Pseudo-random time-varying TX power will be used for this test scenario to display budget adjustment activity for varying Tx power values. The determination of power values will be outlined in the validation report.
- 3) Dynamic budget mode -> Static budget mode
 - a) This test case will display the transition between a mode that uses the dynamic budget algorithm to a mode that uses a fixed budget implementation.
 - b) Pmax will be requested for this test scenario in all operating conditions. The test time for each connection will be sufficient to allow steady state to be reached.

These cases are validated using log information collected from the application processor (AP). Only validation cases applicable for the device under test will be performed.

5.1.1 Test Exclusion

FR2 is not supported in this DUT, which excludes test case 2 for dynamic budget validation.

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5.1.2 Dynamic Budget Validation Test

Test cases 1 and 3 reference the Dynamic Budget Validation assessment listed below in Table 5-1

Table 5-1 TAS Parameters setting for Dynamic Budget Validation Test Case

Test Scenario	Technology/Band	Core/Antenna	Plimit [dBm]	Time Window
Dynamic Budget Validation Test	LTE Band 30	Ant 4b	19.20	100s
	LTE Band 30	Ant 4b	19.20	100s
	2.4 GHz Wi-Fi	Core 0 (Ant 4a)	19.25	
	2.4 GHz Wi-Fi	Core 0 (Ant 4a)	19.25	30s

Test result for Dynamic Budget Validation Test Case

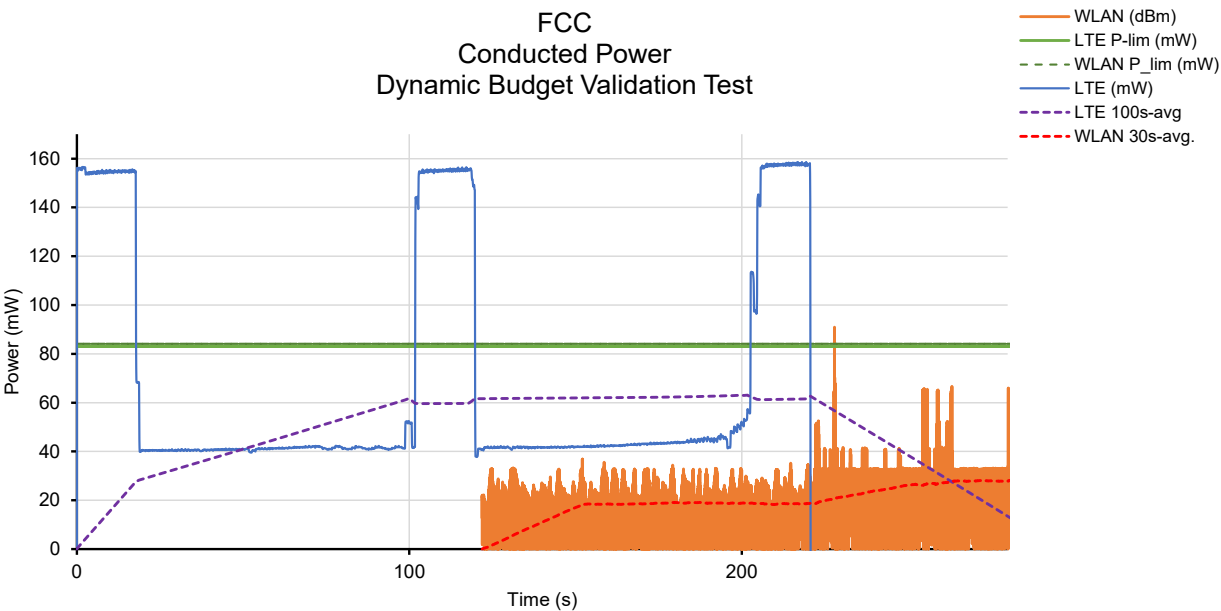


Figure 5-1(a) Dynamic Budget Validation Time-Averaged conducted TX power

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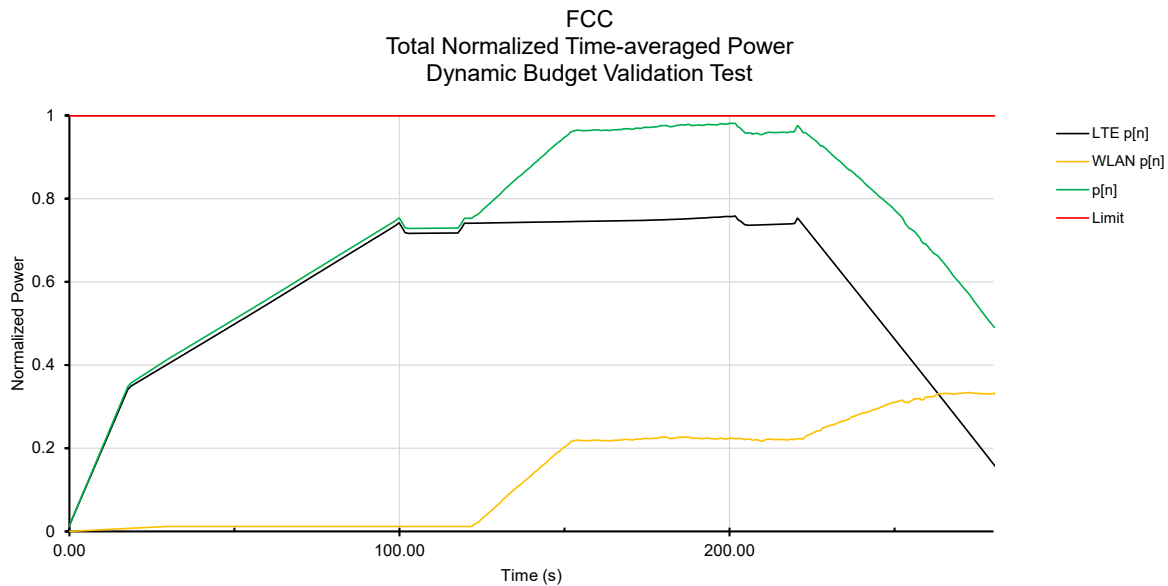


Figure 5-1(b) Dynamic Budget Validation Normalized Time-averaged conducted power

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6 MEASUREMENT TEST SETUP

6.1 Conducted Measurement

LTE test setup

The Rohde & Schwarz CMW500 callbox was used in this test. The test setup schematic is shown in Figure 6-1(a) (Appendix D – Test Setup Photo 1) for measurements with a single antenna of DUT and in Figure 6-1(b) (Appendix D – Test Setup Photo 3) for measurements involving antenna switch. For single antenna measurement, one port (RF1 COM) of the callbox is connected to the RF port of the DUT using a directional coupler. For technology/band switch measurement, one port (RF1 COM) of the callbox used for signaling two different technologies is connected to a combiner, which is in turn connected to a directional coupler. The other end of the directional coupler is connected to a splitter to connect to two RF ports of the DUT corresponding to the two antennas of interest. In the setups, power meter is used to tap the directional coupler for measuring the conducted output power of the DUT. For all LTE conducted tests, only RF1 COM port of the callbox is used to communicate with the DUT.

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

Sub6 NR test setup:

The Keysight UXM 5G callbox was used in this test. The test setup schematic is the same as the LTE Test Setup shown in Figure 6-1(a) (Appendix D – Test Setup Photo 2). One port of the callbox is connected to the RF port of the DUT using a directional coupler. In the setup, the power meter is used to tap the directional coupler for measuring the conducted output power of the DUT.

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

LTE+Sub6 NR test setup:

LTE conducted port and Sub6 NR conducted port are different on this EUT, therefore, the LTE and Sub6 NR signals for power meter measurement are performed on separate paths as shown below in Figure 6-1(c) (Appendix D – Test Setup Photo 4).

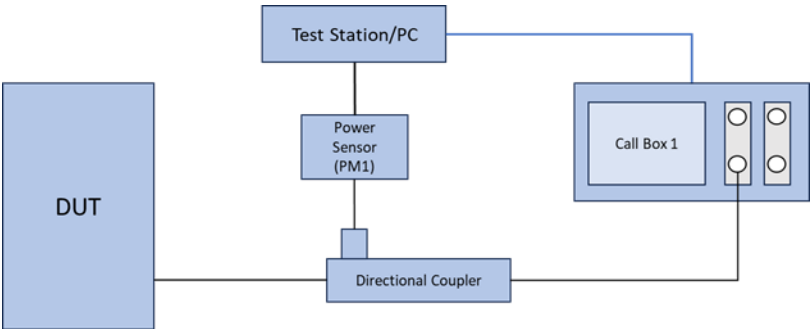
All the path losses from RF port of DUT to the callbox RF COM port and to the power meter are calibrated and automatically entered as offsets in the callbox and the power meter via test scripts on the PC used to control callbox and power meter.

LTE+LTE Inter-band ULCA test setup:

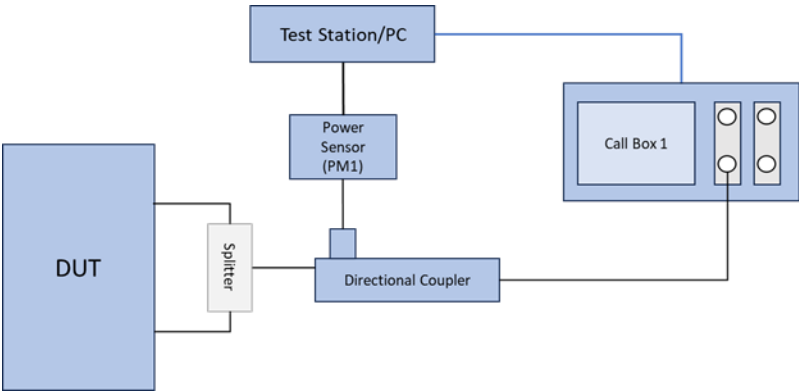
LTE conducted PCC port and LTE conducted SCC conducted port are different on this EUT, therefore, the LTE PCC and LTE SCC signals for power meter measurement are performed on separate paths as shown below in Figure 6-1d (Appendix D – Test Setup Photo 5).

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

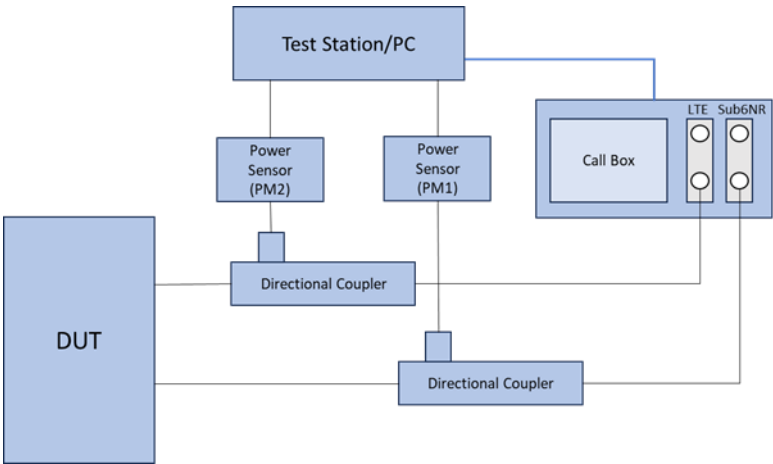
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(a) Appendix D – Test Setup Photo 1 and 2

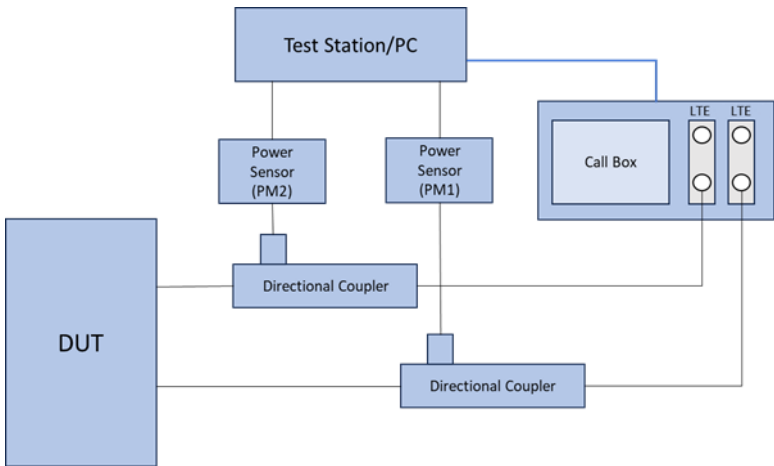


(b) Appendix D – Test Setup Photo 3



(c) Appendix D – Test Setup Photo 4

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(d) Appendix D – Test Setup Photo 5

Figure 6-1
Conducted power measurement setup

Both the callbox and power meter are connected to the PC using ethernet cables. Test scripts are custom made for automation, and the test duration set in the test scripts is 500 seconds.

For time-varying Tx power measurement, the PC runs the 1st test script to send GPIB commands to control the callbox’s requested power versus time, while at the same time to record the conducted power measured at DUT RF port using the power meter. The commands sent to the callbox to request power are:

- 0dBm for 100 seconds
- test sequence A, test sequence B, or pseudo-random test sequence (defined in Section 4.1 and generated in Section 4.2.1), for 100 seconds.
- stay at the last power level of test sequence A, test sequence B, or pseudo-random sequence for the remaining time.

Power meter readings are periodically recorded every 100ms. A running average of this measured Tx power over 100 seconds is performed in the post-data processing to determine the 100s-time averaged power.

For call drop, technology/band/antenna switch, and device state switch tests, after the call is established, the callbox is set to request the DUT’s Tx power at 0dBm for 100 seconds while simultaneously starting the 2nd test script runs at the same time to start recording the Tx power measured at DUT RF port using the power meter. After the initial 100 seconds since starting the Tx power recording, the callbox is set to request maximum power from the DUT for the rest of the test. Note that the call drop/re-establish, or technology/band/antenna switch or device state switch is manually performed when the Tx power of DUT is at the time-averaged reduced level. See Section 4.2-4.8 for detailed test procedure of call drop test, technology/band/antenna switch test and device state switch test.

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SAR Measurement

The measurement setup is similar to normal SAR measurements as described in the RF Exposure Test Report. The difference in SAR measurement setup for time averaging feature validation is that the callbox is signaling in close loop power control mode (instead of requesting maximum power in open loop control mode) and callbox is connected to the PC using ethernet so that the test script executed on PC can send commands to control the callbox's requested power over time (test sequence). The same test script used in conducted setup for time-varying Tx power measurements is also used in this section for running the test sequences during SAR measurements, and the recorded values from the disconnected power meter by the test script were discarded.

As mentioned in Section 4.8, for DUT to follow TPC command sent from the callbox wirelessly, the "path loss" between callbox antenna and the DUT needs to be very well calibrated. Since the SAR chamber is in uncontrolled environment, precautions must be taken to minimize the environmental influences on "path loss".

The DUT is placed in worst-case position according to Table 7-2.

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7 TEST CONFIGURATIONS (FREQ < 6GHZ)

7.1 WWAN Sub6 Transmission

The $P_{limit,nom}$ values for technologies and bands supported by EUT are derived in RF Exposure report Power Level Summary Table and summarized in Table 7-1. Note: all $P_{limit,nom}$ power levels entered in Table 7-1 correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes.

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

Exposure Scenario:	Ant 1	Ant 2b	Ant 3	Ant 4b
Averaging Volume:	1g	1g	1g	1g
Test Distance:	5 mm	5 mm	5 mm	5 mm
OBD:	1, Body	1, Body	1, Body	1, Body
Technology/Band	P_{limit} (Inclusive of Total Device Uncertainty)	P_{max} (Max Allowed Power)	P_{limit} (Inclusive of Total Device Uncertainty)	P_{max} (Max Allowed Power)
UMTS 850	24.00	24.70	N/A	N/A
UMTS 1750	21.80	25.70	20.30	25.70
UMTS 1900	18.80	24.20	20.50	24.20
LTE Band 71	24.00	24.70	N/A	N/A
LTE Band 12	24.00	24.70	N/A	N/A
LTE Band 17	24.00	24.70	N/A	N/A
LTE Band 13	24.00	24.70	N/A	N/A
LTE Band 14	24.00	24.70	N/A	N/A
LTE Band 26	24.00	24.70	N/A	N/A
LTE Band 5	24.00	24.70	N/A	N/A
LTE Band 5 ULCA	24.00	24.70	N/A	N/A
LTE Band 4	21.80	25.70	20.30	25.70
LTE Band 66	21.80	25.70	20.30	25.70
LTE Band 2	18.80	24.20	20.50	24.20
LTE Band 25	18.80	24.20	20.50	24.20
LTE Band 30	20.50	23.70	20.50	24.20
LTE Band 7	18.30	24.20	20.60	24.20
LTE Band 7 ULCA	18.3	24.2	20.6	24.2
LTE Band 41 (PC3) - [Ch. 39750 - 40620]	18.4	23.7	21.0	23.7
LTE Band 41 (PC3) ULCA - [Ch. 39750 - 40620]	18.4	23.7	21.0	23.7
LTE Band 41 (PC2) - [Ch. 39750 - 40620]	18.4	25.1	21.0	25.1
LTE Band 41 (PC2) ULCA - [Ch. 39750 - 40620]	18.4	24.6	21.0	24.6
LTE Band 41 (PC3) - [Ch. 41055 - 41490]	18.4	23.7	21.0	23.7
LTE Band 41 (PC3) ULCA - [Ch. 41055 - 41490]	18.4	23.7	21.0	23.7
LTE Band 41 (PC2) - [Ch. 41055 - 41490]	18.4	25.1	21.0	25.1
LTE Band 41 (PC2) ULCA - [Ch. 41055 - 41490]	18.4	24.6	21.0	24.6
LTE Band 48	17.3	18.9	20.9	23.0
LTE Band 48 ULCA	17.3	18.9	20.9	23.0
NR Band n71	24.00	24.70	N/A	N/A
NR Band n12	24.00	24.70	N/A	N/A
NR Band n14	24.00	24.70	N/A	N/A
NR Band n26	24.00	24.70	N/A	N/A
NR Band n5	24.00	24.70	N/A	N/A
NR Band n70	21.80	25.70	20.30	25.70
NR Band n66	21.80	25.70	20.30	25.70
NR Band n2	18.80	24.20	20.50	24.20
NR Band n25	18.80	24.20	20.50	24.20
NR Band n30	20.50	23.70	20.50	24.20
NR Band n7	18.30	24.20	20.60	24.20
NR Band n41 (PC3) - [Ch. 518598]	18.40	28.70	21.00	28.70
NR Band n41 (PC2) - [Ch. 518598]	18.40	28.70	21.00	28.70
NR Band n41 (PC3) - [Ch. 528000]	18.40	28.70	21.00	28.70
NR Band n41 (PC2) - [Ch. 528000]	18.40	28.70	21.00	28.70
NR Band n48	17.30	20.90	20.90	25.00
NR Band n77 DoD (PC3) - [Ch. 633334]	21.20	25.00	19.80	25.00
NR Band n77 DoD (PC2) - [Ch. 633334]	21.20	25.00	19.80	25.00
NR Band n77 (PC3) - [Ch. 650000]	20.70	25.00	20.50	25.00
NR Band n77 (PC2) - [Ch. 650000]	20.70	25.00	20.50	25.00
NR Band n77 (PC3) - [Ch. 662000]	19.50	25.00	20.10	25.00
NR Band n77 (PC2) - [Ch. 662000]	19.50	25.00	20.10	25.00

Note all $P_{limit,nom}$ and maximum tune up output power $P_{max,nom}$ levels entered in above Table correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes (for e.g., LTE TDD).

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Note: The target powers listed in Table 7-1 for Plim account for the total device uncertainty, while the Pmax values include the specified tolerance.

The selected technologies/bands for testing time-varying test sequences are highlighted in yellow in Table 7-1.

The radio configurations used in time-averaged SAR validation test for selected technologies, bands, and antennas are listed in Table 7-2. The corresponding worst-case radio configuration 1gSAR values for selected technology/band/device state are extracted from RF exposure validation report and are listed in Table 7-1.

The $P_{limit,nom}$ for all the selected radio configurations are listed in below Table 7-2. $P_{max,nom}$ was also used for radio configurations selected for testing time-varying Tx power transmission scenarios in order to generate test sequences following the test procedures in Section 4.1

Table 7-2
Radio configurations selected for TAS test

Test Case #	Test Scenario	Tech	Band	Antenna	OPS	Channel	Frequency [MHz]	Test Configurations	SAR Exposure Scenario	Part 1 Worst Case Measured SAR at Plimit [W/kg]	Plimit, nom [dBm]	Pmax, nom [dBm]
1a	Time-varying Tx Power: Sequence A	LTE FDD	66	3	1	132322	1745	QPSK 1/50/20 MHz BW	Top Edge, 5mm	1.040	17.1	25.0
1b	Time-varying Tx Power: Sequence B	WCDMA	5	3	1	4183	836.6	RMC -	Back Side, 5mm	0.809	23.0	25.0
		LTE FDD	66	3	1	132322	1745	QPSK 1/50/20 MHz BW	Top Edge, 5mm	1.040	17.1	25.0
		LTE TDD	48	4b	1	56207	3646.7	QPSK 1/50/20 MHz BW	Top Edge, 5mm	1.030	18.4	20.8
		NR FR1 FDD	n25 / SA	1	1	376500	1882.5	DFT-S-OFDM, QPSK 1/1/40 MHz BW	Bottom Edge, 5mm	0.861	18.1	23.5
		NR FR1 TDD	n48 / SA	1	1	641666	3624.99	DFT-S-OFDM, QPSK 1/1/40 MHz BW	Bottom Edge, 5mm	0.853	15.7	19.9
1c	Time-varying Tx Power: Pseudo-Random Sequence	LTE FDD	66	3	1	132322	1745	QPSK 1/50/20 MHz BW	Top Edge, 5mm	1.040	17.1	25.0
2	Antenna Switching	LTE	12	3	1	23095	707.5	QPSK 1/25/10 MHz BW	Back Side, 5mm	0.893	23.7	25.0
			7	1	1	21100	2535	QPSK 1/50/20 MHz BW	Back Side, 5mm	1.060	17.5	23.5
3	Change in Band/Frequency	LTE	66	1	1	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 5mm	0.901	20.9	25.0
			25		1	26365	1882.5	QPSK 1/50/20 MHz BW	Bottom Edge, 5mm	0.822	18.1	23.5
4	Change in Technology	LTE	71	3	1	133297	680.5	QPSK 1/50/20 MHz BW	Back Side, 5mm	0.861	23.1	25.0
		WCDMA	4	4b	1	1412	1732.4	RMC -	Top Edge, 5mm	0.691	17.6	25.0
5	TDD/FDD Switch	LTE FDD	66	1	1	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 5mm	0.901	20.9	25.0
		LTE TDD	41A PC3		1	40620	2593	QPSK 1/50/20 MHz BW	Bottom Edge, 5mm	1.020	17.5	23.0
6	Call Drop	LTE FDD	30	3	1	27710	2310	QPSK 1/25/10 MHz BW	Back Side, 5mm	1.070	16.7	22.2
7	Time-varying Tx Power: EN-DC Same Time Window	LTE	5	3	1	20525	836.5	QPSK 1/25/10 MHz BW	Back Side, 5mm	0.891	23.0	25.0
		NR FR1	n66 NSA	4b	1	349000	1745	DFT-S-OFDM, QPSK 1/1/40 MHz BW	Top Edge, 5mm	1.020	17.5	25.0
8	Time-varying Tx Power: Inter-Band ULCA	LTE PCC	5	1	1	20525	836.5	QPSK 1/25/10 MHz BW	Back Side, 5mm	0.898	23.5	24.0
		LTE SCC	66	2b	1	132322	1745	QPSK 1/50/20 MHz BW	Bottom Edge, 5mm	0.983	19.5	25.0

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8 CONDUCTED TX CASES

8.1 Scenario 1: Change in Requested Power

In this scenario, the TAS algorithm is tested under dynamic power test sequences. The test sequences A, B, and Pseudo-Random are shown and tabulated in Appendix E. All of the test cases for this scenario are relegated in Table 7-2, and the test procedure follows section 4.1.2. The measurement setup is shown in Figure 5-1. The following details will demonstrate case-by-case to show how the TAS algorithm behaves for each RAT.

The test case for 3G WCDMA are conducted under WCDMA Band 5, the test cases for 4G LTE are conducted under LTE bands B66 and B48, and the test cases for 5G NR are conducted under NR bands n25 and n48. The corresponding detailed test procedure is described in section 4.1.2. For the figure set of each case, the first figure demonstrates the DUT's instantaneous conducted TX power, the requested power over time, P_{limit} , and P_{max} . The second figure illustrates the corresponding rolling average power over time. For all test cases. The time-averaged SAR does not exceed the FCC limit.

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WCDMA Band 5, Antenna 3

Test result for Test Sequence B

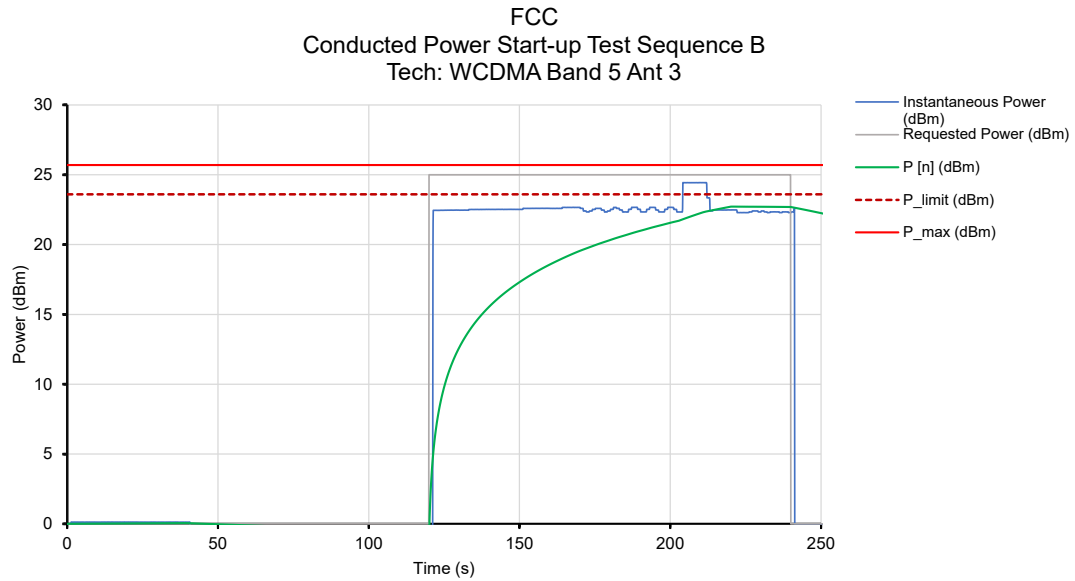


Figure 8-1: Time-averaged conducted TX power over time for Changes in Power case (WCDMA Band 5 – Test Sequence B)

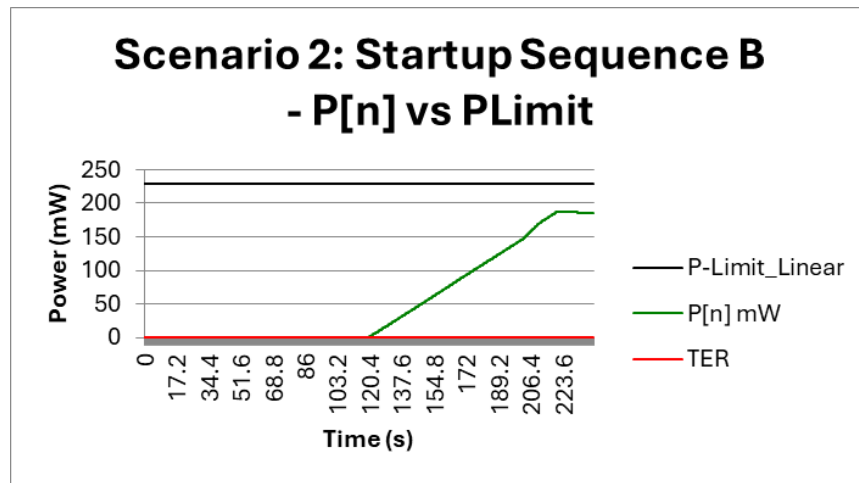


Figure 8-2: Time-averaged Power for Changes in Power case (WCDMA Band 5 – Test Sequence B)

	mW
Plimit (Plimit,nom with uncertainty)	229.1
Max P[n]	187.1
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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LTE Band 66, Antenna 3

Test result for Test Sequence A

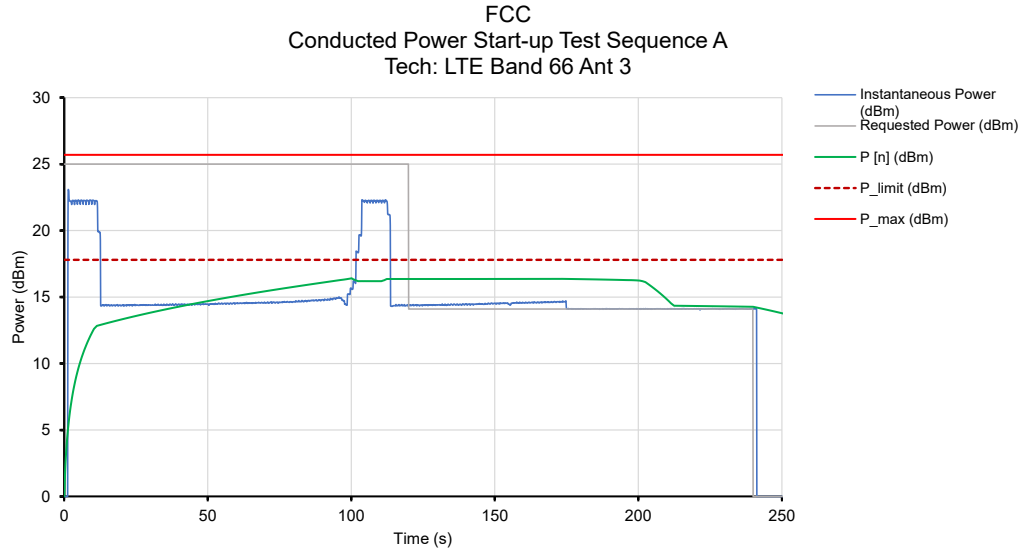


Figure 8-3: Time-averaged conducted TX power over time for Changes in Power case (LTE Band 66 – Test Sequence A)

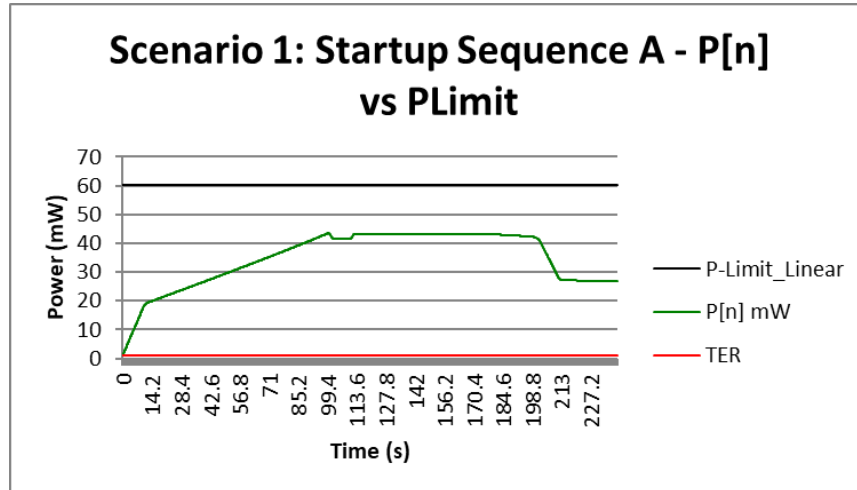


Figure 8-4: Time-averaged Power for Changes in Power case (LTE Band 66 – Test Sequence A)

	mW
Plimit (Plimit,nom with uncertainty)	60.3
Max P[n]	43.7
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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Test result for Test Sequence B

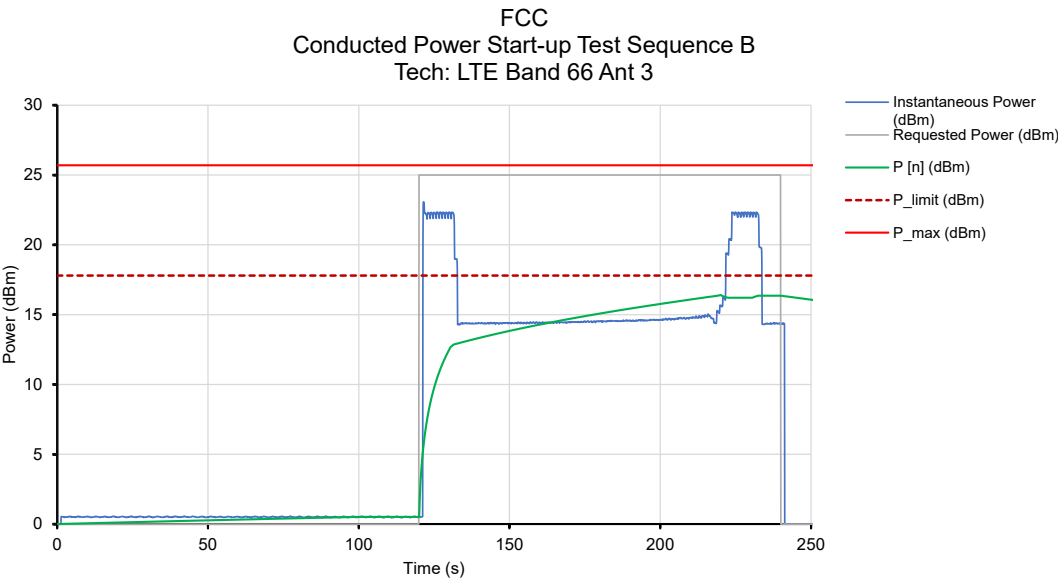


Figure 8-5: Time-averaged conducted TX power over time for Changes in Power case (LTE Band 66 – Test Sequence B)

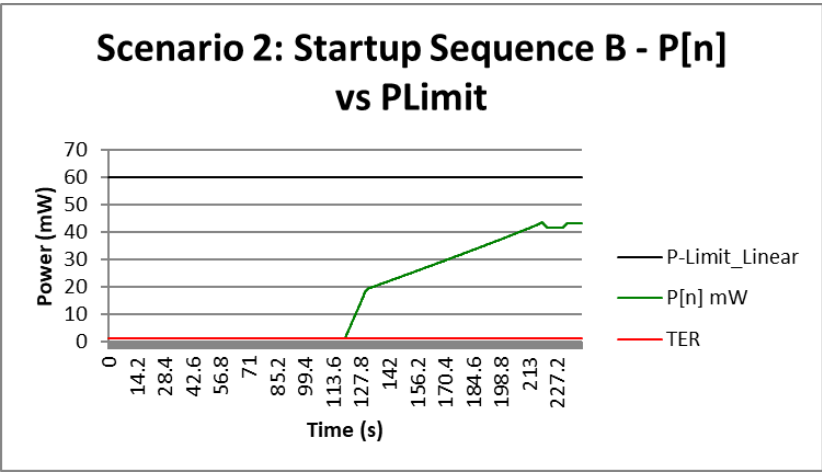


Figure 8-6: Time-averaged Power for Changes in Power case (LTE Band 66 – Test Sequence B)

	mW
Plimit (Plimit,nom with uncertainty)	60.3
Max P[n]	43.7
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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Test result for Test Sequence Pseudo-Random

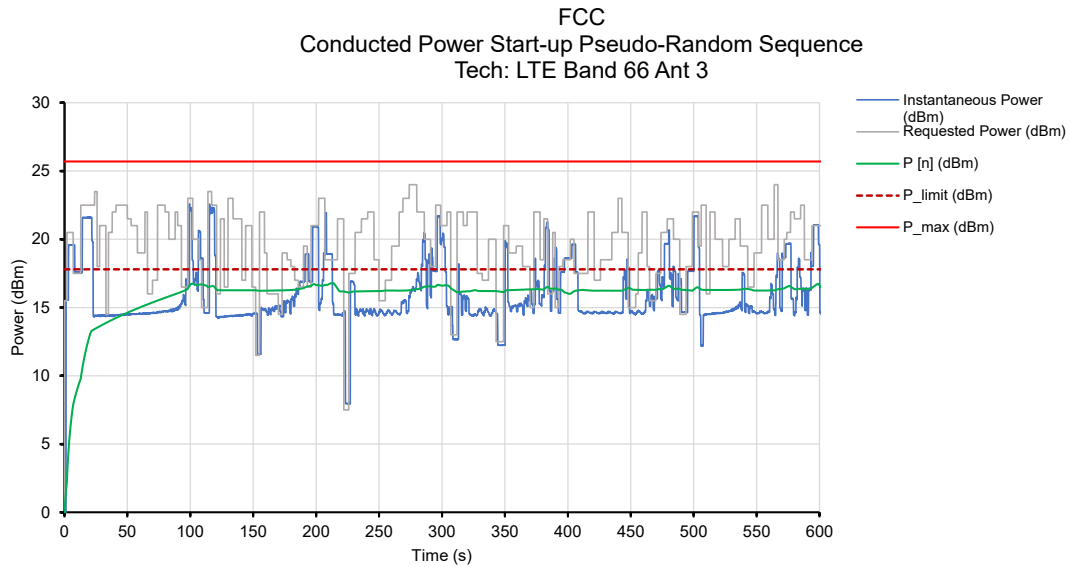


Figure 8-7: Time-averaged conducted TX power over time for Changes in Power case (LTE Band 66 – Pseudo-Random Test Sequence)

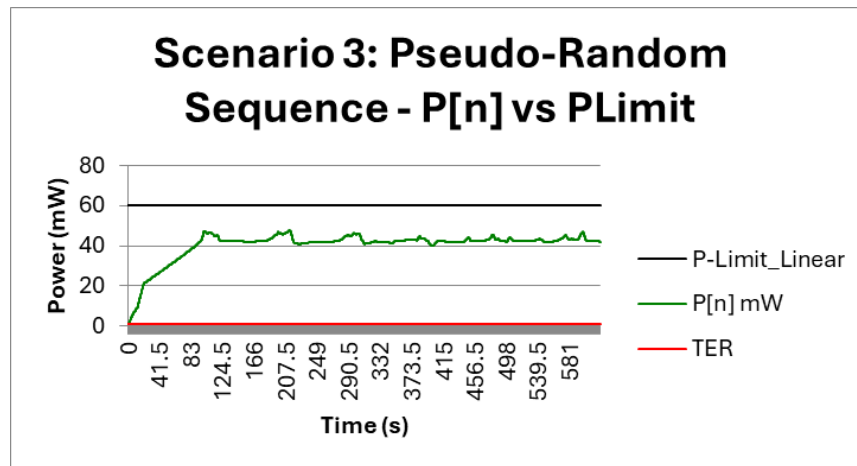


Figure 8-8: Time-averaged Power for Changes in Power case (LTE Band 66 – Pseudo-Random Test Sequence)

	mW
Plimit (Plimit,nom with uncertainty)	60.3
Max P[n]	43.9
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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LTE Band 48, Antenna 4b

Test result for Test Sequence B

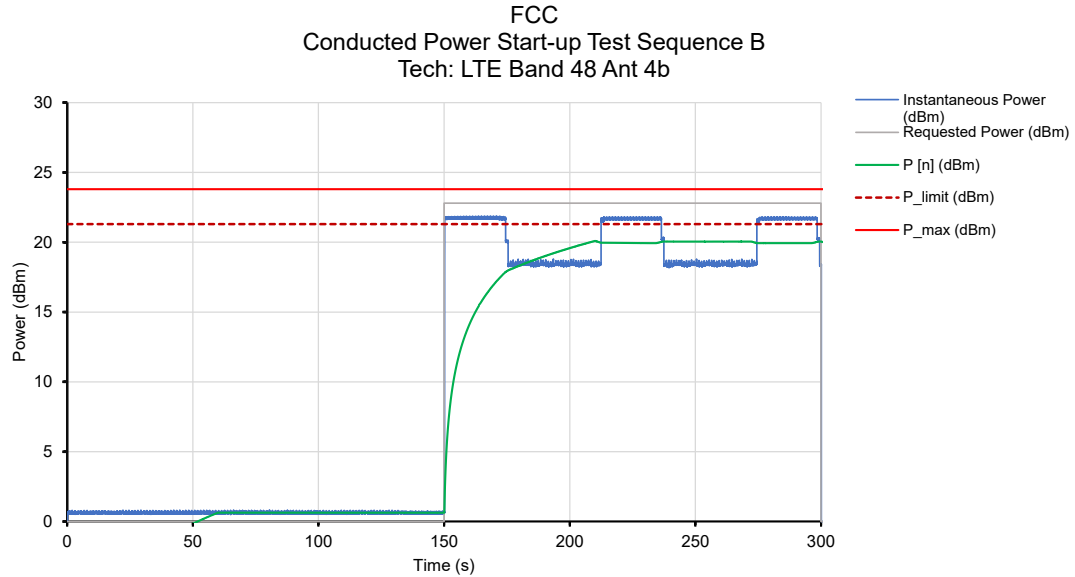


Figure 8-9: Time-averaged conducted TX power over time for Changes in Power case (LTE Band 48 – Test Sequence B)

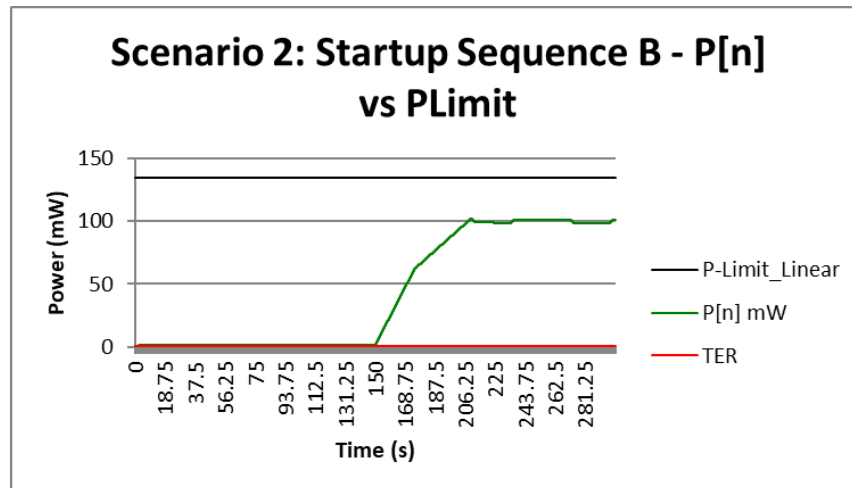


Figure 8-10: Time-averaged Power for Changes in Power case (LTE Band 48 – Test Sequence B)

	mW
Plimit (Plimit,nom with uncertainty)	134.9
Max P[n]	115.8
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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NR n25 SA, Antenna 1

Test result for Test Sequence B

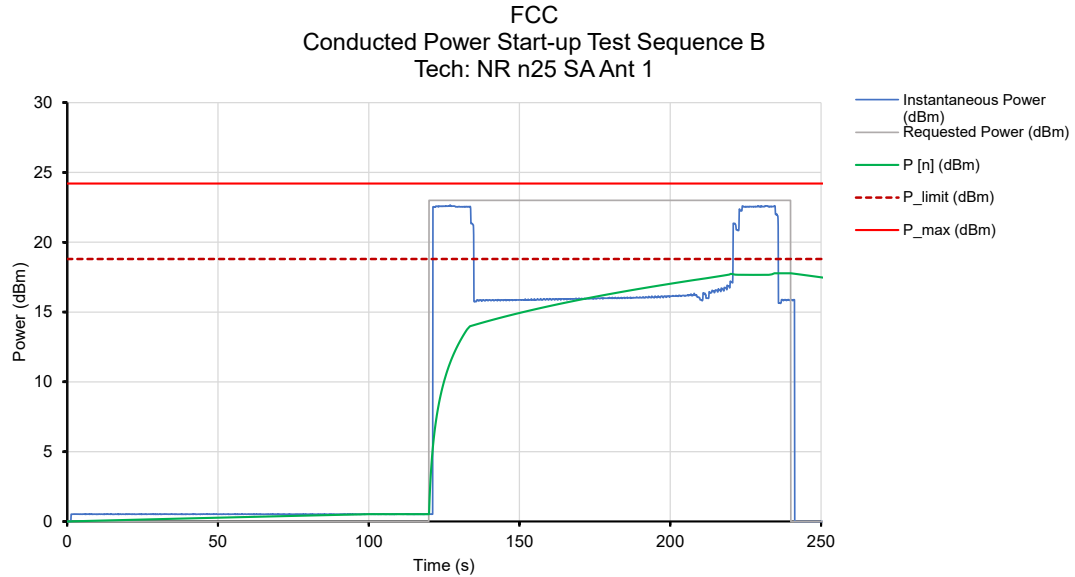


Figure 8-11: Time-averaged conducted TX power over time for Changes in Power case (NR n25 SA – Test Sequence B)

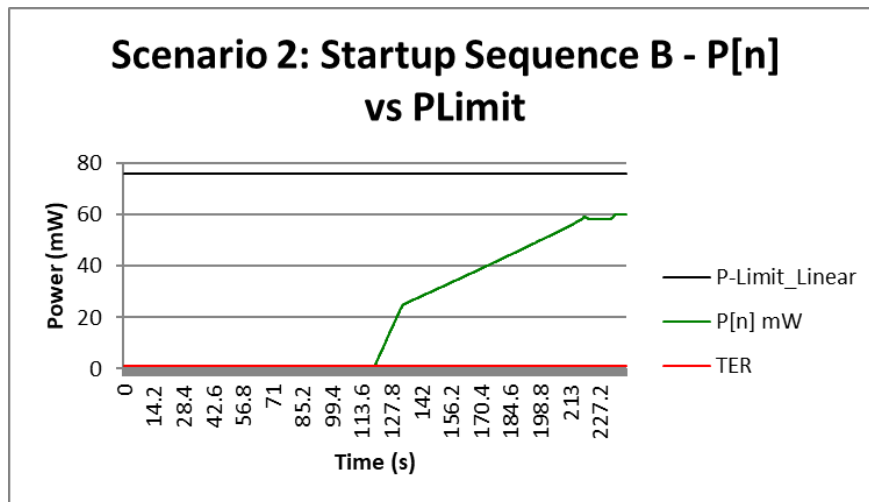


Figure 8-12: Time-averaged Power for Changes in Power case (NR n25 SA – Test Sequence B)

	mW
Plimit (Plimit,nom with uncertainty)	75.9
Max P[n]	60.0
Validation: $P[n] \leq P_{limit}$ for all n, that is for every time step associated with the test	

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