TAS Validation Test Report

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Revision History

Rev.	Date	Revisions	Revised By
V1	2026/07/06	Initial Issue	--
V2	2026/07/06	1. Updated §7.1.1 with the correct MSS transition plots 2. Updated §9 with the correct TER for the MSS transition test case	Nathan Sousa
V3	2026/07/15	1. Updated Table 9-3 with an appropriate naming scheme 2. Updated Figure 7-2 3. Updated Figures 8-1 and 8-2: Corrected plot titles	Nathan Sousa

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1. Test Specifications, Methods/Procedures, and Facilities

The tests documented in this report were performed following the OEM's pre-approval guidance KDB 388624 D02 Pre-Approval Guidance List v18r06, PWRCNG).

The test sites and measurement facilities used to collect data are located at:

47173 Benicia Street	47266 Benicia Street
SAR Labs A to Q	SAR Labs 1 to 30

The Test Lab Conformity Assessment Body Identifier (CABID)

Location	CABID	Company Number
47173 Benicia Street, Fremont, CA, 94538 UNITED STATES	US0104	2324A
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2. Introduction

The modem is enabled with WWAN/WLAN/Bluetooth/NB U-NII/802.15.4/MSS TAS technology feature to control and manage transmitting power, in real time.

This DUT supports a time-average method of transmit power control for the aforementioned technologies. 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 $SAR_{Reported}$.

The purpose of this document is to demonstrate the validity of the TAS feature(s) implemented within this product with a technology agnostic approach.

Table 2-1 defines the applicable time-averaging durations per regulatory body:

Table 2-1: Time-averaging Duration

FCC						
Frequency (GHz)	**WWAN (s)**	**MSS (s)**	**WLAN (s)**	**Bluetooth (s)**	**NB U-NII (s)**	**802.15.4 (s)**
< 3	100	99.84	100	100	N/A	100
3 - 6	60	N/A	60	N/A	60	N/A
6 - 10	N/A	N/A	30	N/A	30	N/A
24 - 42	4	N/A	N/A	N/A	N/A	N/A

3. Key TAS Parameters

This section defines the relevant power and RF Exposure parameters related to the TAS mechanism for this DUT.

3.1 Operating State Summary

Table 3-1 summarizes the operating states supported by the DUT:

Table 3-1: DUT Supported Operating States

RF Exposure	Power/Index State	Description
Head	Mode A	Max permissible power relative to P_{Limit} when the device is used against the user's head
Body-worn	Mode B	Max permissible power relative to P_{Limit} when the device is used in a Body-worn configuration
Hotspot	Mode B	Max permissible power relative to P_{Limit} when the device is used in a Hotspot configuration
Extremity	Mode B	Max permissible power relative to P_{Limit} when the device is used in an Extremity configuration

3.2 TAS Parameter Definitions

P_{Max}: The maximum possible instantaneous power

P_{Limit}: The maximum possible time-averaged power

$P_{Limit,\ nom}$: The listed time-averaged target power, excluding total device uncertainty

$P_{Max,\ nom}$: The maximum possible instantaneous power, excluding total device uncertainty

$SAR_{Measred}$: The maximum spatial peak averaged SAR value corresponding to $P_{Limit,\ nom}$

$SAR_{Reported}$: The maximum spatial peak averaged SAR value inclusive of total device uncertainty, corresponding to P_{Limit}

$PD_{Reported}$: The maximum 4 cm^2 Square averaged PD value inclusive of total device uncertainty, corresponding to P_{Limit}

$P_{Limit,\ nom}$, P_{Limit}, $P_{Max,\ nom}$, and P_{Max} values are defined for all antennas, technologies, bands, power states, and operating states combinations supporting TAS on the DUT. Instantaneous power for the specified antenna/technology/band/operating state combinations is capped at P_{Max}.

3.3 Device Characterizations

The device characterizations can be found within the SAR Report 15982152-S1, Appendix G.

4. Test Sequences

4.1 Conducted

The TAS algorithm shall be validated when the base station requests different power levels to manage the link budget.

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}, e.g. 2 to 4 dB lower. Whenever possible, the same band should not be repeated for different technologies.

4.1.1 Start-up Test Sequences

4.1.1.1 Start-up Sequence A

- Upon start-up, request a power level of $P_{\text{Max, nom}}$ for a period of at least 1.5x of the Time-averaging Duration, followed by $0.5 \cdot P_{\text{Limit, nom}}$ for a period of at least 1.5x of the Time-averaging Duration.

4.1.1.2 Start-up Sequence B

- Upon start-up, request a power level of 1 mW (0 dBm) for a period of at least 1.5x of the Time-averaging Duration, followed by $P_{\text{Max, nom}}$ for a period of at least 1.5x of the Time-averaging Duration.

4.1.2 Pseudo-random Sequence

A pseudo-random sequence of power requests shall be applied to validate the dynamic behavior of the TAS algorithm. Each test shall be performed with a unique sequence of 150 independent power requests for WWAN and 40 independent power requests for WLAN. These power levels are calculated as follows (Equation 1):

Equation 1: Power Level Equation

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

where P_{req} is the requested power in watts and x is a random value drawn from the Weibull distribution with shape and scale parameters of 2.0 and 0.8, and 1.0 and 0.4, respectively, for WWAN and WLAN . These values were chosen to ensure that P_{req} exceeds $P_{\text{Limit, nom}}$ on average, while maintaining a reasonable likelihood that some P_{req} values will sometimes fall well below $P_{\text{Limit, nom}}$.

The corresponding request durations are given by (Equation 2):

Equation 2: T_{req} Durations

$$T_{req} = d * 2(1 + 2y)$$

where T_{req} is the duration of the power request in seconds, d is the extended duration (1 for WWAN and 4 for WLAN), and y is a uniformly distributed random value between 0 and 1.

4.1.3 Antenna Switching

Conducted power measurements shall be performed to validate the TAS algorithm in antenna switching scenarios. Maximum power shall be requested from the DUT throughout the test. The switch between antennas and duplexes shall occur once the TAS algorithm has reached steady state for the first antenna and duplex, and the test shall conclude once the algorithm has reached steady state for the second antenna and duplex.

When different P_{Limit} and P_{Max} values are associated with each transmitting antenna and duplex, consideration shall be given to the combinations of antennas/duplexes and operating state(s) for which the P_{Limit} values are below the corresponding P_{Max} values and where one of the largest differences between P_{Max} and P_{Limit} occurs. Of these combinations, the performance of the TAS algorithm shall be validated when the DUT switches from the antenna with the highest P_{Limit} value to the lowest.

4.1.4 Change in Operating State

Conducted power measurements shall be performed to validate the TAS algorithm when the DUT changes between operating states with different P_{Limit} values, e.g., when sensors or other mechanisms are used to change operating states. Maximum power shall be requested from the DUT throughout the test. The change in operating state shall occur once the TAS algorithm has reached steady state for the first operating state, and the test shall conclude once the algorithm has reached steady state for the second operating state.

4.1.5 Frequency Band Hand-off or Redirect

Conducted power measurements shall be performed to validate the TAS algorithm when the DUT switches between frequency bands with different P_{Limit} values. When the frequency band hand-off or redirect logic of the algorithm is the same regardless of the technology, only one test is required. Maximum power shall be requested from the DUT throughout the test. The change in frequency band shall occur once the TAS algorithm has reached steady state, and the test shall also conclude once the algorithm has reached steady state.

4.1.6 Technology Hand-off

Conducted power measurements shall be performed to validate the TAS algorithm when the DUT switches between technologies with different P_{Limit} values. Maximum power shall be requested from the DUT throughout the test. The technology hand-off shall occur once the TAS algorithm has reached steady state for the first technology(ies), and the test shall conclude once the algorithm has reached steady state for the second technology(ies). When there are more than two technologies that are supported by the TAS algorithm or the final product implementation, more than two technologies can be tested within one test as long as the TAS algorithm has reached steady state prior to commencing the next technology hand-off.

4.1.6.1 Additional WWAN Test Coverage

Intra-technology hand-off shall include the following test(s) for WWAN:

- Enhanced New Radio Dual Connectivity (EN-DC) with LTE and NR transmitting simultaneously

Note: If non-standalone (NSA) is supported, when power is requested for NR, LTE shall be set at low power.

- Uplink Carrier Aggregation (ULCA) transmitting simultaneously for two tests, one with two LTE Bands and the other with two NR bands

These test cases shall be performed in the following sequence: Standalone technology with one of the highest P_{Limit}, simultaneous transmission of technologies, and standalone technology with one of the lowest P_{Limit}.

4.1.7 Switching Between Time Division Duplexing and Frequency Division Duplexing

Conducted power measurements shall be performed to validate the TAS algorithm when the DUT switches between TDD and FDD configurations with different P_{Limit} values, both of which should be lower than the corresponding P_{Max} values and where one of the largest differences between P_{Max} and P_{Limit} occurs. Maximum power shall be requested from the DUT throughout the test. The switch between configurations shall occur once the TAS algorithm has reached steady state and the test shall also conclude once the algorithms has reached steady state.

Note: This test case can be combined with frequency band hand-off or redirect.

4.1.8 Change in Modulation Scheme within a Communication Technology

Conducted power measurements shall be performed to validate the TAS algorithm for approval and final product implementations for WWAN and WLAN when the DUT changes between modulation schemes with different P_{Limit} values. For example, measurements would be required to validate a change from a higher order, for example, 64 QAM (quadrature amplitude modulation), to a lower order, such as QPSK (quadrature phase shift keying) and vice versa.

Only one test is required with the configurations where both P_{Limit} values are lower than the corresponding P_{Max} values and where one of the largest differences between P_{Max} and P_{Limit} occurs. Maximum power shall be requested from the DUT throughout the test. The switch between modulation schemes shall occur once the TAS algorithm has reached steady state and the test shall also conclude once the algorithm has reached steady state.

Note: This test case may be waived if the same P_{Limit} applies to all modulations for the technology under test.

4.1.9 Dropped Connection

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. When the dropped connection logic of the algorithm is the same regardless of the technology, only one test is required. Only one test is required with one of the configurations for which P_{Limit} is below P_{Max} and where one of the largest differences between P_{Max} and P_{Limit} occurs. Maximum power shall be requested from the DUT throughout the test. The dropped connection shall occur once the TAS algorithm has reached steady state, and the test shall conclude once steady state has been regained after the dropped connection.

4.1.10 Test Sequence Validation

Validation plots are included for the applicable test cases for this DUT. These plots serve to validate the operation of this TAS algorithm by ensuring that the measured power averaged over the applicable regulatory limit (P[n]) is always maintained below the defined P_{Limit}.

Conducted power measurements (P_{Meas}) are used to validate all TAS test cases. In test cases where P_{Limit} remains constant, the equation, Equation 3, below is used to calculate the rolling time-averaged power for the n^{th} time step (P[n]).

Equation 3: Rolling Time-averaged Power (Constant P_{Limit})

$$P[n] = \frac{1}{M}\sum_{m=0}^{M-1} P_{Meas}[n-m]$$

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[n] is maintained less than or equal to P_{Limit}.

In test cases where P_{Limit} is not constant, the equation, Equation 4, below is used to calculate the normalized rolling time-averaged power (p[n]).

Equation 4: Rolling Time-averaged Power (P_{Limit} not Constant)

$$p[n] = \frac{1}{M}\sum_{m=0}^{M-1} \frac{P_{Meas}[n-m]}{P_{Limit}[n-m]}$$

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[n] is maintained less than or equal to 1.

4.2 Radiated

4.2.1 Test Procedure and Validation

To validate linearity, point SAR measurements are performed with TAS operation turned off. Per antenna, the mode with the largest difference between P_{Limit} and P_{Max} will be selected for measurement. When possible, different frequency bands will be assessed per antenna.

Point SAR measurements are performed in 2 dB steps from P_{Max} to at least P_{Limit} minus 4 dB.

Linearity is sufficiently validated when the SAR versus requested power is within the defined device uncertainties.

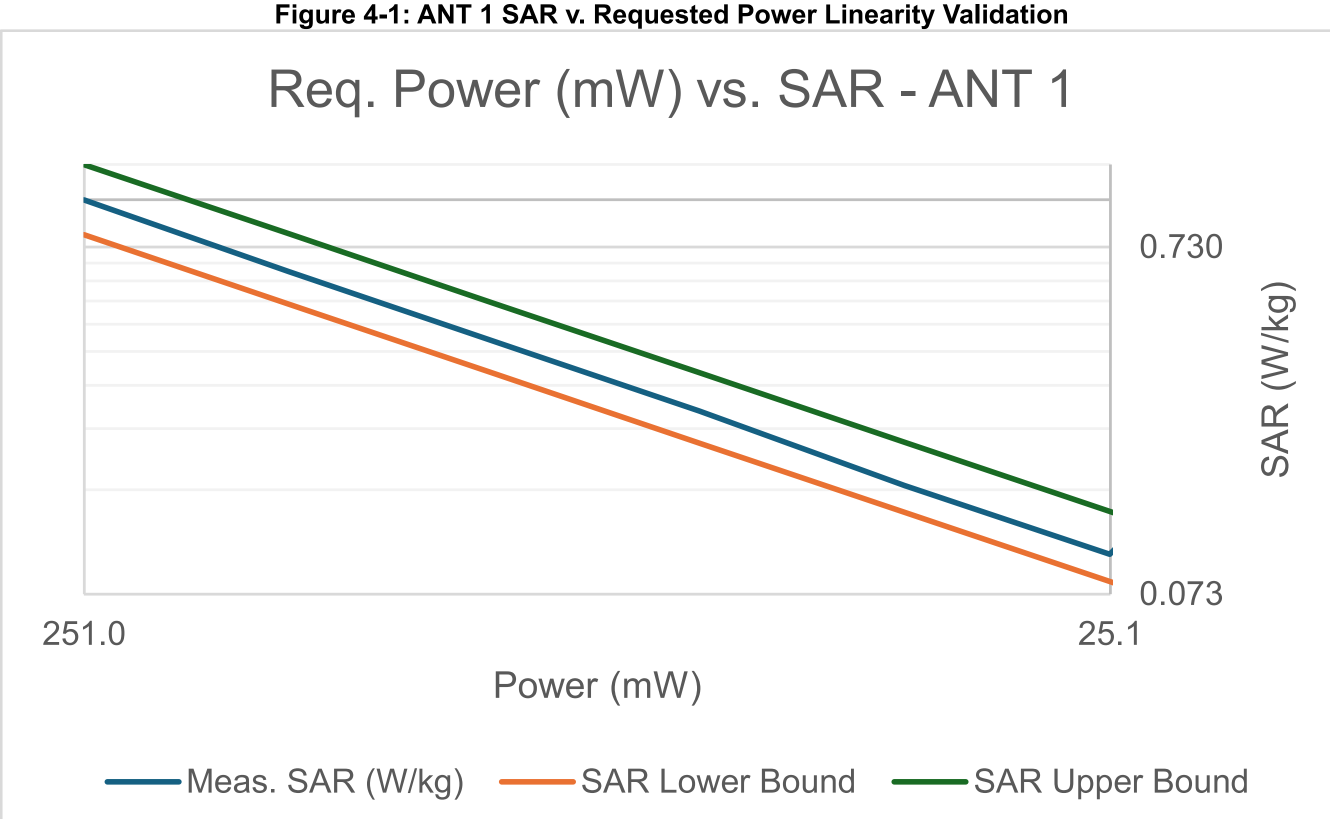
4.2.1.1 ANT 1

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-1: ANT 1 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 1	n41	1.01	25.7	21.6	24	251.2	1.000	0.793	1.262
ANT 1	n41	1.01	25.7	21.6	22	158.5	0.619	0.500	0.796
ANT 1	n41	1.01	25.7	21.6	20	100.0	0.390	0.316	0.502
ANT 1	n41	1.01	25.7	21.6	18	63.1	0.246	0.199	0.317
ANT 1	n41	1.01	25.7	21.6	16	39.8	0.150	0.126	0.200
ANT 1	n41	1.01	25.7	21.6	14	25.1	0.095	0.079	0.126

Figure 4-1: ANT 1 SAR v. Requested Power Linearity Validation



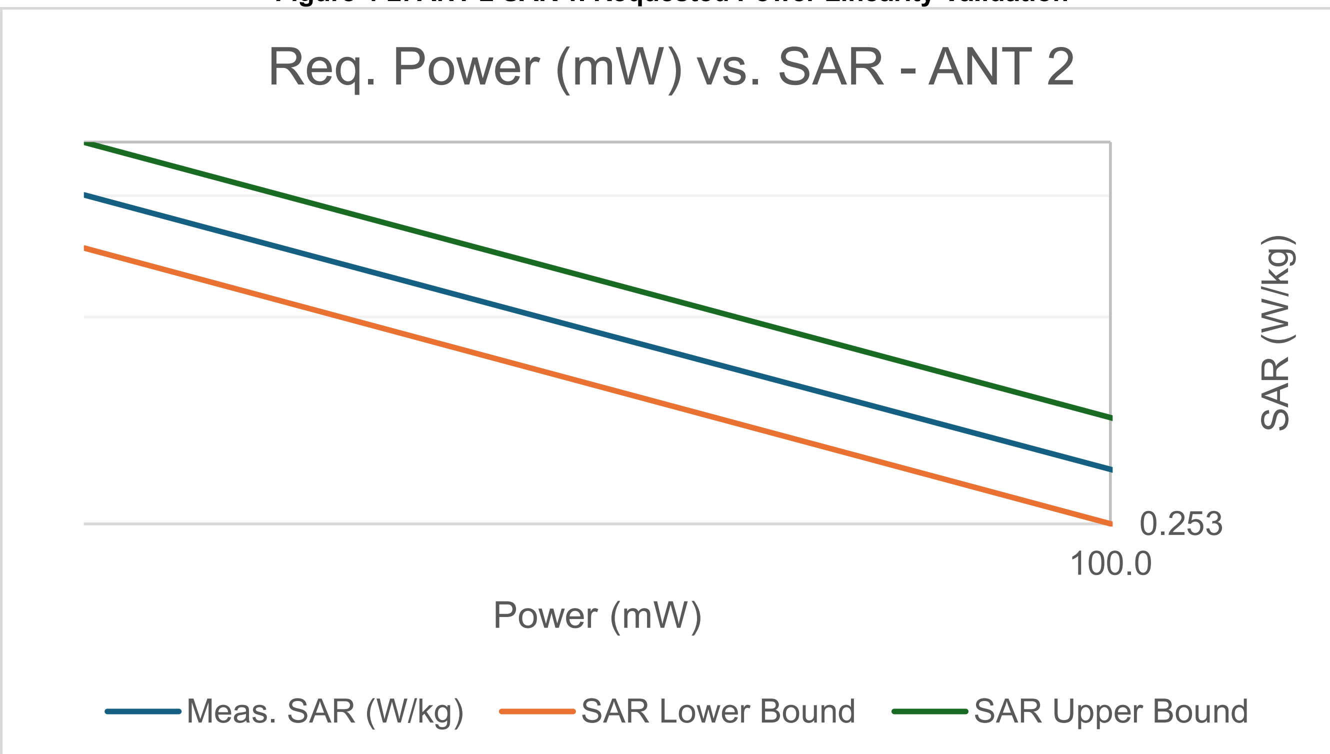
4.2.1.2 ANT 2

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-2: ANT 2 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 2	LTE B106	0.77	25.7	24.6	24	251.2	0.760	0.637	0.907
ANT 2	LTE B106	0.77	25.7	24.6	22	158.5	0.480	0.402	0.573
ANT 2	LTE B106	0.77	25.7	24.6	20	100.0	0.304	0.253	0.361

Figure 4-2: ANT 2 SAR v. Requested Power Linearity Validation



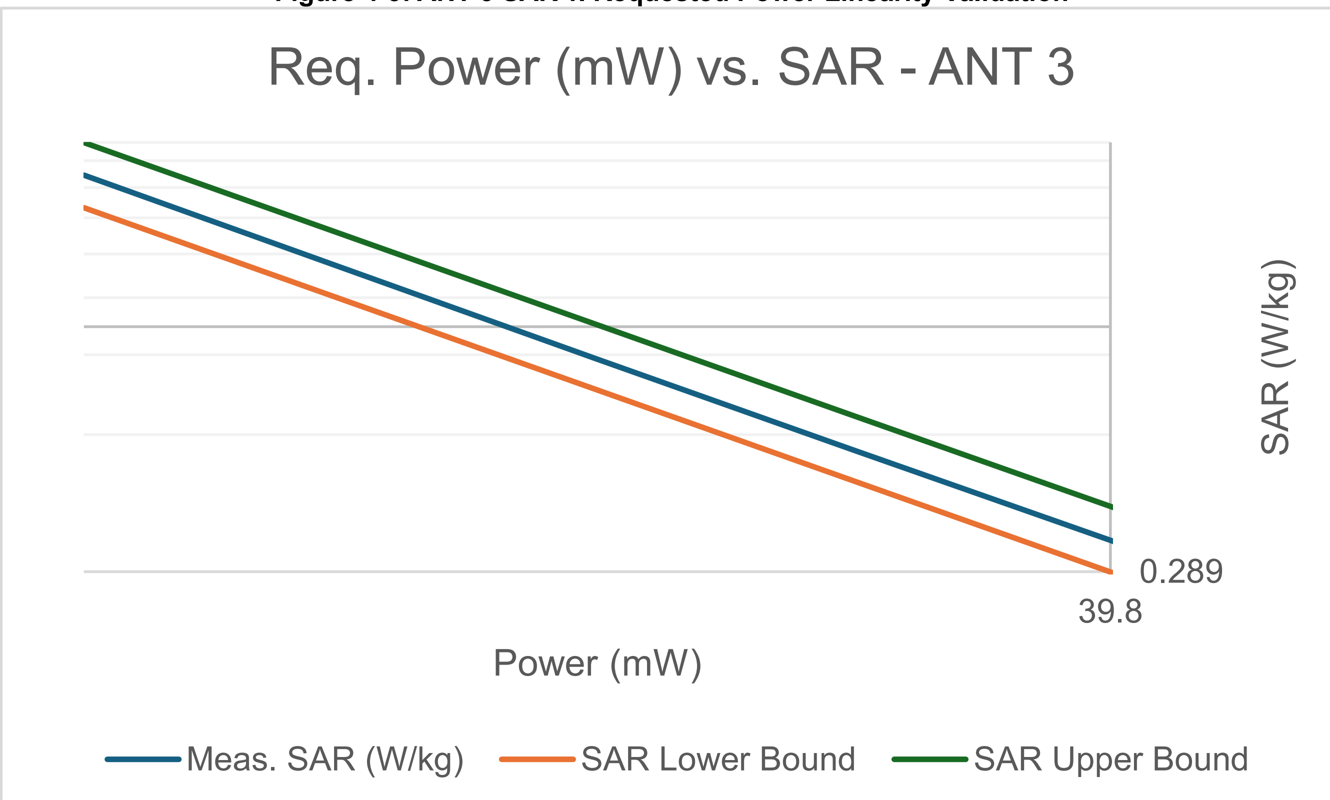
4.2.1.3 ANT 3

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-3: ANT 3 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 3	LTE B7	0.72	25.7	20.7	24	251.2	2.150	1.822	2.538
ANT 3	LTE B7	0.72	25.7	20.7	22	158.5	1.350	1.149	1.601
ANT 3	LTE B7	0.72	25.7	20.7	20	100.0	0.848	0.725	1.010
ANT 3	LTE B7	0.72	25.7	20.7	18	63.1	0.535	0.458	0.637
ANT 3	LTE B7	0.72	25.7	20.7	16	39.8	0.339	0.289	0.402

Figure 4-3: ANT 3 SAR v. Requested Power Linearity Validation



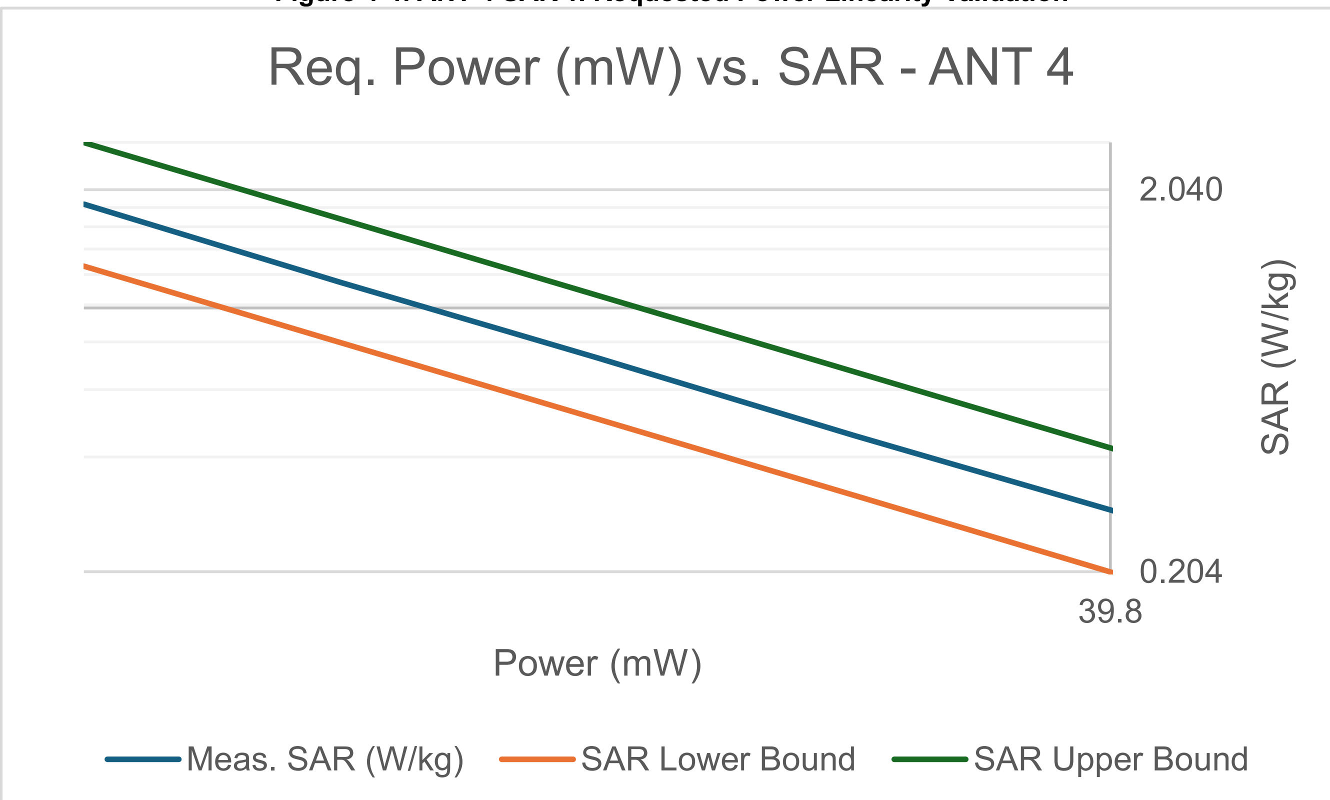
4.2.1.4 ANT 4

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-4: ANT 4 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 4	LTE B25	1.62	24.9	20.4	24	251.2	1.870	1.288	2.715
ANT 4	LTE B25	1.62	24.9	20.4	22	158.5	1.170	0.813	1.713
ANT 4	LTE B25	1.62	24.9	20.4	20	100.0	0.742	0.513	1.081
ANT 4	LTE B25	1.62	24.9	20.4	18	63.1	0.465	0.323	0.682
ANT 4	LTE B25	1.62	24.9	20.4	16	39.8	0.296	0.204	0.430

Figure 4-4: ANT 4 SAR v. Requested Power Linearity Validation



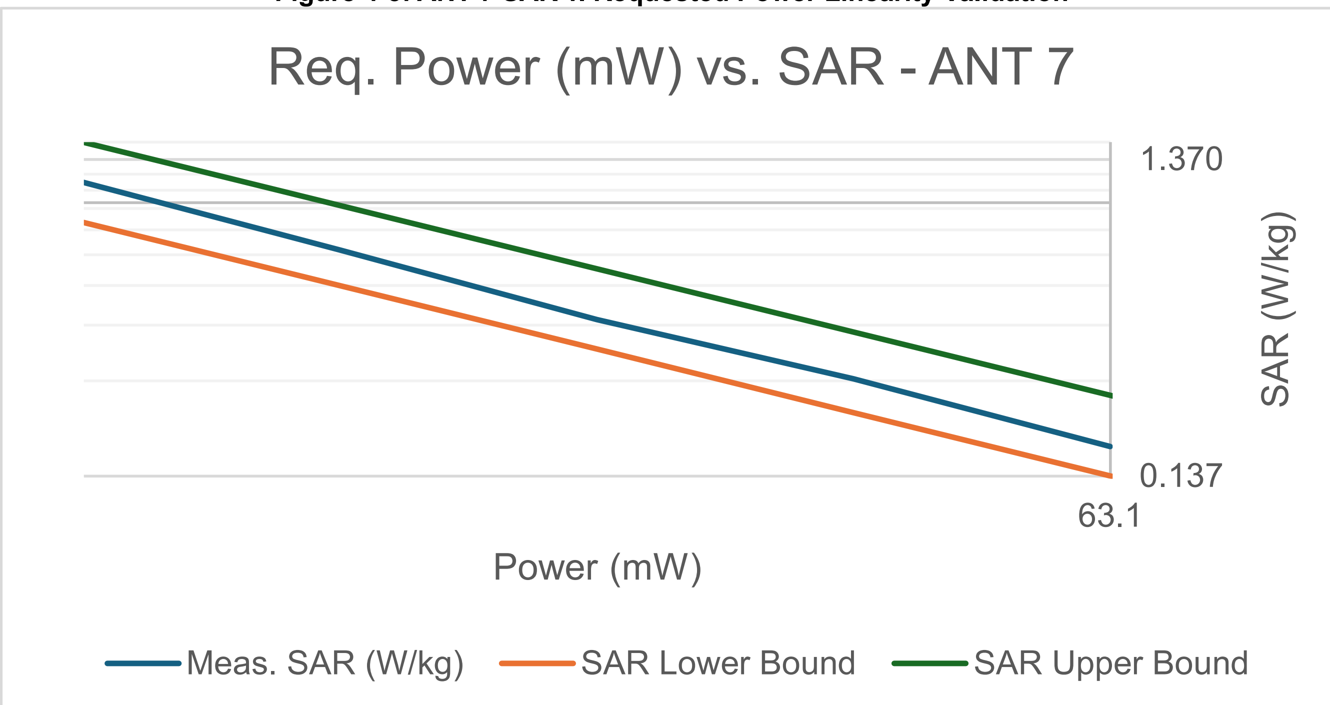
4.2.1.5 ANT 7

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-5: ANT 7 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 7	n77 (Block C)	1.27	26.0	23.7	26	398.1	1.160	0.866	1.554
ANT 7	n77 (Block C)	1.27	26.0	23.7	24	251.2	0.709	0.546	0.981
ANT 7	n77 (Block C)	1.27	26.0	23.7	22	158.5	0.428	0.345	0.619
ANT 7	n77 (Block C)	1.27	26.0	23.7	20	100.0	0.278	0.217	0.390
ANT 7	n77 (Block C)	1.27	26.0	23.7	18	63.1	0.170	0.137	0.246

Figure 4-5: ANT 7 SAR v. Requested Power Linearity Validation



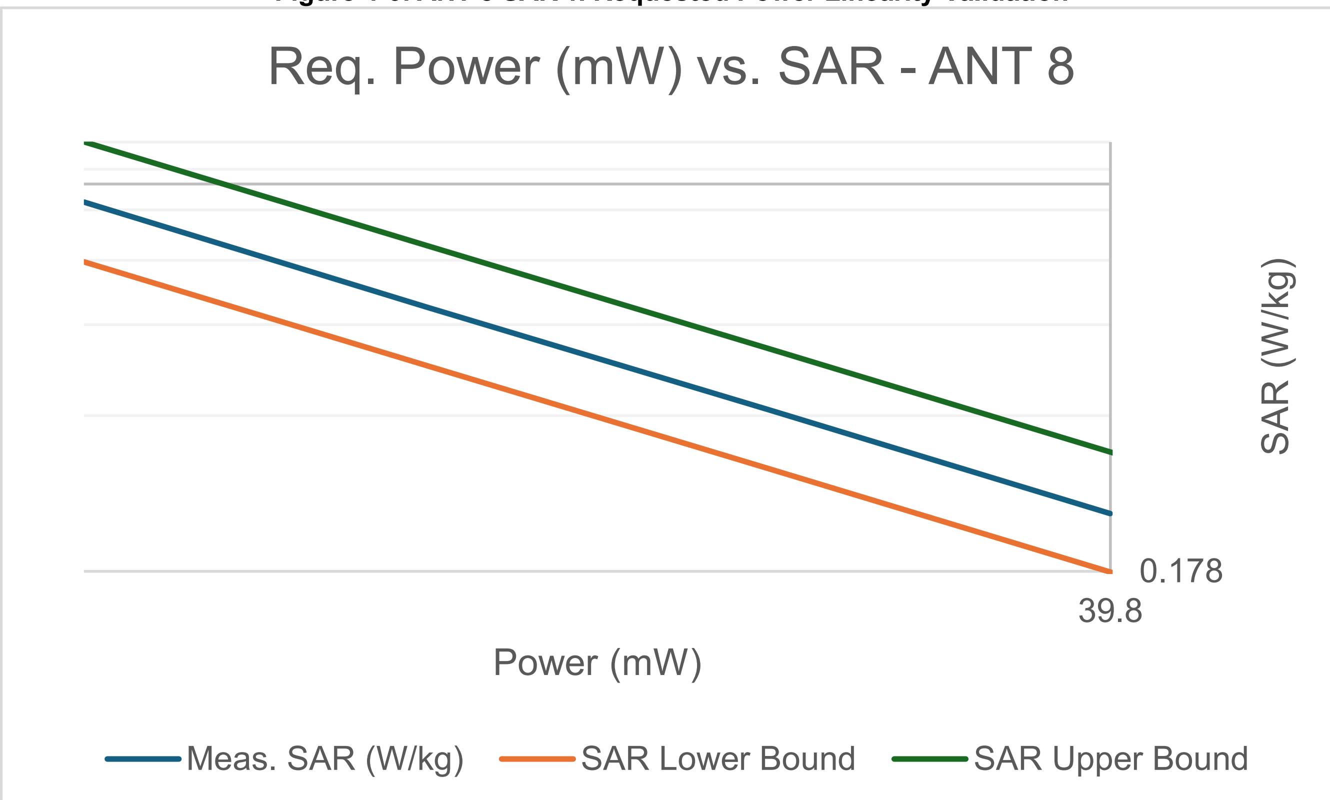
4.2.1.6 ANT 8

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-6: ANT 8 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 8	LTE B48	1.16	23.9	20.6	22	158.5	0.923	0.707	1.206
ANT 8	LTE B48	1.16	23.9	20.6	20	100.0	0.578	0.446	0.761
ANT 8	LTE B48	1.16	23.9	20.6	18	63.1	0.366	0.281	0.480
ANT 8	LTE B48	1.16	23.9	20.6	16	39.8	0.230	0.178	0.303

Figure 4-6: ANT 8 SAR v. Requested Power Linearity Validation



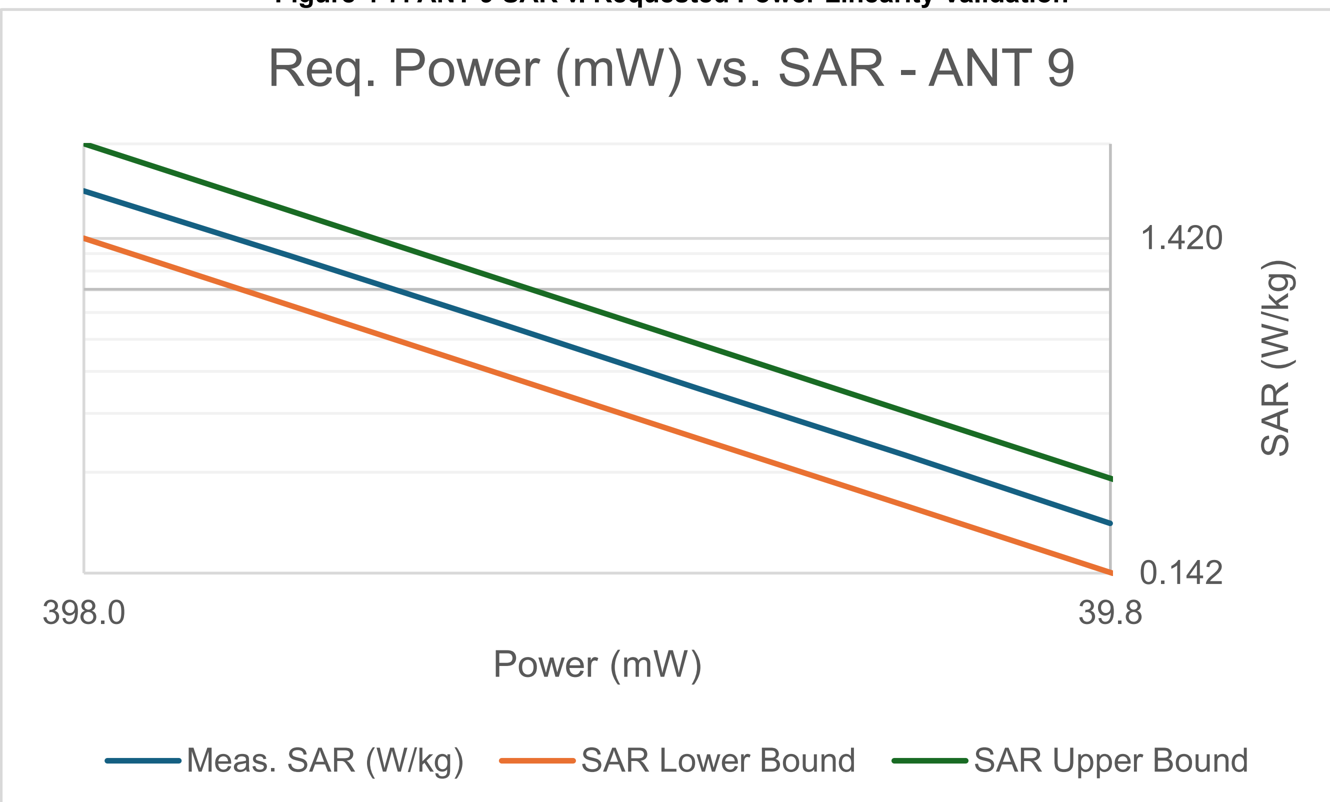
4.2.1.7 ANT 9

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-7: ANT 9 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 9	n77 (Block A)	1.41	26.0	21.8	26	398.1	1.970	1.424	2.726
ANT 9	n77 (Block A)	1.41	26.0	21.8	24	251.2	1.260	0.898	1.720
ANT 9	n77 (Block A)	1.41	26.0	21.8	22	158.5	0.801	0.567	1.085
ANT 9	n77 (Block A)	1.41	26.0	21.8	20	100.0	0.503	0.358	0.685
ANT 9	n77 (Block A)	1.41	26.0	21.8	18	63.1	0.320	0.226	0.432
ANT 9	n77 (Block A)	1.41	26.0	21.8	16	39.8	0.200	0.142	0.273

Figure 4-7: ANT 9 SAR v. Requested Power Linearity Validation



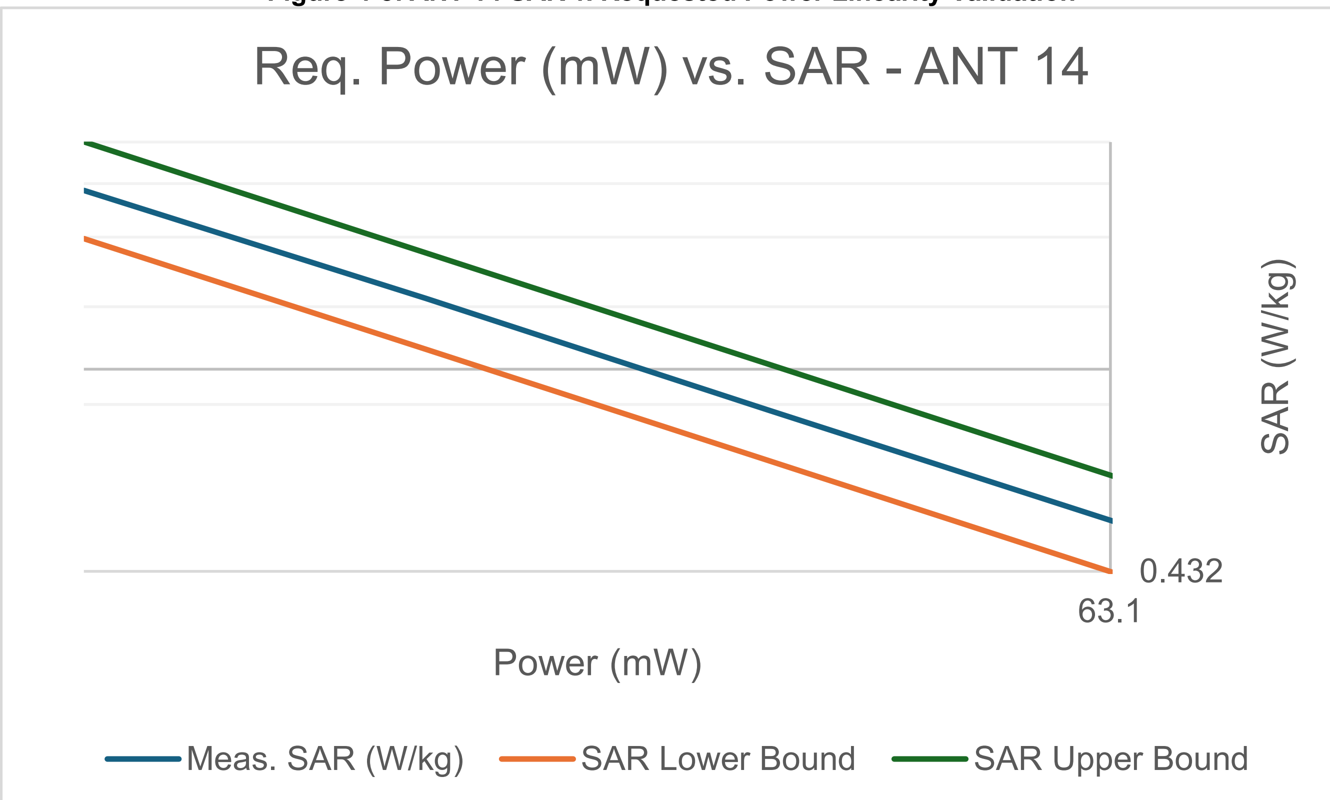
4.2.1.8 ANT 14

The table and figure below demonstrate that the linearity is sufficiently validated as the SAR versus requested power is within the expected uncertainties.

Table 4-8: ANT 14 SAR v. Requested Power

Transmitter	Technology	Uncert. (±)	PMax	PLimit	Req. Power (dBm)	Req. Power (mW)	Meas. SAR (W/kg)	SAR Lower Bound	SAR Upper Bound
ANT 14	LTE B41	0.87	25.7	22.3	24	251.2	2.100	1.719	2.566
ANT 14	LTE B41	0.87	25.7	22.3	22	158.5	1.340	1.084	1.619
ANT 14	LTE B41	0.87	25.7	22.3	20	100.0	0.844	0.684	1.021
ANT 14	LTE B41	0.87	25.7	22.3	18	63.1	0.534	0.432	0.644

Figure 4-8: ANT 14 SAR v. Requested Power Linearity Validation



4.3 PD (mmW)

4.3.1 SAR to MPE Switch

LTE sub-6 GHz (P_{Max}) + FR-2 (all down bits/lowest power configuration) to LTE sub-6 GHz (P_{Max}) + FR-2 (P_{Max}) to LTE sub-6 GHz (all down bits/lowest power configuration) + FR2 (P_{Max})

- The test should be performed for a single test case. The test time will be sufficient to allow steady state to be reached for both connections.

Conducted power measurements will be used to validate the sub-6 GHz test configuration. Radiated power measurements will be used to validate the FR-2 test configuration.

4.3.2 Beam Switch

LTE sub-6 GHz (all down bits/lowest power configuration) + FR-2 beam 1 (P_{Max}) to LTE sub-6 GHz (all down bits/lowest power configuration) + FR-2 beam 2 (P_{Max})

- The test should be performed for a single test case. The test time will be sufficient to allow steady state to be reached for both connections.

Conducted power measurements will be used to validate the sub-6 GHz test configuration. Radiated power measurements will be used to validate the FR-2 test configuration.

5. Test Cases

5.1 Sub-7.2 GHz

The test cases are summarized in Table 5-1.

Table 5-1: Selected Test Cases for sub-7.2 GHz TAS Validation

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Duty Cycle (%)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Max} Corr. (dBm)	P_{Limit} (dBm)	P_{Limit} Corr. (dBm)	P_{Max} (mW)	P_{Max} Corr. (mW)	P_{Limit} (mW)	P_{Limit} Corr. (mW)
1	Sequence A	FR-1 TDD	n77 (Block C)	DFT-s π/2 BPSK	N/A	PC3	100	67.0%	Port D	ANT 8	Body	26.0	27.7	20.2	21.9	398.1	594.2	104.7	156.3
2	Sequence B	GSM	1900	GMSK	2 Slot(s)	N/A	N/A	25.0%	Port D	ANT 4	Body	29.5	29.5	26.2	26.2	891.3	891.3	416.9	416.9
3		W-CDMA	B2	QPSK	N/A	N/A	N/A	100.0%	Port A	ANT 14	Body	25.7	25.7	21.1	21.1	371.5	371.5	128.8	128.8
4		LTE FDD	B30	QPSK	N/A	N/A	10	100.0%	Port D	ANT 4	Body	24.2	24.2	20.7	20.7	263.0	263.0	117.5	117.5
5		LTE TDD	B41	QPSK	N/A	PC3	20	63.3%	Port A	ANT 14	Body	25.7	25.7	22.3	22.3	371.5	371.5	169.8	169.8
6		FR-1 FDD	n70	DFT-s π/2 BPSK	N/A	N/A	15	90.0%	Port A	ANT 14	Body	25.7	26.2	22.0	22.5	371.5	412.8	158.5	176.1
7		FR-1 TDD	n77 (Block A)	DFT-s π/2 BPSK	N/A	PC3	100	67.0%	Port A	ANT 7	Body	26.0	27.7	24.6	26.3	398.1	594.2	288.4	430.5
8		Wi-Fi	U-NII 3	BPSK	N/A	N/A	80	N/A	N/A	ANT 16	Body	20.0	20.0	16.0	16.0	100.0	100.0	39.8	39.8
9		Wi-Fi	U-NII 5	BPSK	N/A	N/A	160	N/A	N/A	ANT 16	Body	19.0	19.0	14.0	14.0	79.4	79.4	25.1	25.1
10		Bluetooth	2.4 GHz	LE	N/A	N/A	N/A	N/A	N/A	ANT 4	Head	21.0	21.0	20.5	20.5	125.9	125.9	112.2	112.2
11	Pseudo-random	LTE FDD	B7	QPSK	N/A	N/A	20	100.0%	Port A	ANT 14	Body	25.7	25.7	20.0	20.0	371.5	371.5	100.0	100.0
17	Dropped Connection	LTE	B48	QPSK	N/A	N/A	20	63.3%	Port D	ANT 8	Body	23.9	23.9	20.6	20.6	245.5	245.5	114.8	114.8

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Duty Cycle (%)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Max} Corr. (dBm)	P_{Limit} (dBm)	P_{Limit} Corr. (dBm)	P_{Max} (mW)	P_{Max} Corr. (mW)	P_{Limit} (mW)	P_{Limit} Corr. (mW)
12	Antenna Switching	Wi-Fi	2.4 GHz	DSSS	N/A	N/A	20	N/A	N/A	ANT 4	Head	21.5	21.5	21.5	21.5	141.3	141.3	141.3	141.3
		Wi-Fi	U-NII 2C	BPSK	N/A	N/A	80	N/A	N/A	ANT 6	Body	20.0	20.0	18.0	18.0	100.0	100.0	63.1	63.1
13	Change in Operating State	NB U-NII	U-NII 3	GFSK	N/A	N/A	N/A	N/A	N/A	ANT 16	Head	19.0	19.0	19.0	19.0	79.4	79.4	79.4	79.4
		NB U-NII	U-NII 3	GFSK	N/A	N/A	N/A	N/A	N/A	ANT 16	Body	19.0	19.0	16.0	16.0	79.4	79.4	39.8	39.8
16	Switching Between Duplexes	LTE	B41	QPSK	N/A	PC3	20	63.3%	Port D	ANT 4	Head	25.7	25.7	21.1	21.1	371.5	371.5	128.8	128.8
		LTE	B25	QPSK	N/A	N/A	20	100.0%	Port D	ANT 4	Head	24.9	24.9	20.4	20.4	309.0	309.0	109.6	109.6
14	Technology Hand-off (ULCA)	LTE	B5	QPSK	N/A	N/A	10	100.0%	Port B	ANT 2	Head	25.7	25.7	25.3	25.3	371.5	371.5	338.8	338.8
		LTE	B66	QPSK	N/A	N/A	20	100.0%	Port A	ANT 14	Head	25.7	25.7	23.0	23.0	371.5	371.5	199.5	199.5
15	Technology Hand-off (ENDC)	LTE	B66	QPSK	N/A	N/A	20	100.0%	Port B	ANT 1	Body	25.7	25.7	25.4	25.4	371.5	371.5	346.7	346.7
		FR-1	n25	DFT-s π/2 BPSK	N/A	N/A	40	90.0%	Port C	ANT 3	Body	25.7	26.2	23.6	24.1	371.5	412.8	229.1	254.5
18	MSS Switch Case	MSS	N/A	N/A	N/A	N/A	N/A	N/A	Port D	ANT 4	Extremity	28.7	28.7	26.7	26.7	741.3	741.3	467.7	467.7
		LTE	B66	QPSK	N/A	N/A	20	100.0%	Port B	ANT 1	Body	25.7	25.7	25.4	25.4	371.5	371.5	346.7	346.7

The following figures outline the test setup for the applicable test cases:

Figure 5-1: Time-varying, Change in Operating State, Change in Duplex/Modulation, and Dropped Connection

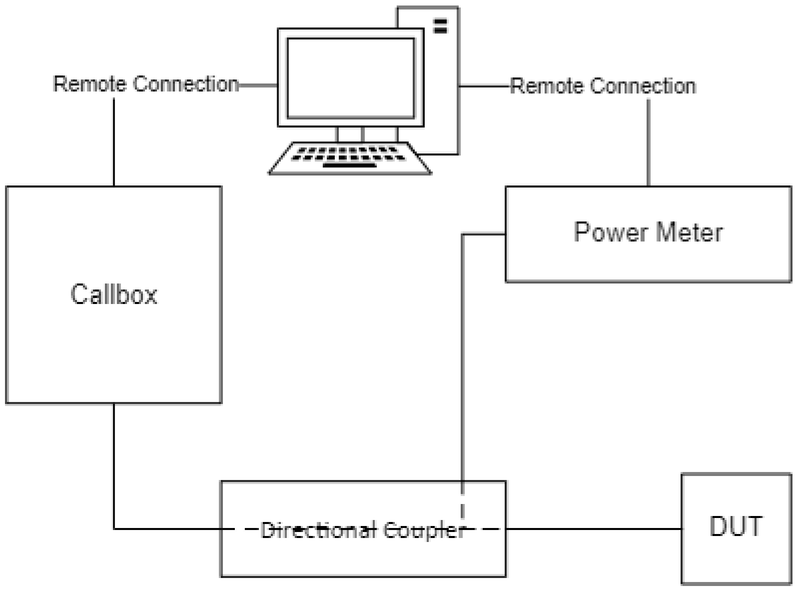


Figure 5-2: Antenna Switching and Frequency Band Hand-off or Redirect

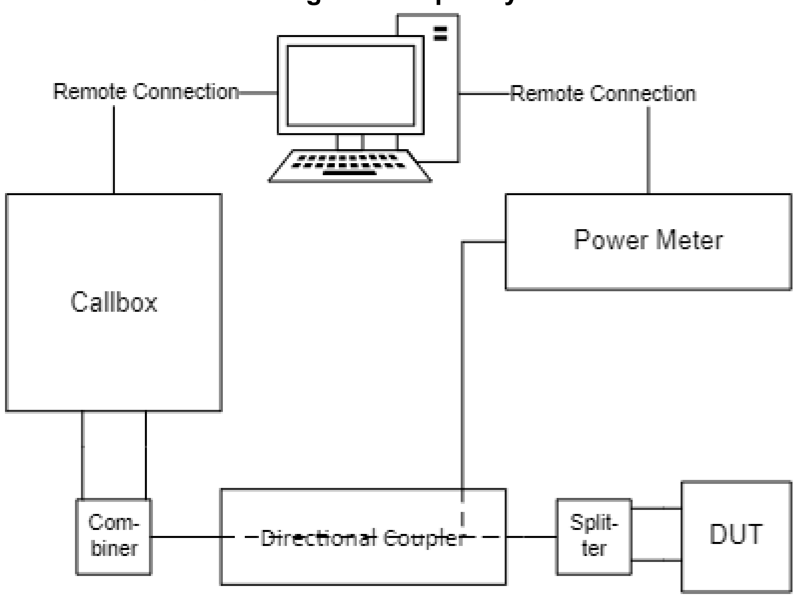


Figure 5-3: Technology Hand-off

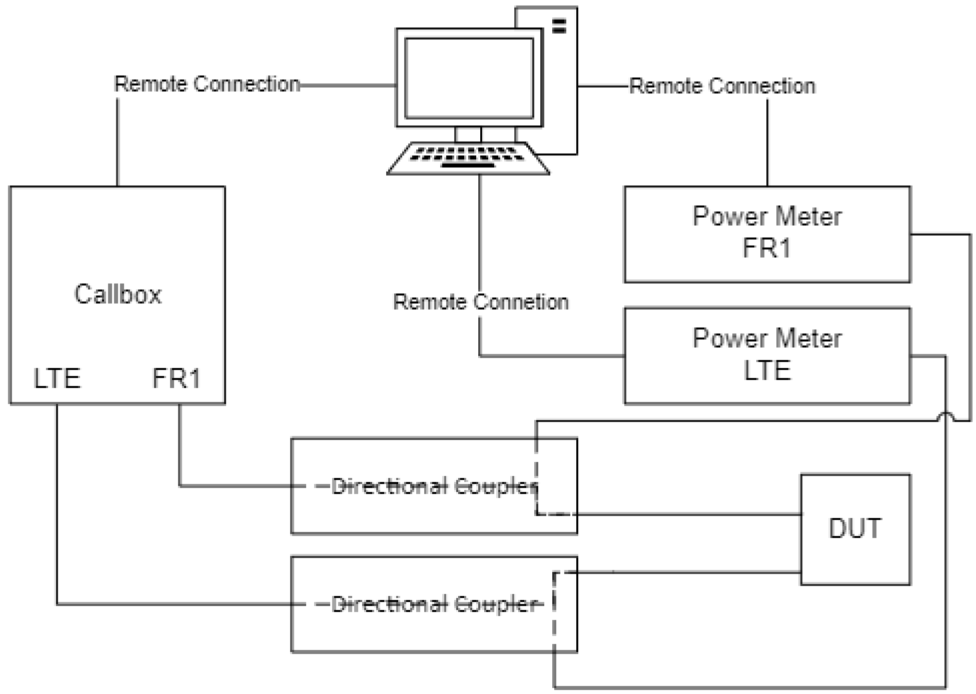
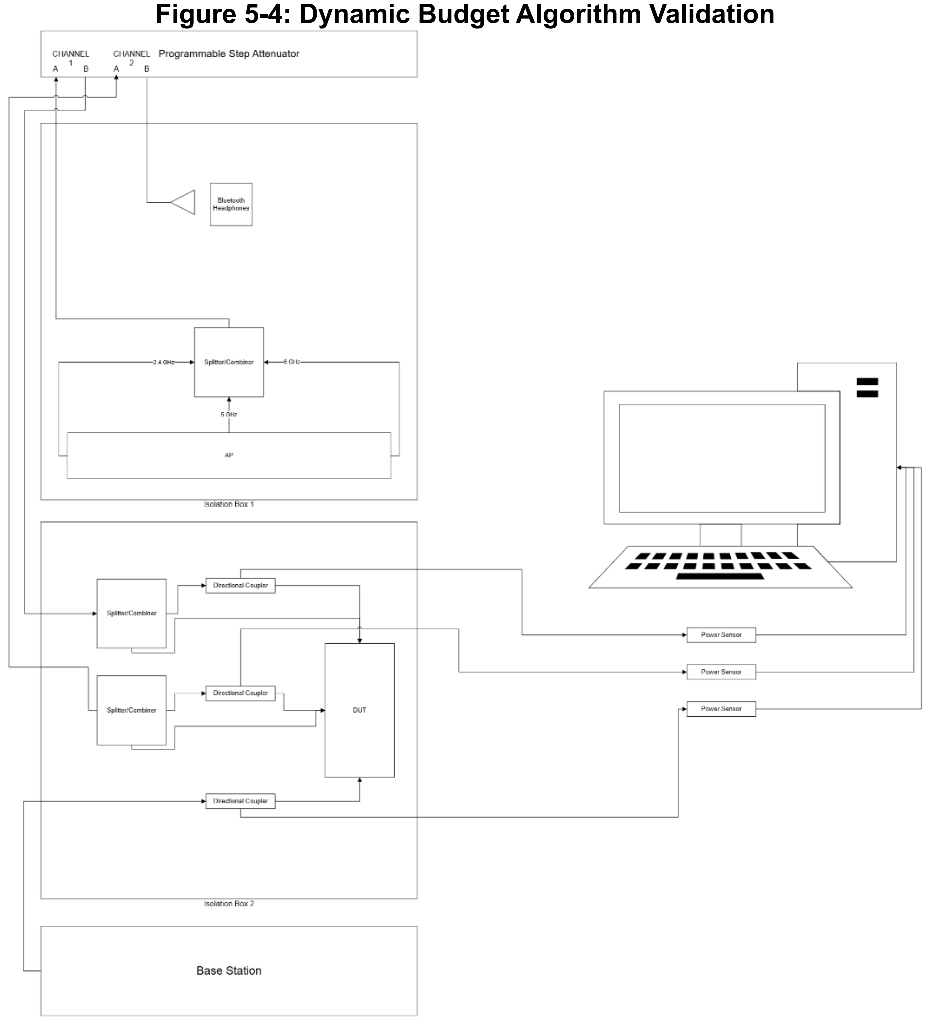


Figure 5-4: Dynamic Budget Algorithm Validation



5.2 PD (mmWave)

The test cases are summarized in Table 5-2.

Table 5-2: Selected Test Cases for PD TAS Validation

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Port	Transmitter	Polarity	Beam ID	P_{Max} (dBm)	P_{Limit} (dBm)	P_{Max} (mW)	P_{Limit} (mW)
19	SAR to MPE	LTE	B25	QPSK	N/A	N/A	20	Port A	ANT 14	N/A	N/A	25.7	18.8	371.5	75.9
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	3	20.3	-0.8	108.1	0.8
20	Beam Switch	LTE	B25/2	QPSK	N/A	N/A	20	Port D	ANT 4	N/A	N/A	25.7	18.8	371.5	75.9
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	3	20.3	-0.8	108.1	0.8
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	5	14.2	1.3	26.4	1.3

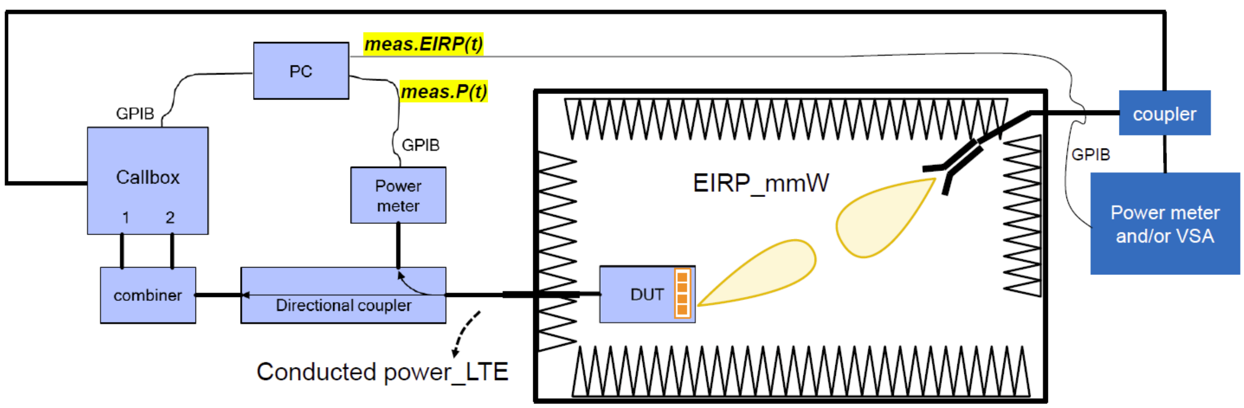
5.2.1 Measurement Setup

5.2.1.1 Radiated Power

A mmW capable call box is used in this test. The call box has two RF radio heads to up/down convert the IF to mmW frequencies, which, in turn, are connected to two horn antennas for V- and H-polarizations for downlink communication. In the uplink, a directional coupler is used in the path of one of the horn antennas to measure and record radiated power using an appropriate power sensor and meter.[1]

The DUT is placed inside an anechoic chamber with V- and H-polarity horn antennas to establish the radio link as shown in Figure 5-5. The call box's anchor port is directly connected to the DUT's RF port via a directional coupler to measure the DUT's conducted transmission power using a power sensor and power meter. Additionally, the DUT is connected to the PC via USB connection for sending beam switch commands. Care is taken to route the USB and RF cable away from the DUT's mmW antenna module(s).

Figure 5-5: mmW Radiated Power Measurement Setup



Both the call box and power meter are connected to the PC using USB cables. Test scripts are custom made for automation, i.e., establishing an anchor + mmW call, conducted transmission power recording for the anchor, and radiated transmission power recording for mmW. These tests are manually stopped after the desired time duration. The test script is programmed to set the anchor transmission power to minimum power on the call box immediately after the mmW link is established and programmed to toggle between all up and minimum power depending on the transmission scenario being evaluated. Similarly, the test script is also programmed to send beam switching commands manually to the DUT via a USB connection. For all the tests, the call box is set to request maximum transmission power from the mmW radio.

In simultaneous transmission scenarios involving sub-7.2 GHz + mmW, for a given operating state, both sub-7.2 GHz exposure and mmW exposure will be evaluated at the operating state corresponding separation distance in the TER analysis; but in the same time, the compliance of mmW exposure at 2 mm is ensured for all operating states. Thus, the following steps are implemented:

[1] The isolation of the directional coupler may not be sufficient to attenuate the downlink signal from the call box, which will result in high noise floor masking the recording of the radiated power from the DUT. In that case, either lower the downlink signal strength emanating from the RF radio heads of the call box or add an attenuator between the call box radio heads and the directional coupler. Additionally, since the measurements performed in this validation are all relative, measurement of the DUT's radiated power in one polarization is sufficient.

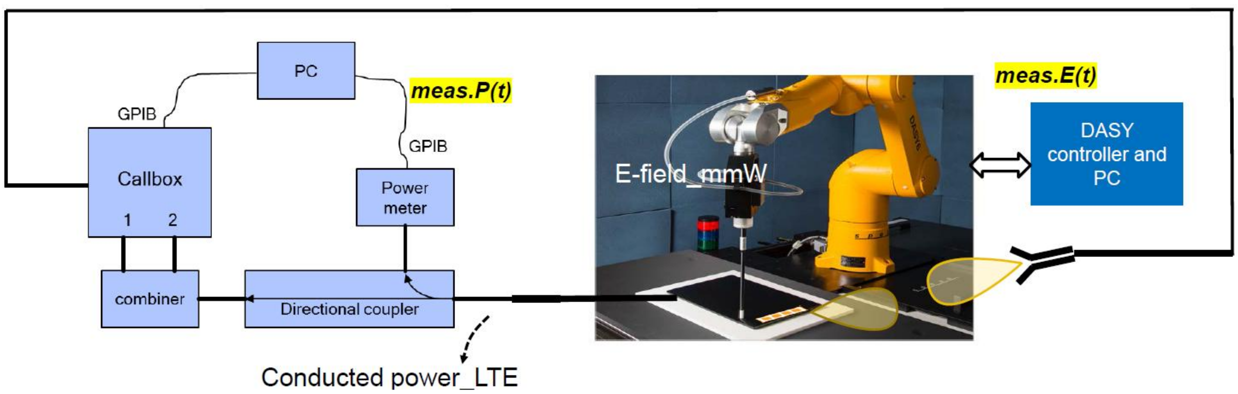
1. For TER calculation, scale the PD exposure at 2 mm to the same separation distance at which the sub-7.2 GHz exposure is measured for that operating state
    a. This is outlined within SAR Report 15982152-S1, Appendix H
2. PD at 2 mm is ≤ 1

5.2.1.2 PD Measurements

The measurement setup is like normal PD measurements where the DUT is positioned on the cDASY6/8 platform and is connected with the call box (conducted for sub-7.2 GHz and wirelessly for mmW). The call box is set to request maximum mmW transmission power always form the DUT. Hence, “path loss” calibration between call box antenna and DUT is not needed in this test. The call box’s sub-7.2 GHz port is directly connected to the DUT’s RF port via a directional coupler to measure the DUT’s conducted transmission power using a power sensor and power meter. Additionally, the DUT is connected to the PC via a USB connection for toggling between FTM and *online* modes with the algorithm enabled.

Worst-surface of the DUT (for the mmW beam being tested) is positioned facing up for PD measurements with the cDASY6/8 mmW probe as sshown in Figure 5-6.

Figure 5-6: PD Measurement Setup



Both the call box and the power meter are connected to the PC using USB cables. Test scripts are custom made for automation of established sub-7.2 GHz + mmW call and for conducted transmission power recording of sub-7.2 GHz transmission. These tests are manually stopped after the desired time duration. Once the mmW link is established, the sub-7.2 GHz transmission power is programmed to toggle between all up and minimum power on the call box. For all the tests, the call box is set to request maximum transmission power for the mmW radio from the DUT. Therefore, the calibration for the “path loss” between the DUT and the horn antenna connected to the remote radio head of the call box is not required.

Power meter readings are periodically recorded every 10 milliseconds on the power sensor for sub-7.2 GHz conducted transmission power. Time-averaged E-field measurements are performed using the mmW probe at peak location of the measurement. The distance between the mmW probe tip to the DUT’s surface is ~0.5 mm and the distance between the mmW probe sensor to the probe tip is 1.5 millimeters. cDASY6/8 records relative point E-field, i.e., ratio $\frac{[pointE(t)]^2}{\left[pointE_{P_{Limit}}\right]^2}$ versus time for mmW transmission.

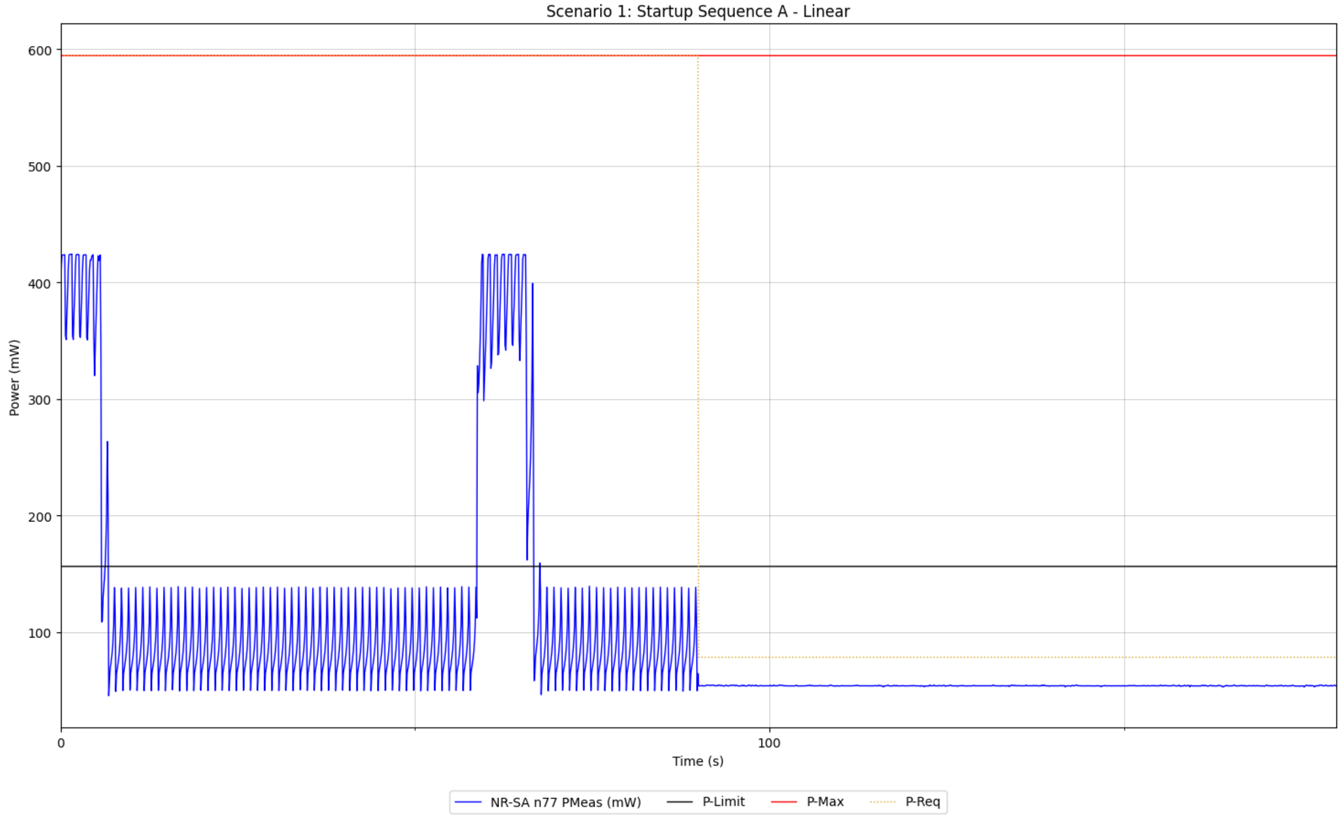
6. TAS Validation

6.1 Conducted

6.1.1 Start-up Sequence A

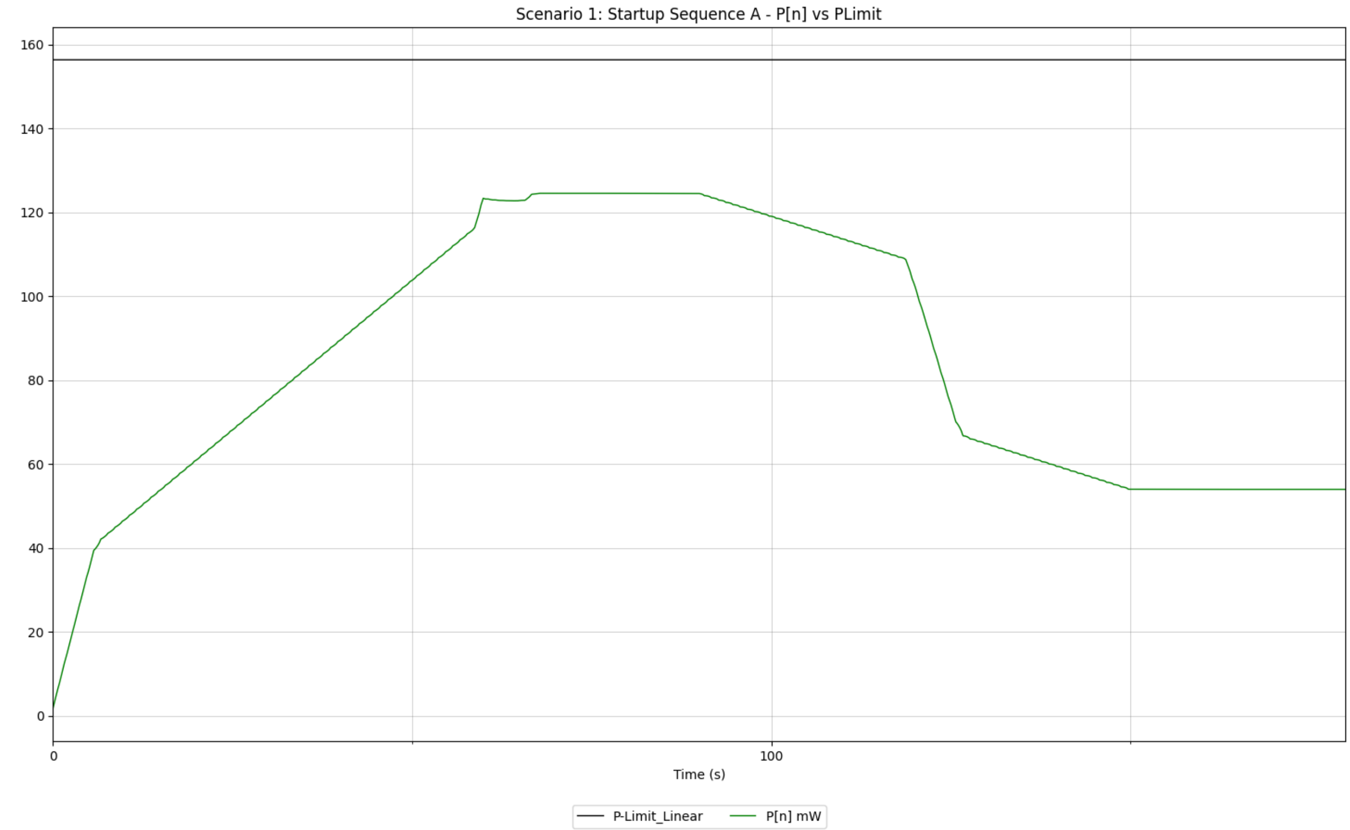
6.1.1.1 Test Case 1: FR-1 TDD Start-up Sequence A[2]

Figure 6-1: FR-1 TDD n77 (Block C) Start-up Sequence A (Conducted)



[2] P_{Max} and P_{Limit} were adjusted to an operating 67% duty cycle.

Figure 6-2: FR-1 TDD n77 (Block C) P[n] vs. P_{Limit} Sequence A Validation (Conducted)



P[n] was calculated using the 60 second time-averaging duration.

6.1.2 Test Cases 2-10: Start-up Sequence B

6.1.2.1 Test Case 2: GSM Start-up Sequence B

Figure 6-3: GSM Start-up Sequence B (Conducted)

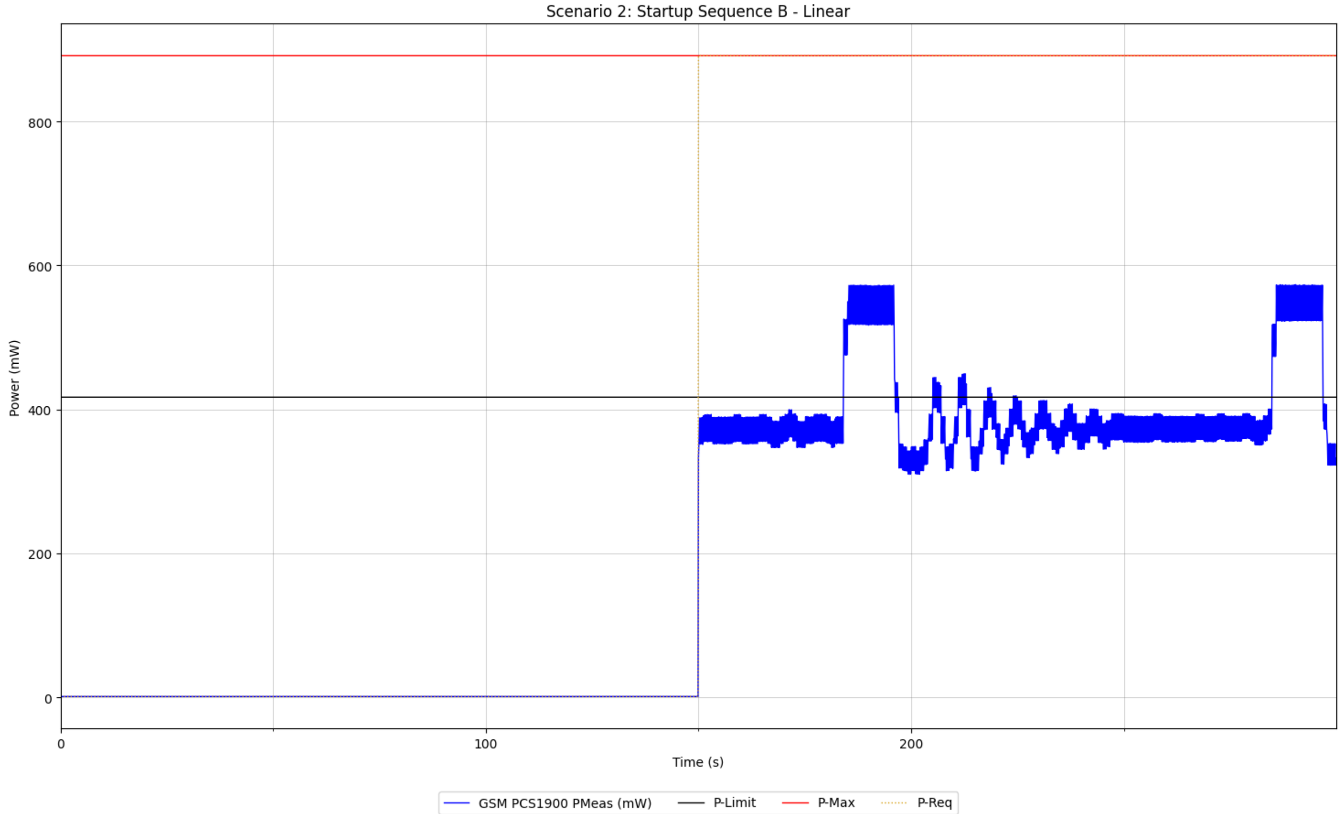
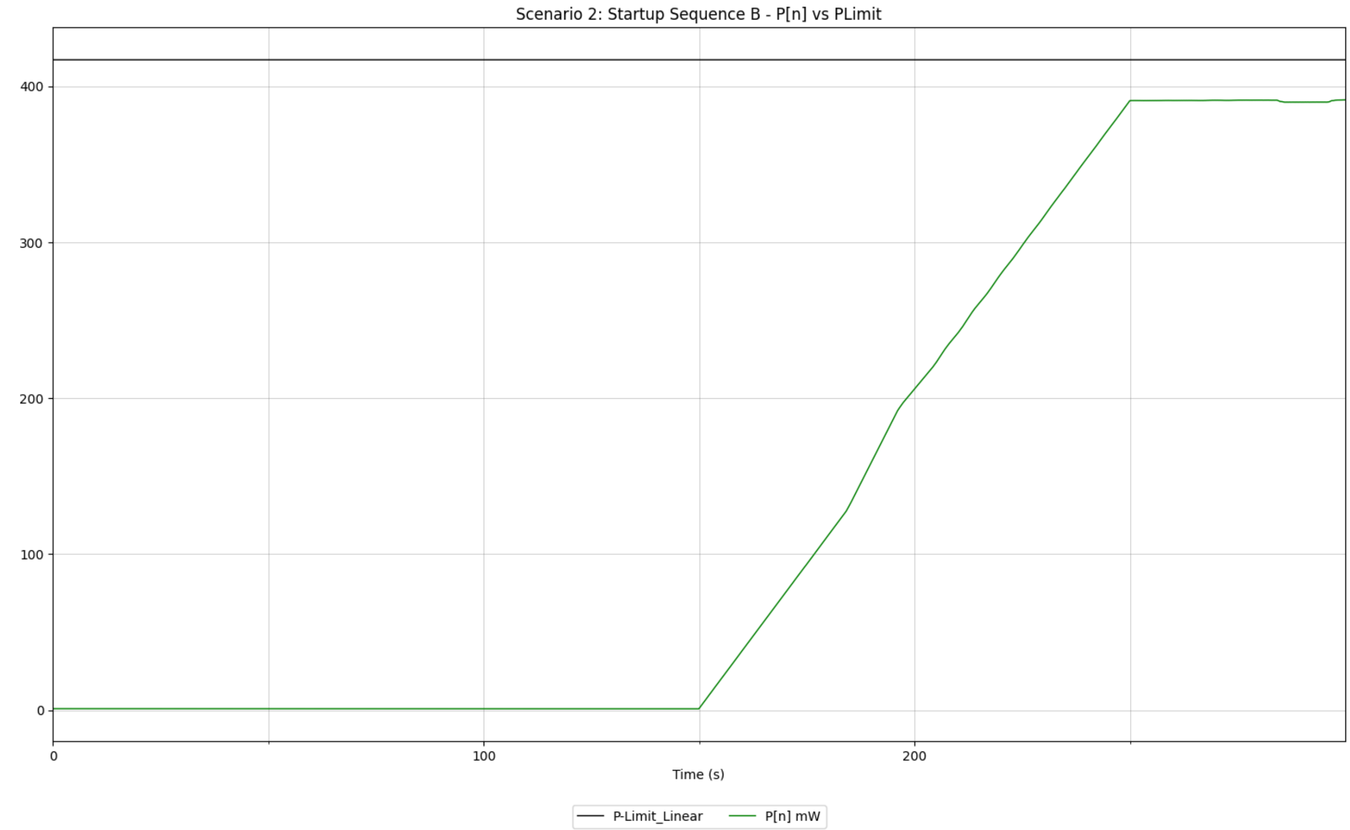


Figure 6-4: GSM P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

6.1.2.2 Test Case 3: W-CDMA Start-up Sequence B

Figure 6-5: W-CDMA Start-up Sequence B (Conducted)

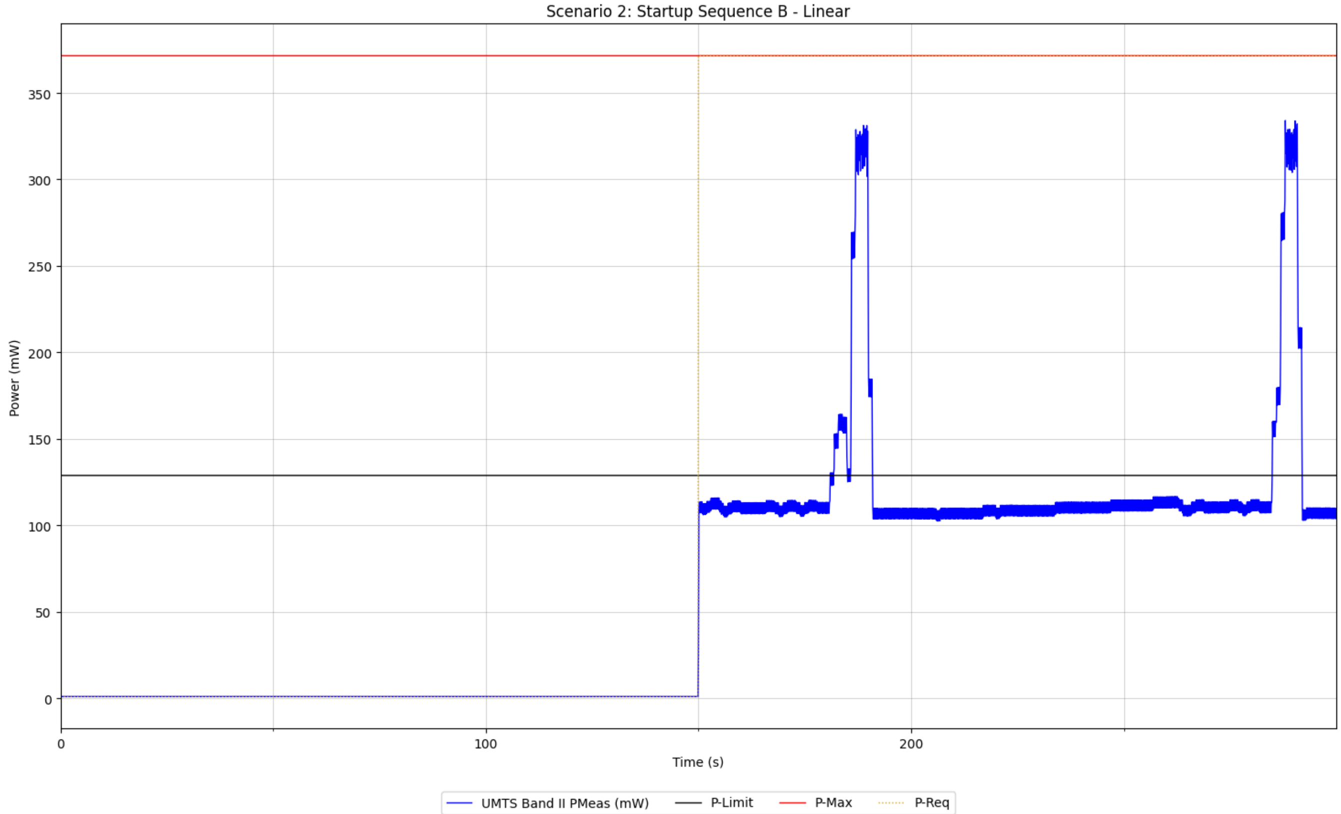
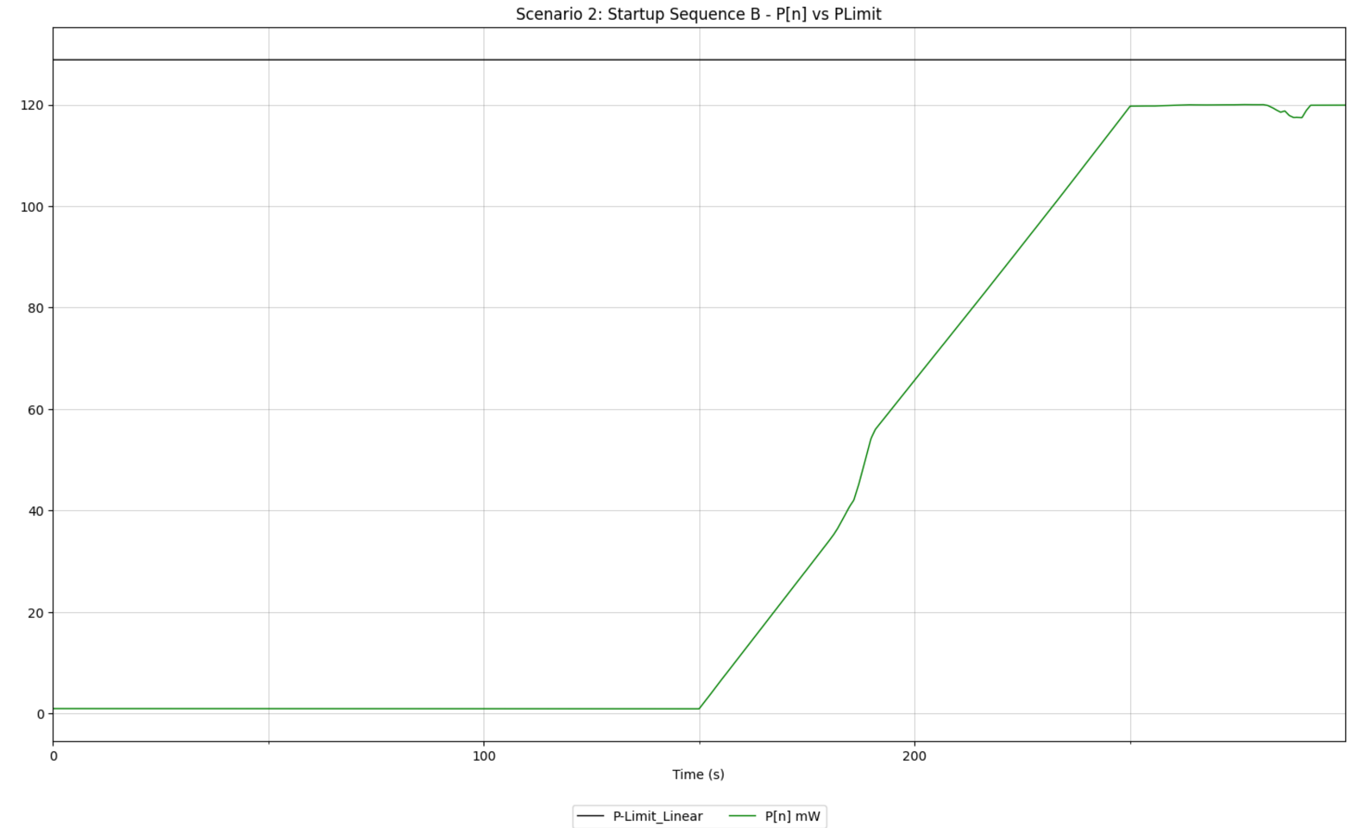


Figure 6-6: W-CDMA P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

6.1.2.3 Test Case 4: LTE FDD Start-up Sequence B

Figure 6-7: LTE FDD Start-up Sequence B (Conducted)

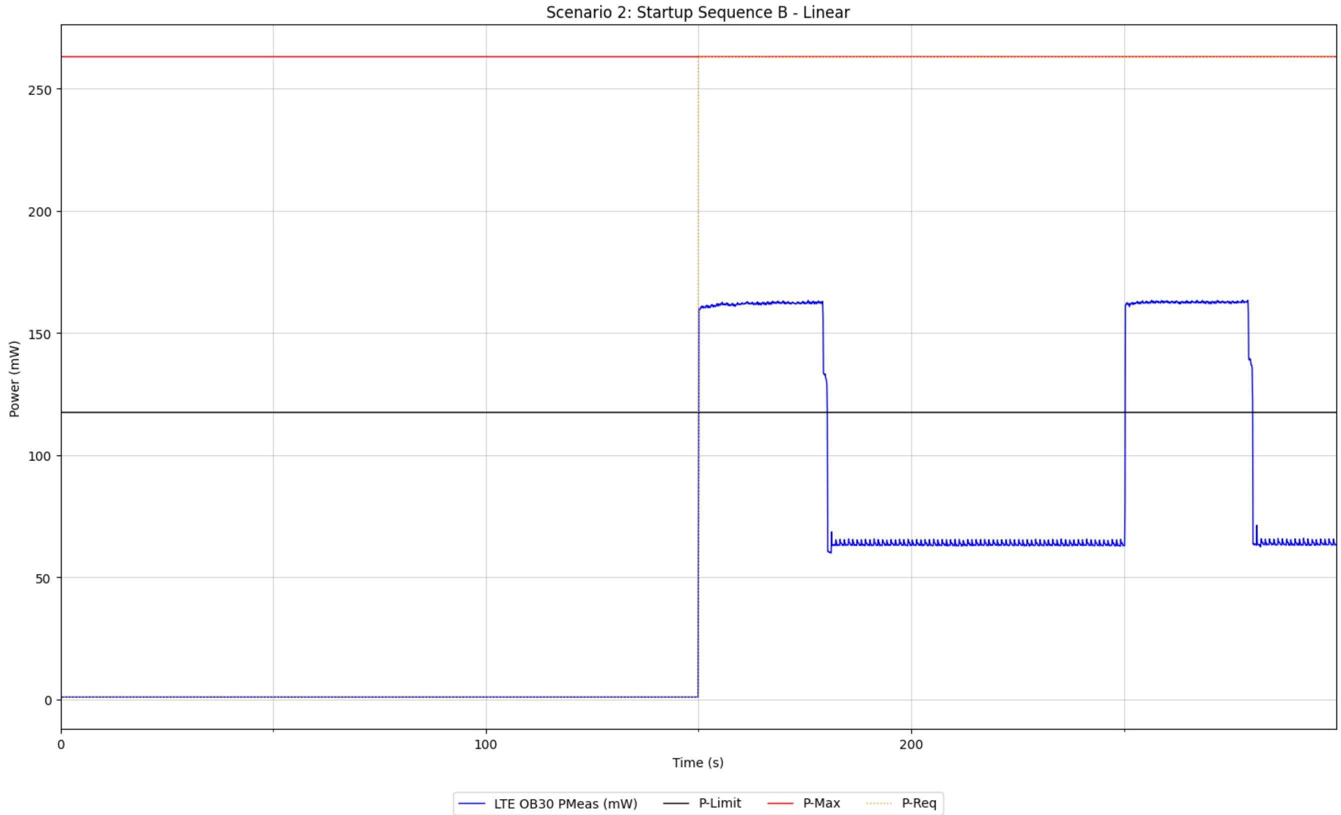
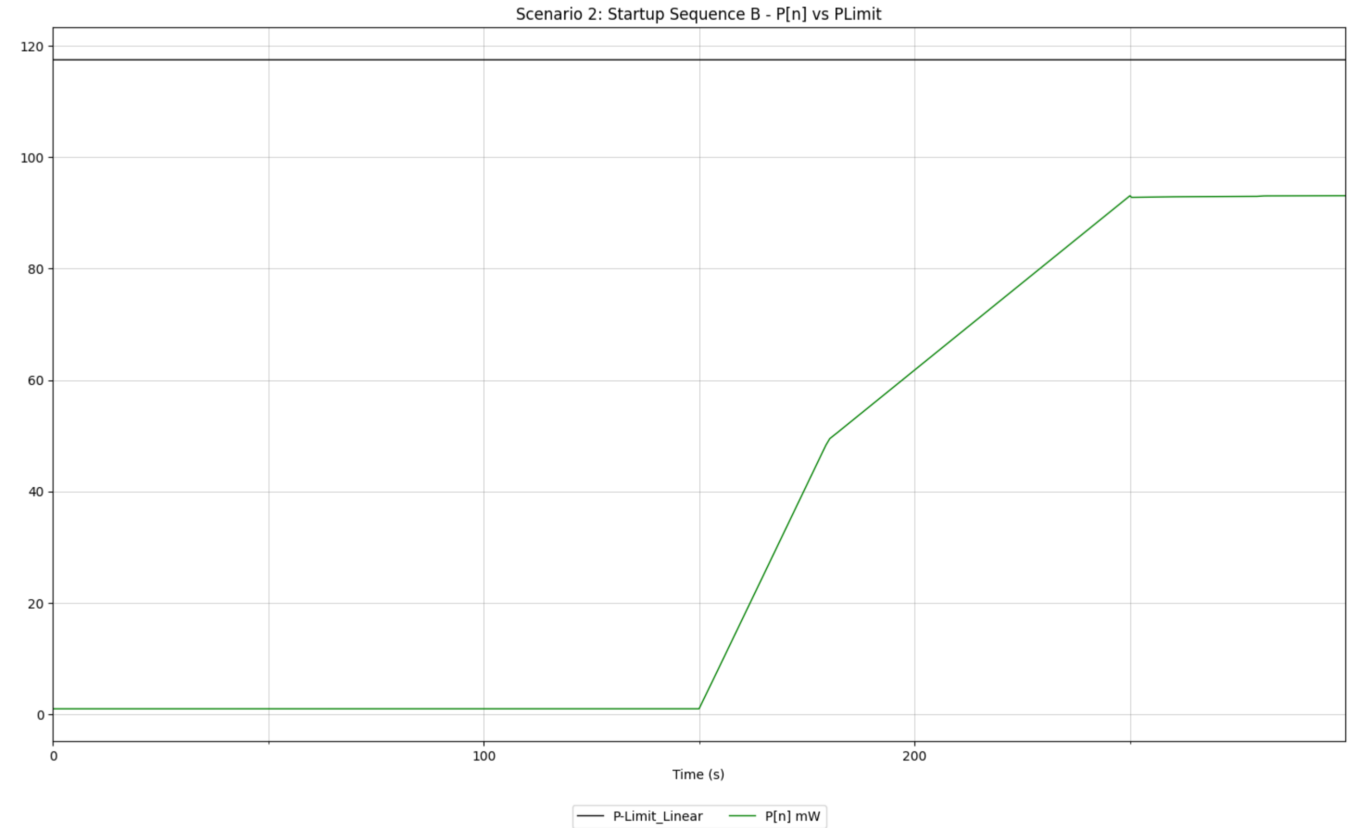


Figure 6-8: LTE FDD P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

6.1.2.4 Test Case 5: LTE TDD Start-up Sequence B

Figure 6-9: LTE TDD Start-up Sequence B (Conducted)

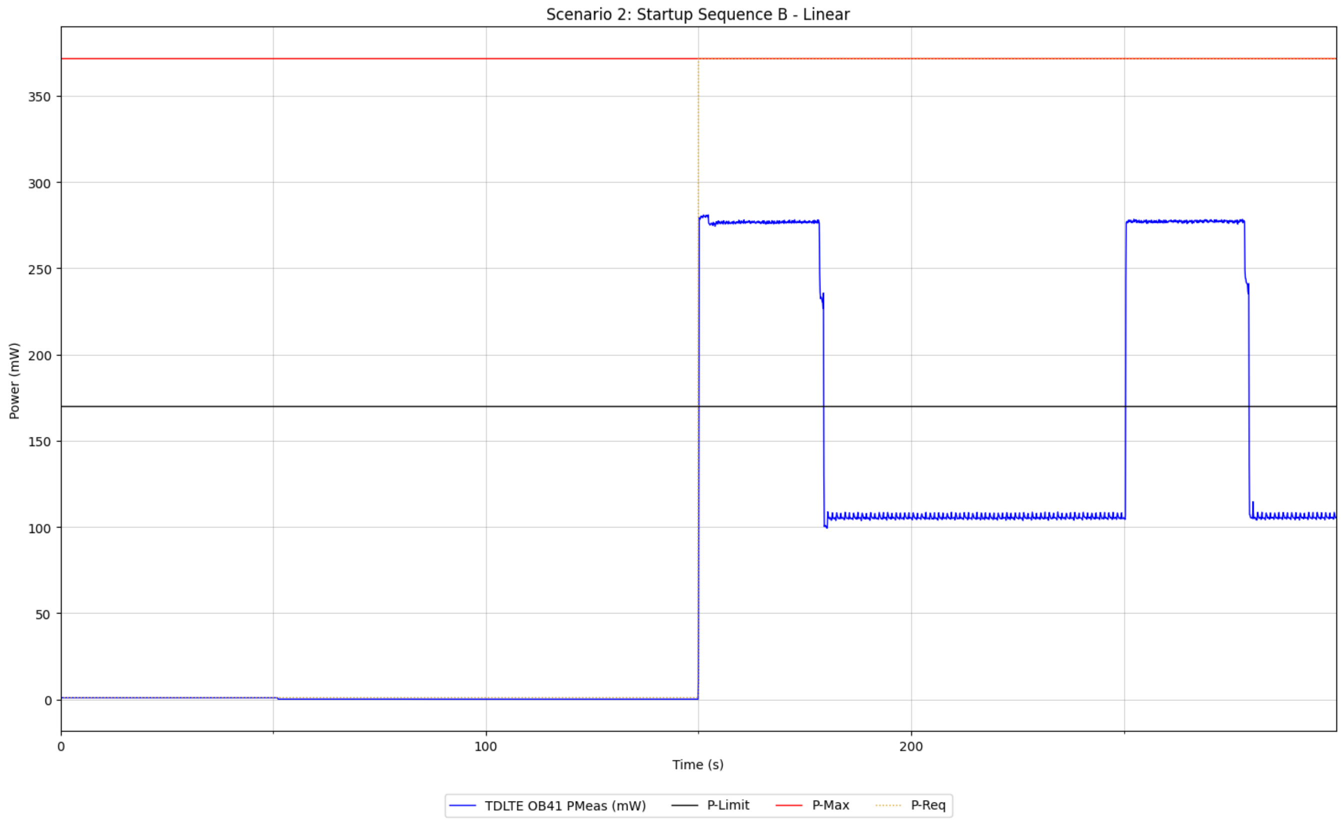
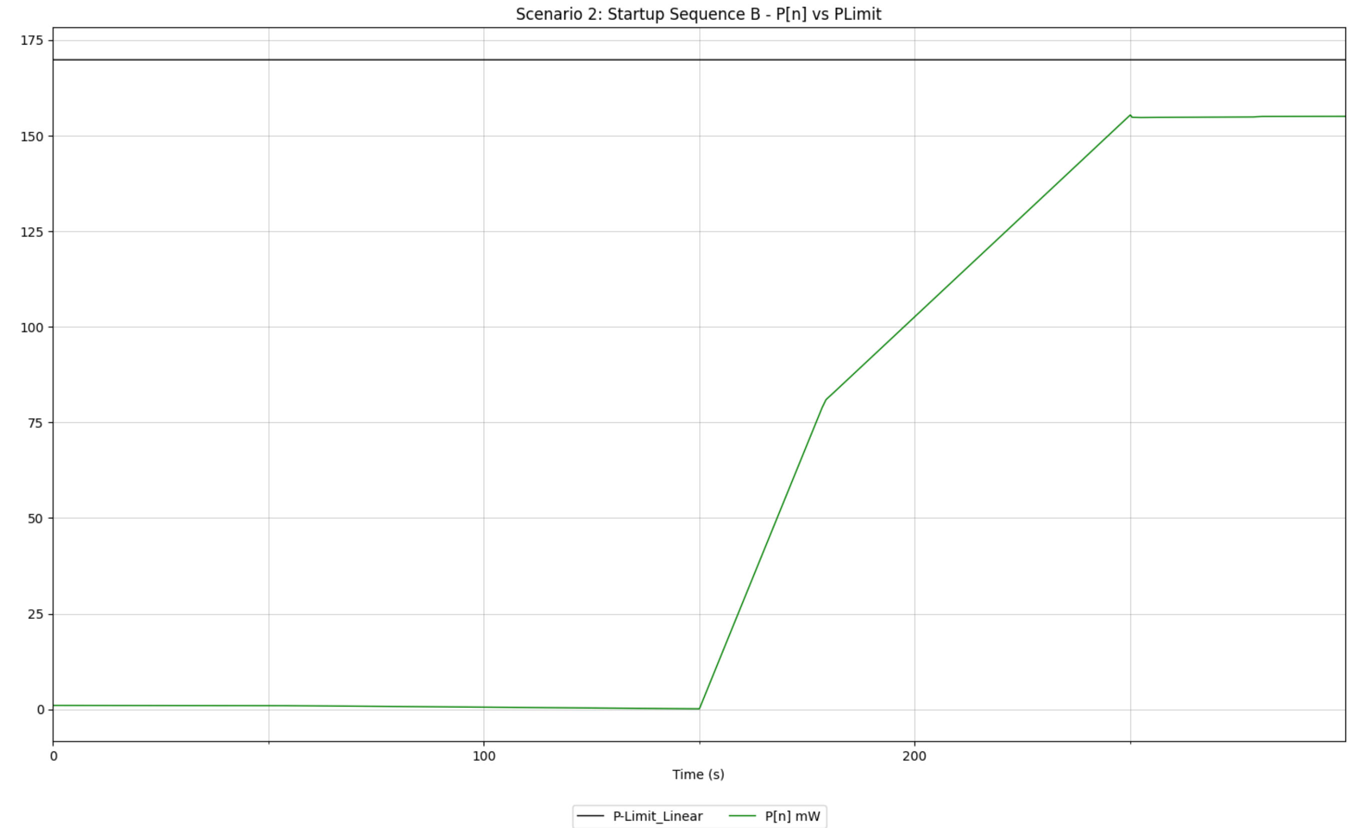


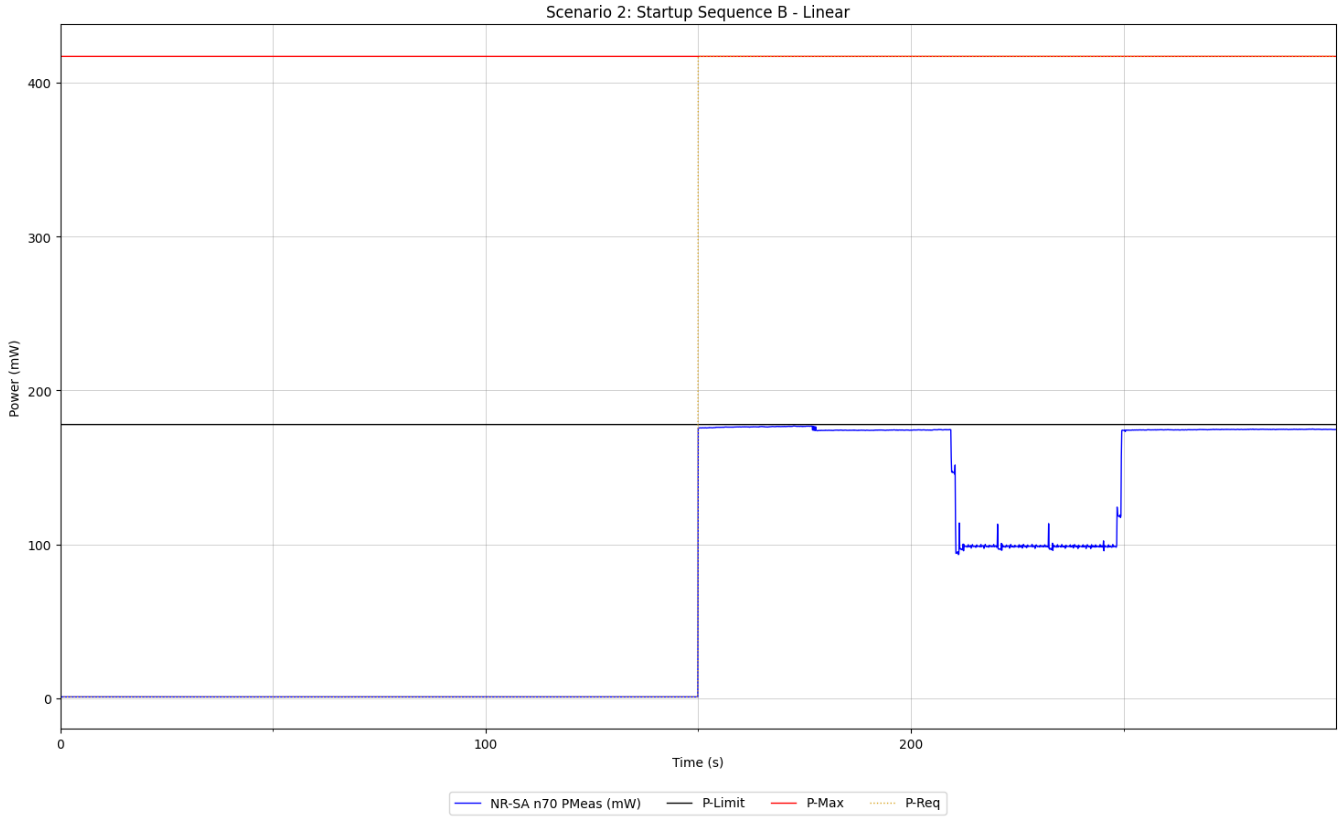
Figure 6-10: LTE TDD P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

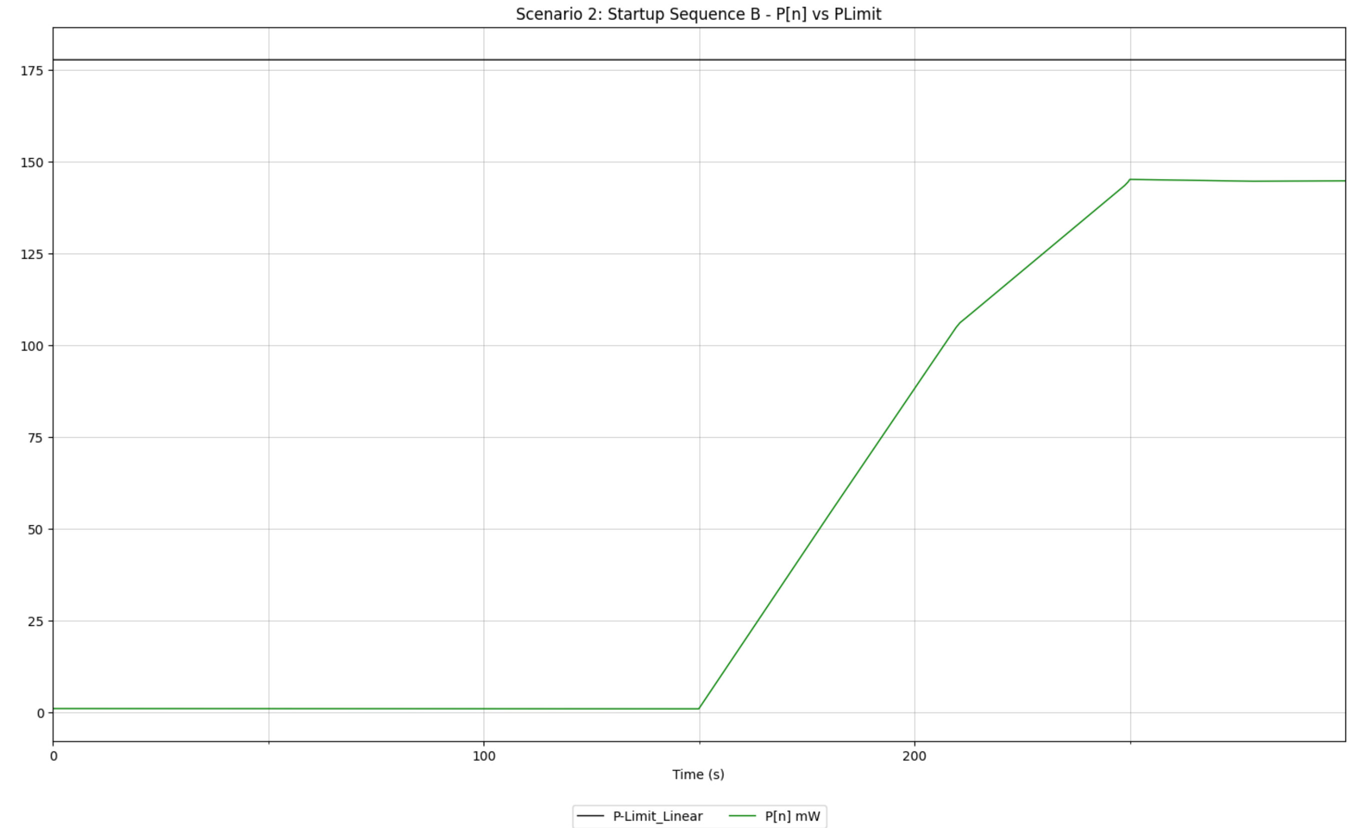
6.1.2.5 Test Case 6: FR-1 FDD Start-up Sequence B[3]

Figure 6-11: FR-1 FDD Start-up Sequence B (Conducted)



[3] P_{Max} and P_{Limit} were adjusted to an operating 90% duty cycle.

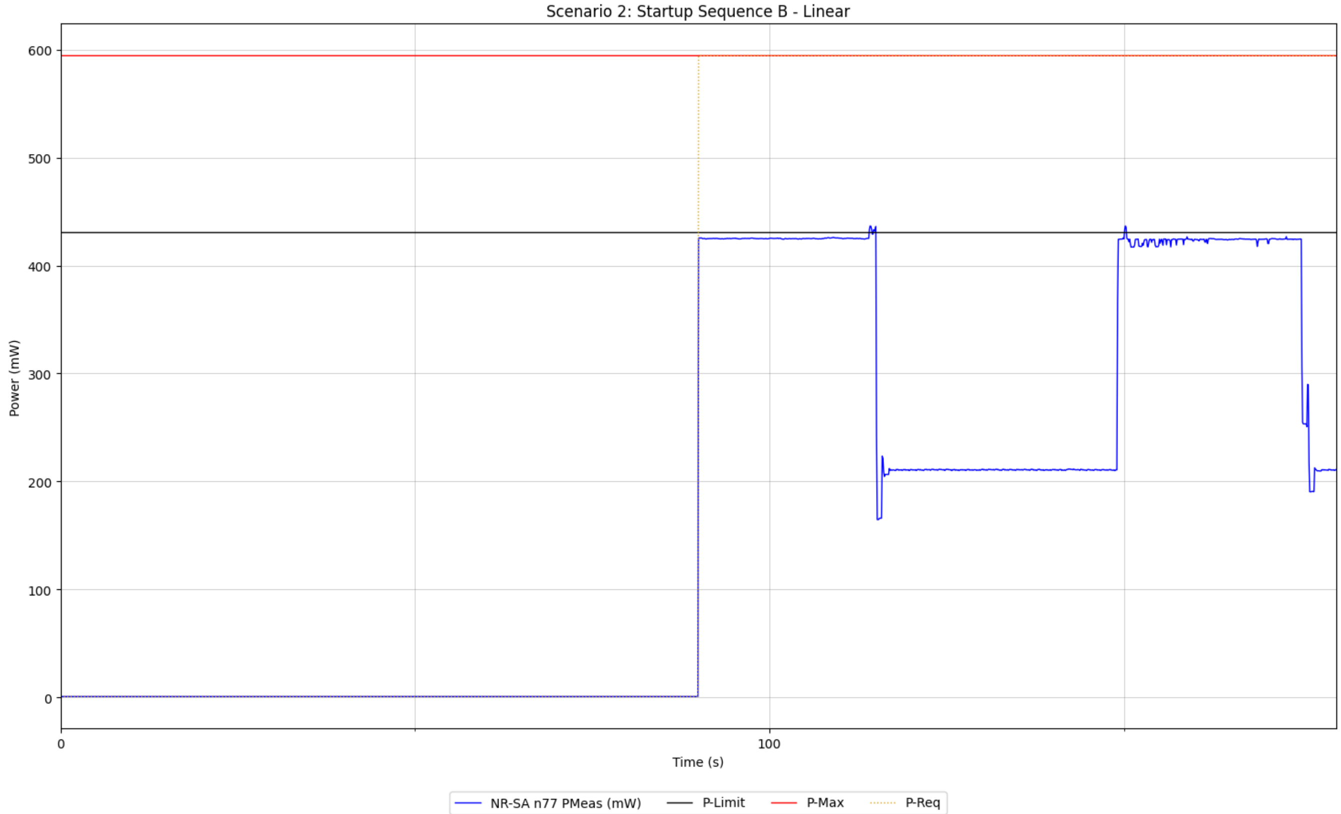
Figure 6-12: FR-1 FDD P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

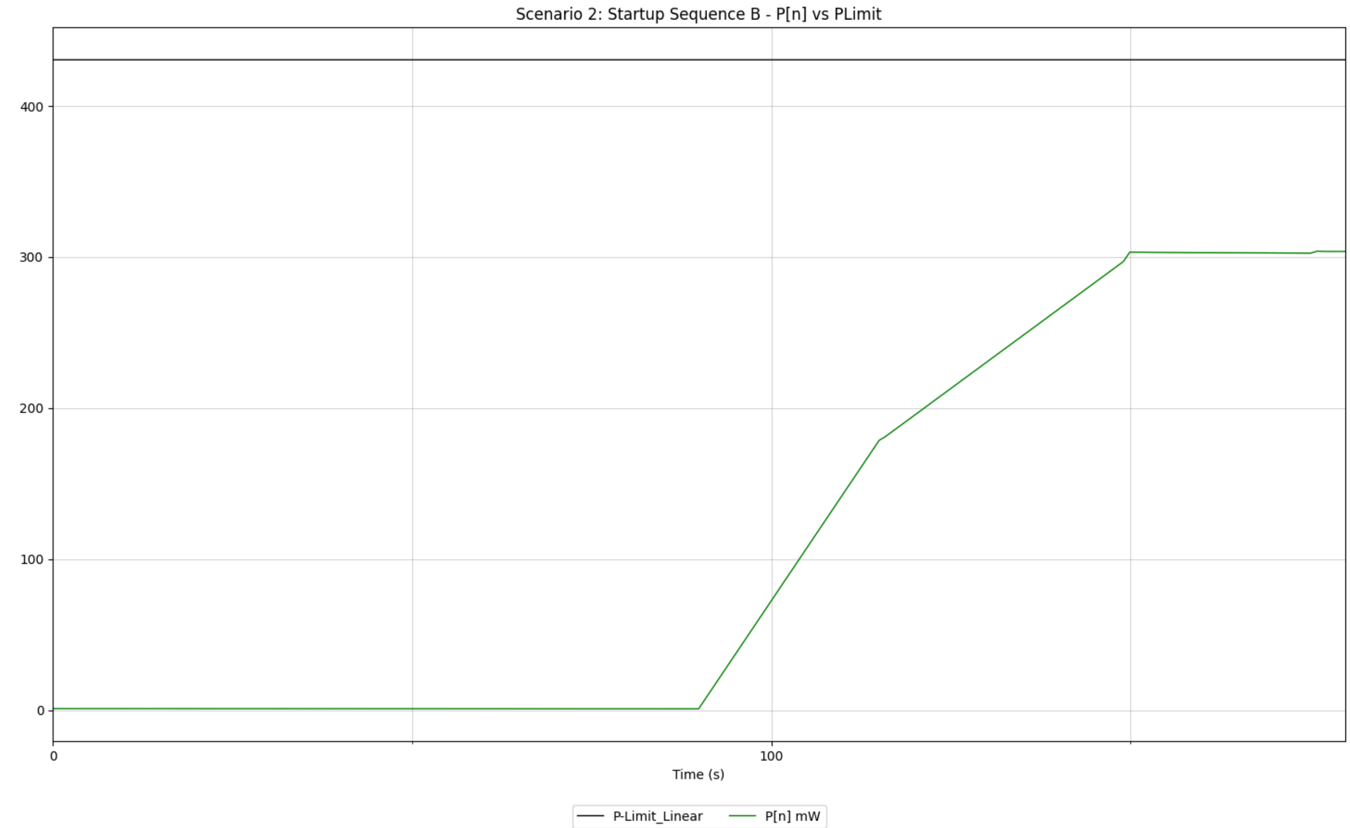
6.1.2.6 Test Case 7: FR-1 TDD Start-up Sequence B[4]

Figure 6-13: FR-1 TDD Start-up Sequence B (Conducted)



[4] P_{Max} and P_{Limit} were adjusted to an operating 67% duty cycle.

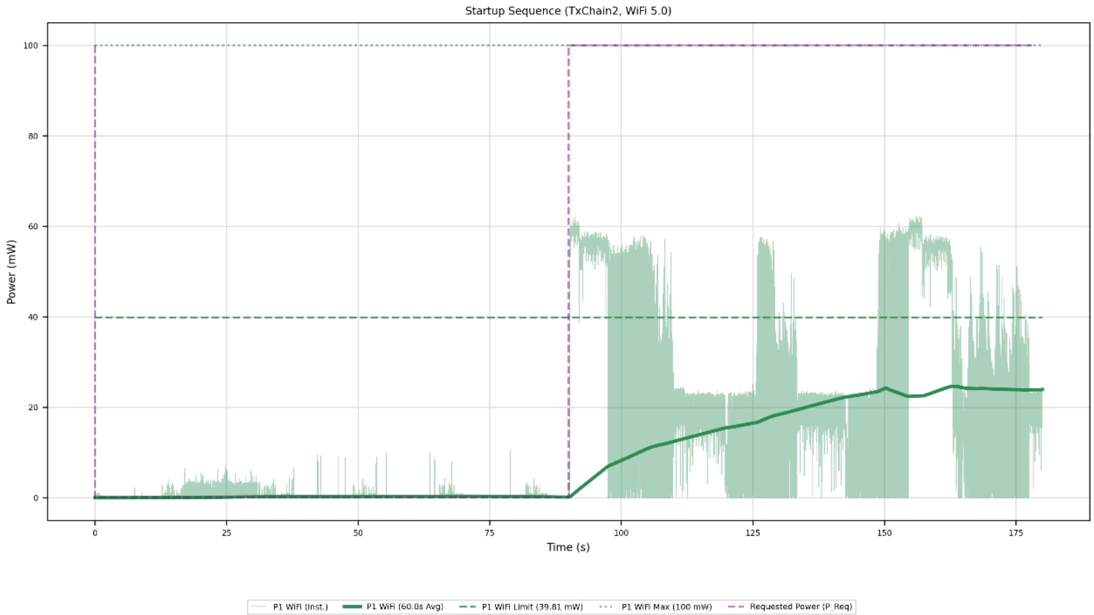
Figure 6-14: FR-1 TDD P[n] vs. P_{Limit} Sequence B Validation (Conducted)



P[n] was calculated using the 60 second time-averaging duration.

6.1.2.7 Test Case 8: Wi-Fi 5 GHz Start-up Sequence B

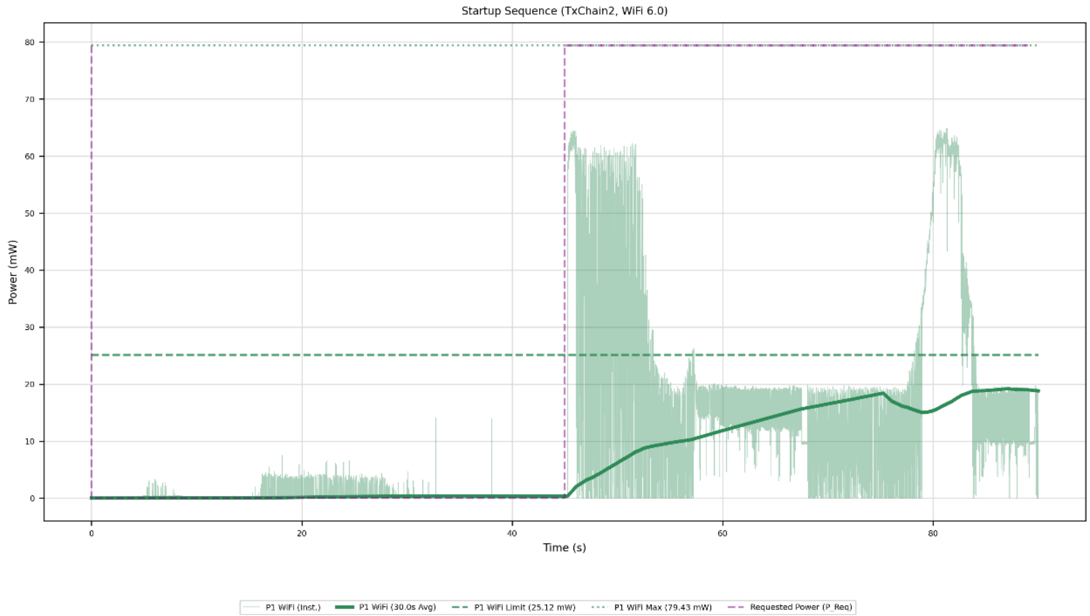
Figure 6-15: Wi-Fi 5 GHz Start-up Sequence B and P[n] vs. P_{Limit} (Conducted)



P[n] was calculated using the 60 second time-averaging duration.

6.1.2.8 Test Case 9: Wi-Fi 6 GHz Start-up Sequence B

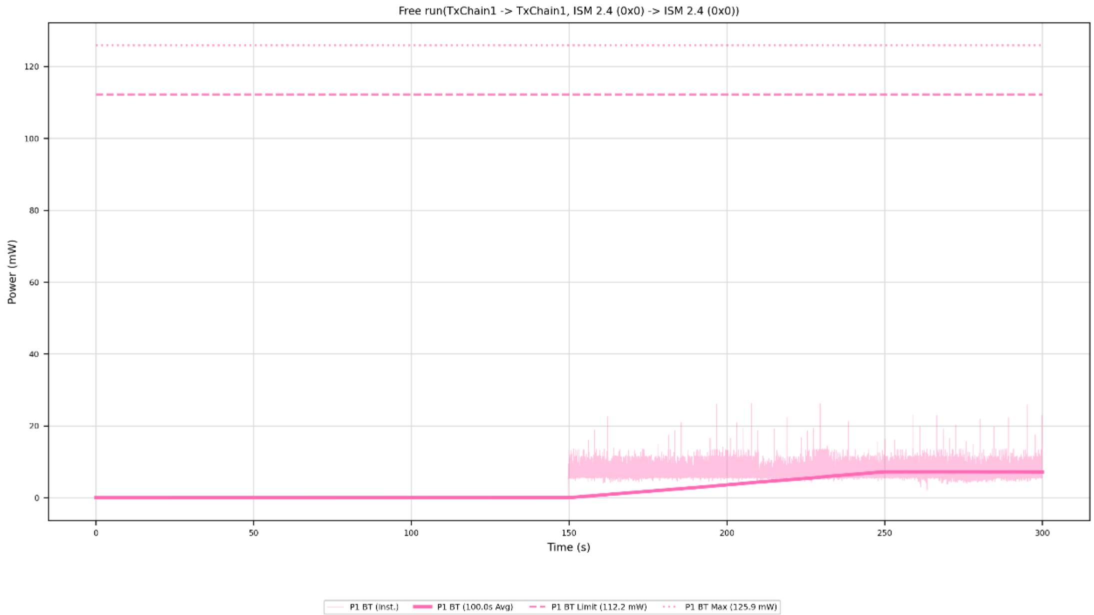
Figure 6-16: Wi-Fi 6 GHz Start-up Sequence B and P[n] vs. P_{Limit} (Conducted)



P[n] was calculated using the 30 second time-averaging duration.

6.1.2.9 Test Case 10: Bluetooth 2.4 GHz Start-up Sequence B

Figure 6-17: Bluetooth 2.4 GHz Start-up Sequence B and P[n] vs. P_{Limit} (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

6.1.3 Pseudo-random Sequence

6.1.3.1 Test Case 11: LTE FDD Pseudo-random Sequence

Figure 6-18: LTE FDD Pseudo-random Sequence (Conducted)

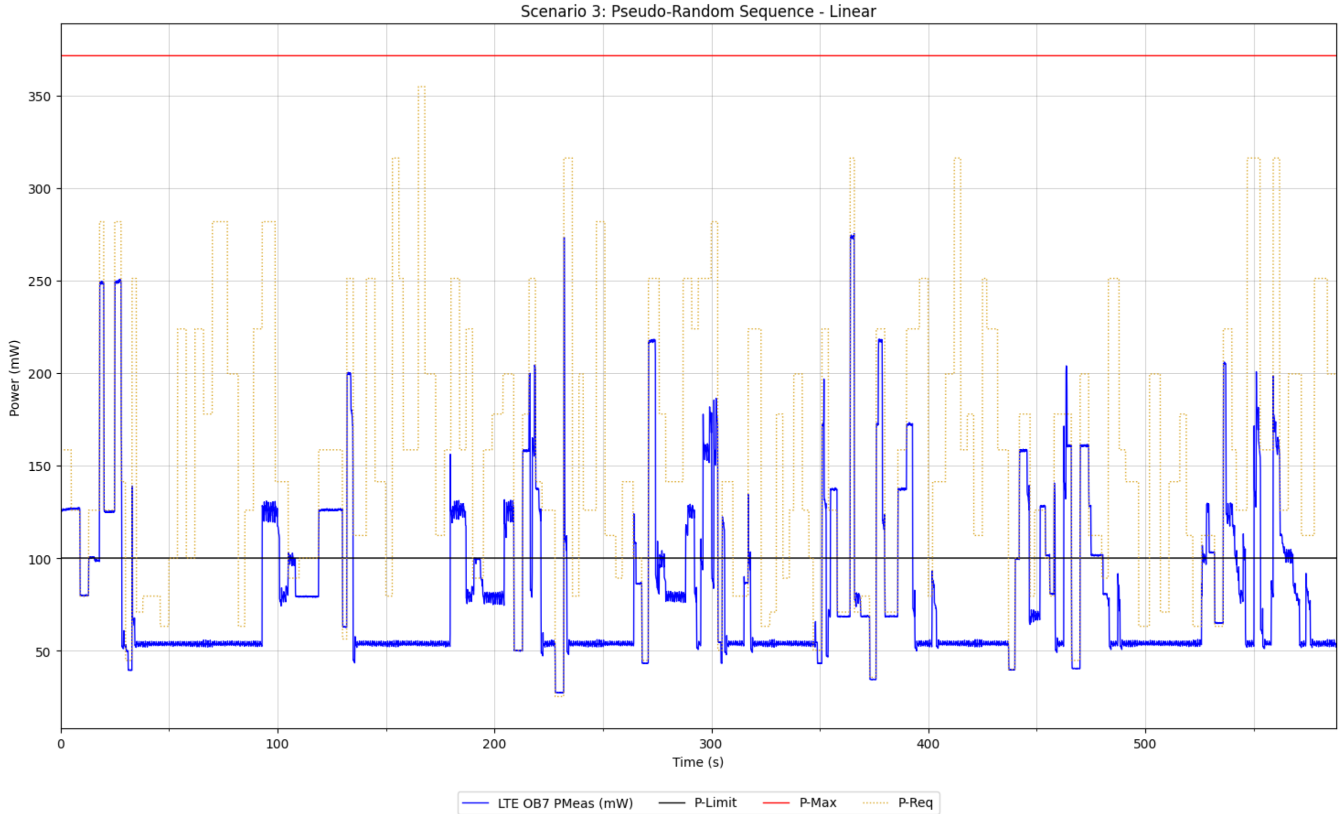
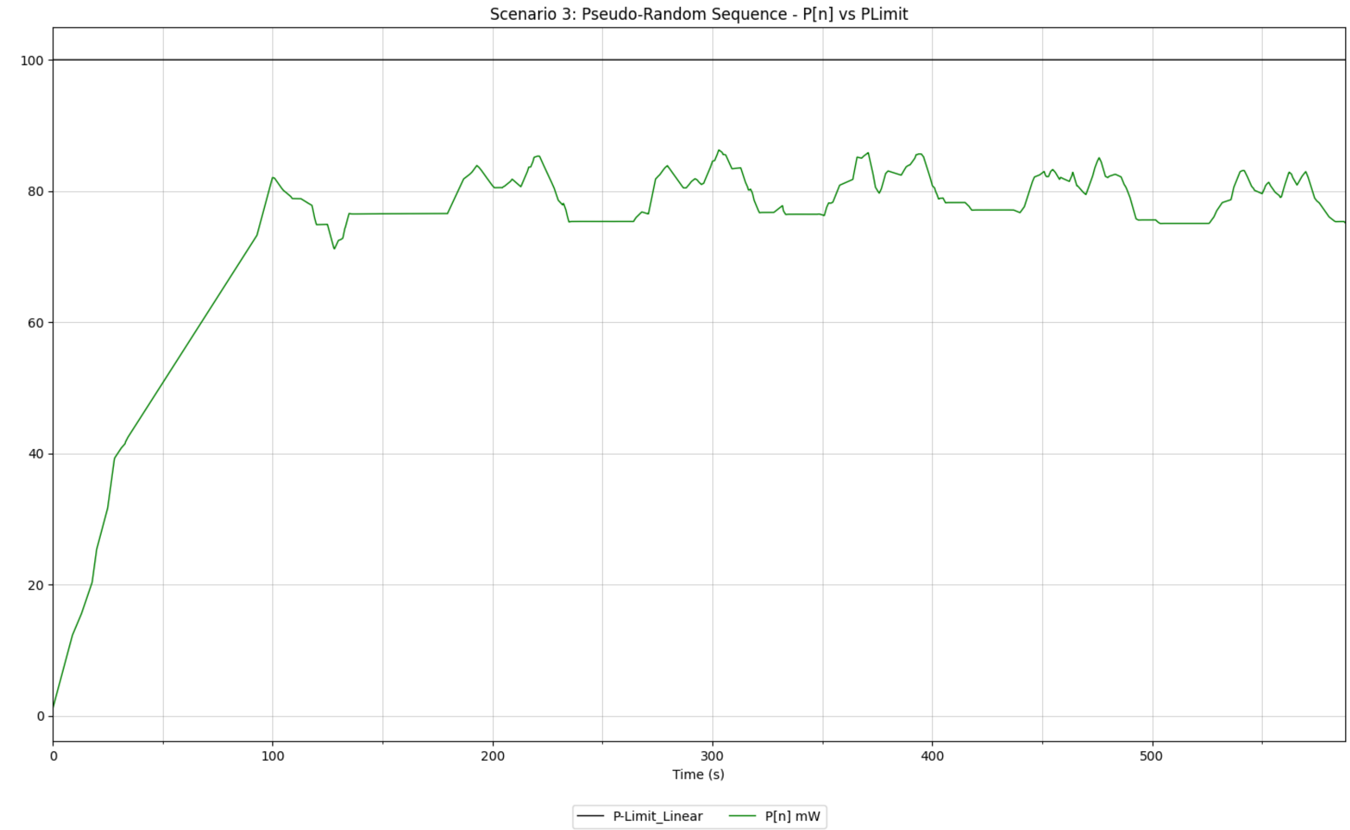


Figure 6-19: LTE FDD P[n] vs. P_{Limit} Pseudo-random Sequence Validation (Conducted)



P[n] was calculated using the 100 second time-averaging duration.

Table 6-1: LTE FDD T_{req} vs. P_{req} (Conducted)

Time (s)	T_{Req} (s)	P_{Req} (dBm)	P_{Req} (mW)	Time (s)	T_{Req} (s)	P_{Req} (dBm)	P_{Req} (mW)	Time (s)	T_{Req} (s)	P_{Req} (dBm)	P_{Req} (mW)
0	5	22.0	158.5	195	4	22.0	158.5	380	6	18.5	70.8
5	4	21.0	125.9	199	5	22.5	177.8	386	4	22.0	158.5
9	4	19.0	79.4	204	5	23.0	199.5	390	6	23.5	223.9
13	5	21.0	125.9	209	4	17.0	50.1	396	4	24.0	251.2
18	2	24.5	281.8	213	3	22.5	177.8	400	2	19.0	79.4
20	5	21.0	125.9	216	3	24.0	251.2	402	6	21.5	141.3
25	3	24.5	281.8	219	3	21.5	141.3	408	4	23.0	199.5
28	2	21.5	141.3	222	4	21.0	125.9	412	3	25.0	316.2
30	3	16.5	44.7	226	2	21.0	125.9	415	3	22.0	158.5
33	2	24.0	251.2	228	4	14.0	25.1	418	3	22.5	177.8
35	3	18.5	70.8	232	4	25.0	316.2	421	4	20.5	112.2
38	3	19.0	79.4	236	3	19.0	79.4	425	2	24.0	251.2
41	5	19.0	79.4	239	2	23.0	199.5	427	5	23.5	223.9
46	4	18.0	63.1	241	6	21.0	125.9	432	5	22.0	158.5
50	4	20.0	100.0	247	4	24.5	281.8	437	3	16.0	39.8
54	4	23.5	223.9	251	5	20.5	112.2	440	2	20.0	100.0
58	4	20.0	100.0	256	3	19.5	89.1	442	5	22.5	177.8
62	4	23.5	223.9	259	5	21.5	141.3	447	2	19.0	79.4
66	4	22.5	177.8	264	4	20.0	100.0	449	5	21.0	125.9
70	4	24.5	281.8	268	3	16.5	44.7	454	2	20.0	100.0
74	3	24.5	281.8	271	5	24.0	251.2	456	2	19.0	79.4
77	5	23.0	199.5	276	3	22.5	177.8	458	4	22.5	177.8
82	3	18.0	63.1	279	3	21.5	141.3	462	4	22.5	177.8
85	4	21.0	125.9	282	5	21.5	141.3	466	4	16.5	44.7
89	4	23.5	223.9	287	4	24.0	251.2	470	4	23.0	199.5
93	6	24.5	281.8	291	3	23.5	223.9	474	6	20.5	112.2
99	6	21.5	141.3	294	6	24.0	251.2	480	3	19.5	89.1
105	5	19.5	89.1	300	3	24.5	281.8	483	5	24.0	251.2
110	3	20.0	100.0	303	2	17.0	50.1	488	3	22.0	158.5
113	6	20.0	100.0	305	5	21.5	141.3	491	6	21.5	141.3
119	6	22.0	158.5	310	3	19.0	79.4	497	5	18.0	63.1
125	5	22.0	158.5	313	4	19.0	79.4	502	5	23.0	199.5
130	2	17.5	56.2	317	6	23.5	223.9	507	4	18.5	70.8
132	3	24.0	251.2	323	4	18.0	63.1	511	5	21.5	141.3
135	6	20.5	112.2	327	3	18.5	70.8	516	3	22.5	177.8
141	4	24.0	251.2	330	3	22.5	177.8	519	3	20.5	112.2
145	5	21.5	141.3	333	3	19.5	89.1	522	4	18.0	63.1
150	3	19.0	79.4	336	2	21.0	125.9	526	6	20.5	112.2
153	3	25.0	316.2	338	4	23.0	199.5	532	4	18.0	63.1
156	2	24.0	251.2	342	3	21.0	125.9	536	4	23.5	223.9
158	4	22.0	158.5	345	2	20.0	100.0	540	2	22.0	158.5
162	3	22.0	158.5	347	4	17.0	50.1	542	5	21.0	125.9
165	3	25.5	354.8	351	3	23.5	223.9	547	6	25.0	316.2
168	5	23.0	199.5	354	4	21.0	125.9	553	6	22.0	158.5
173	4	20.5	112.2	358	6	18.5	70.8	559	3	25.0	316.2
177	3	22.0	158.5	364	2	25.0	316.2	562	4	21.0	125.9
180	4	24.0	251.2	366	3	18.5	70.8	566	6	23.0	199.5
184	3	22.0	158.5	369	4	19.0	79.4	572	6	20.5	112.2
187	3	23.5	223.9	373	3	15.5	35.5	578	6	24.0	251.2
190	5	19.5	89.1	376	4	23.5	223.9	584	4	23.0	199.5

6.1.4 Test Case 12: Antenna Switching

Figure 6-20: Antenna Switch Plot (Conducted)

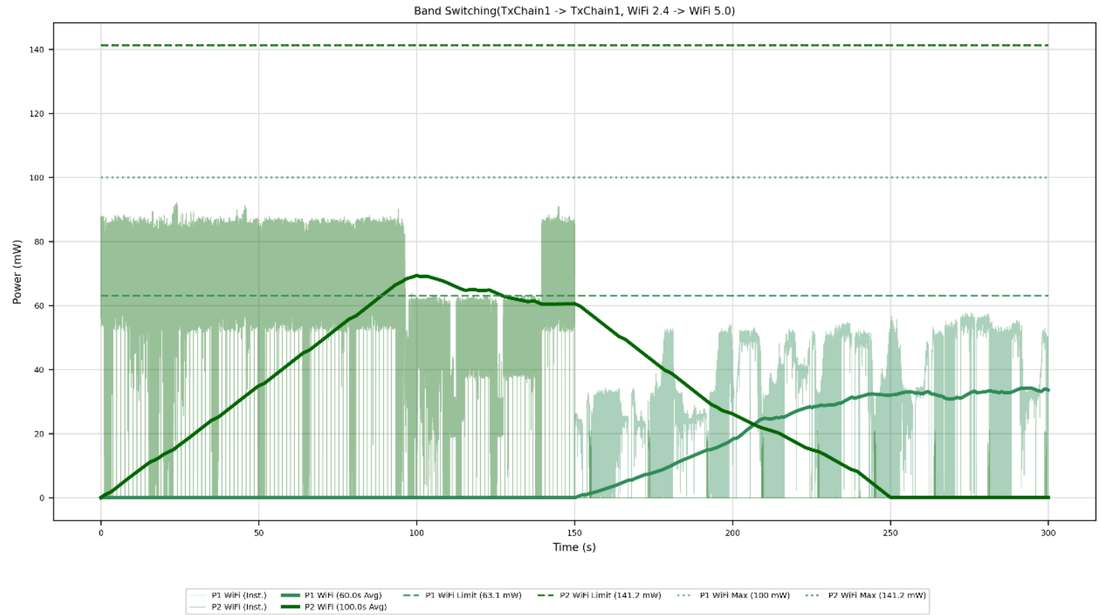
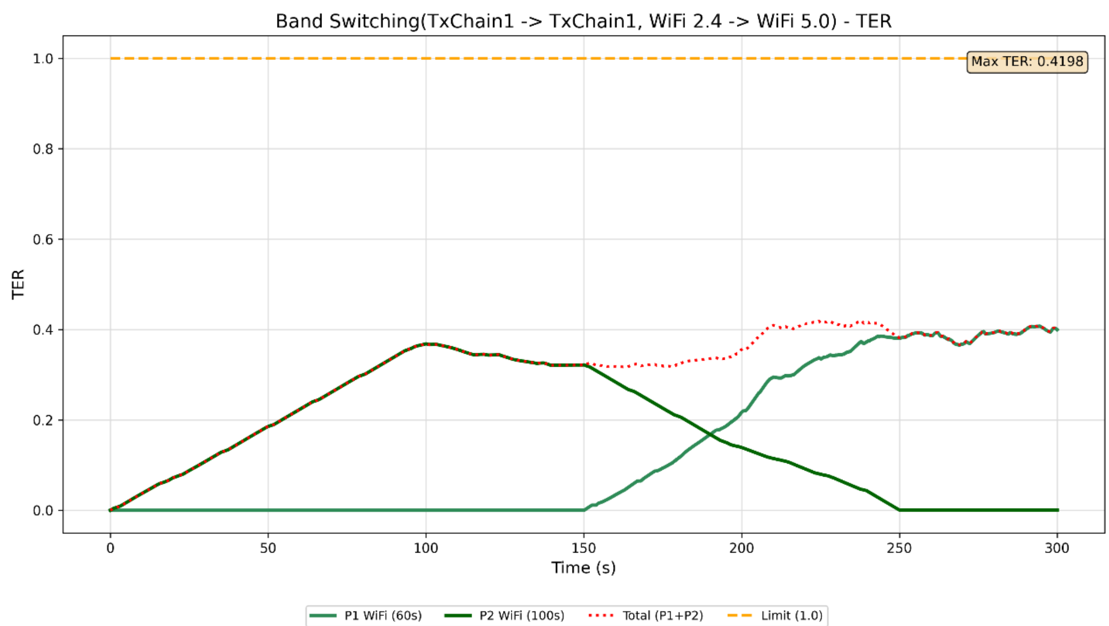


Figure 6-21: Antenna Switch Validation (Conducted)



p[n] was calculated using the sum of Wi-Fi 2.4 GHz’s 100 second time-averaging duration and Wi-Fi 5 GHz’s 60 second time-averaging duration.

6.1.5 Test Case 13: Change in Operating State

Figure 6-22: Change in Operating State Plot (Conducted)

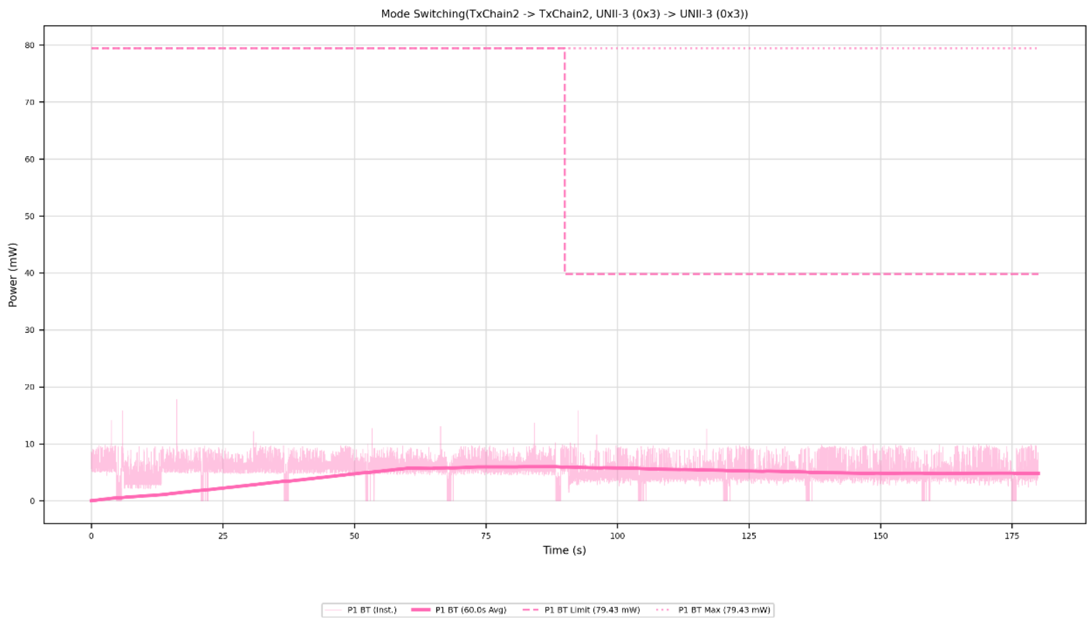
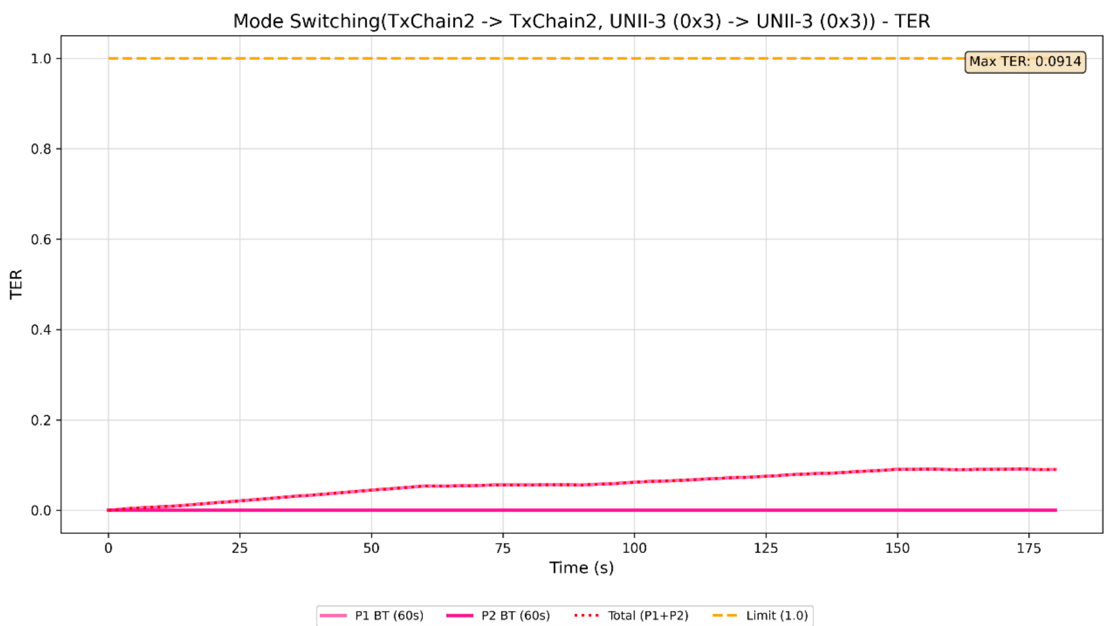


Figure 6-23: Change in Operating State Validation (Conducted)



p[n] was calculated using the sum of NB U-NII 3's 60 second time-averaging duration.

6.1.6 Test Case 14: Technology Hand-off ULCA

Figure 6-24: Technology Hand-off ULCA Test Case (Conducted)

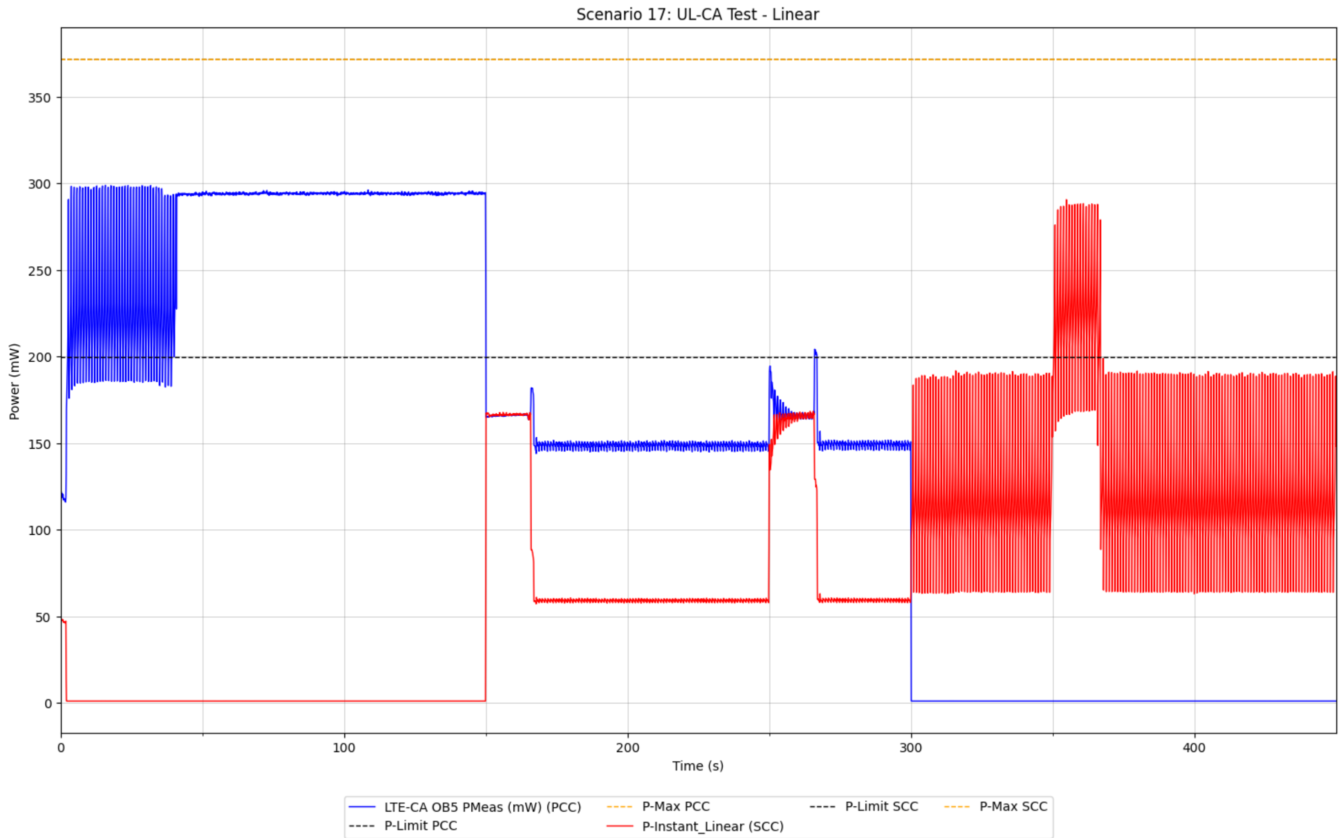
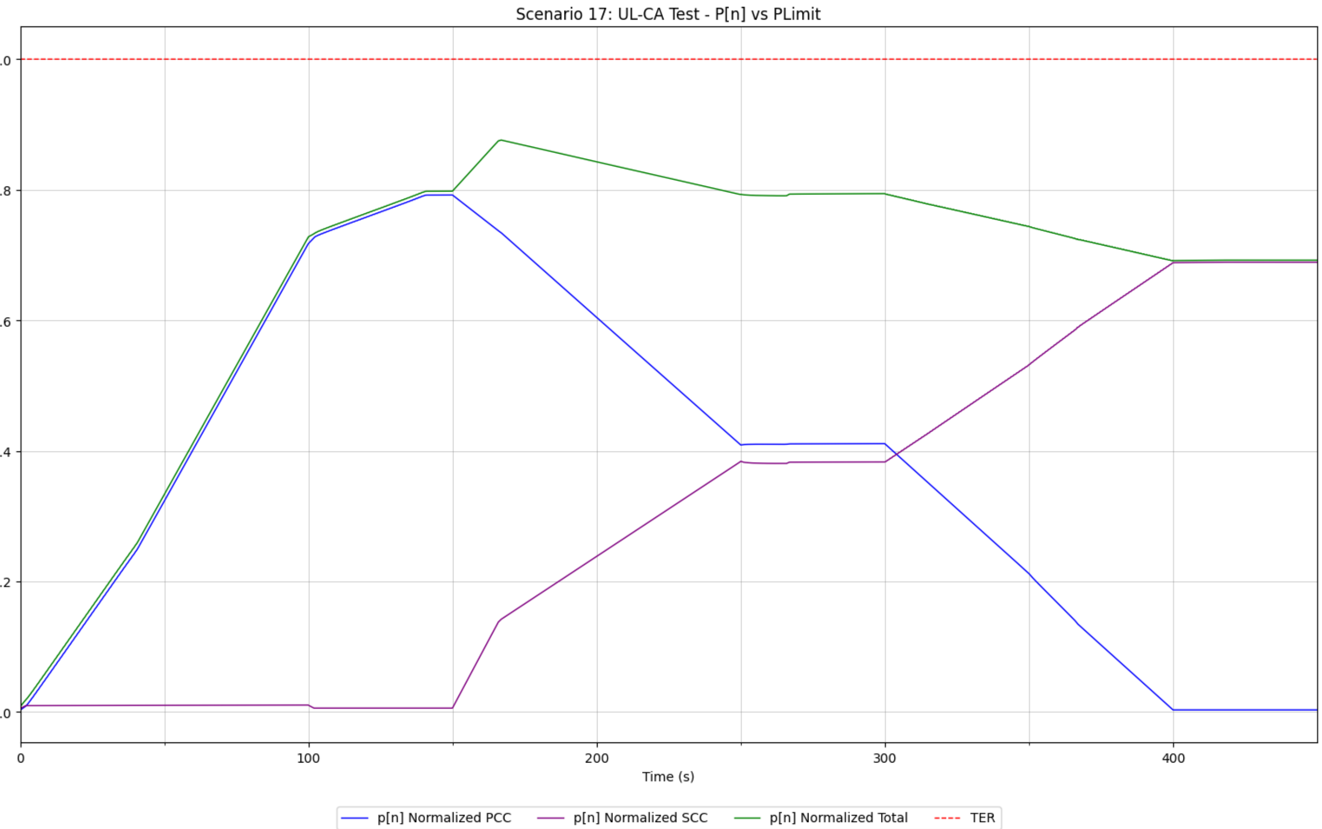


Figure 6-25: Technology Hand-off ULCA Test Case Validation (Conducted)



p[n] was calculated using the sum of LTE PCC's and LTE SCC's 100 second time-averaging duration.

6.1.7 Test Case 15: Technology Hand-off EN-DC

Figure 6-26: Technology Hand-off EN-DC (Conducted)

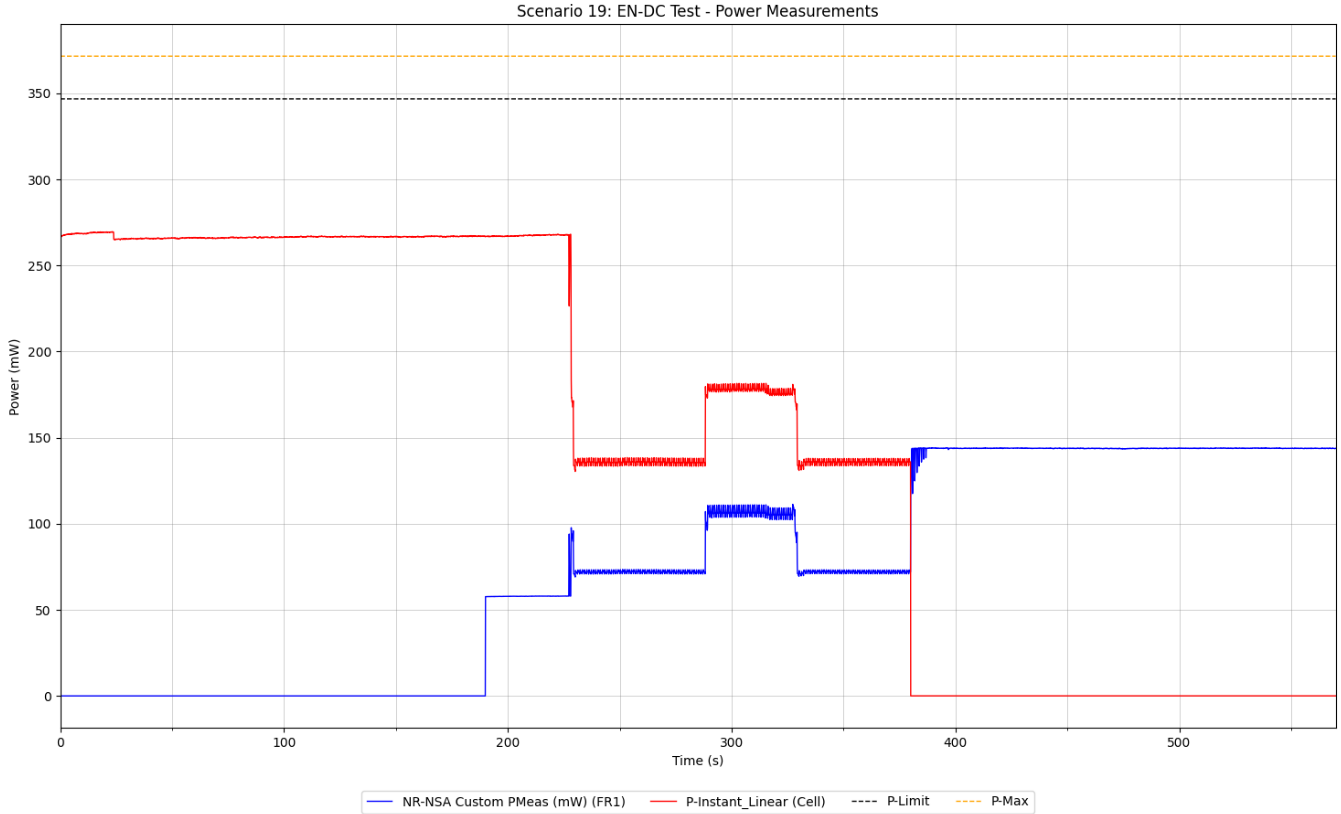
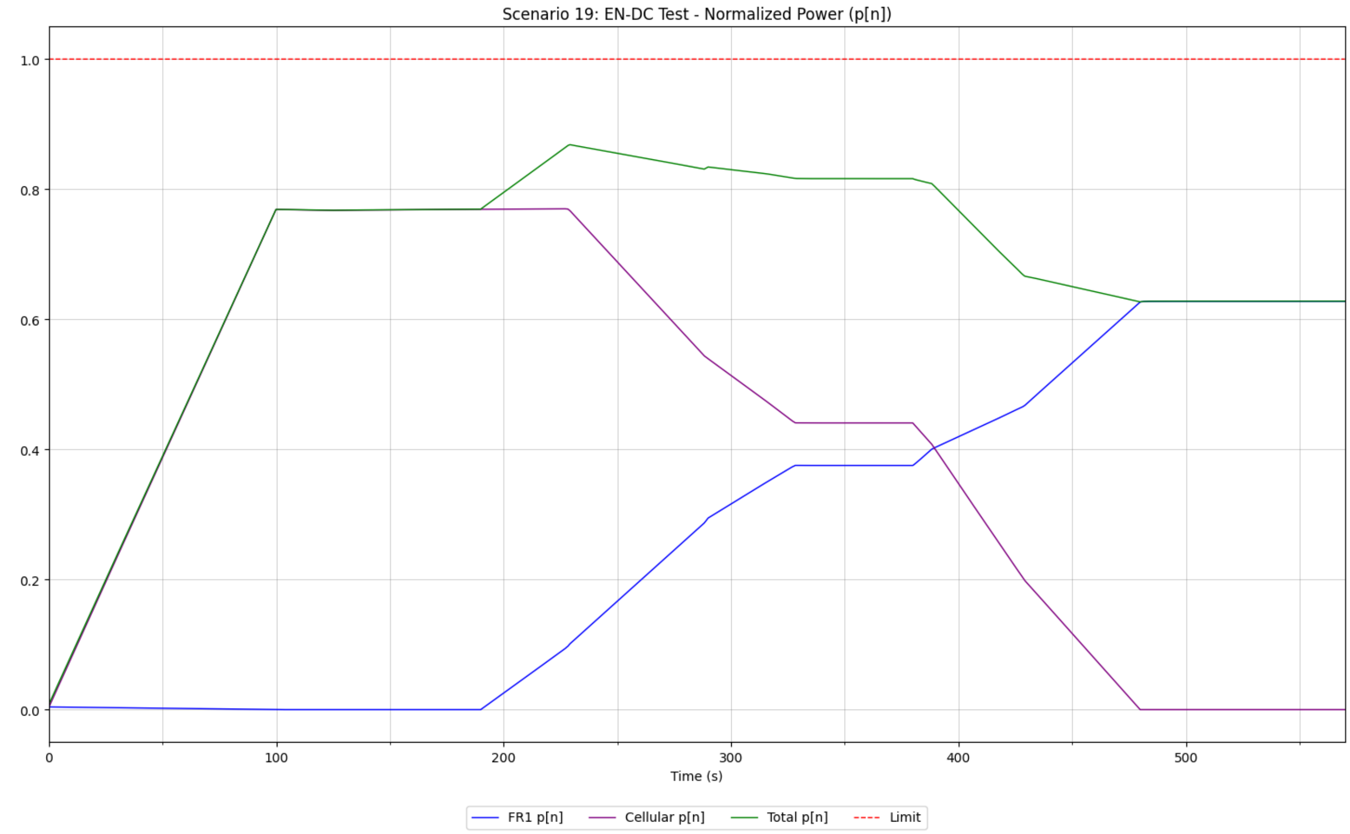


Figure 6-27: Technology Hand-off EN-DC Validation (Conducted)



p[n] was calculated using the sum of LTE's and FR-1's 100 second time-averaging duration.

6.1.8 Test Case 16: Switching Between Duplexes

Figure 6-28: Switching Between Duplexes Test Case (Conducted)

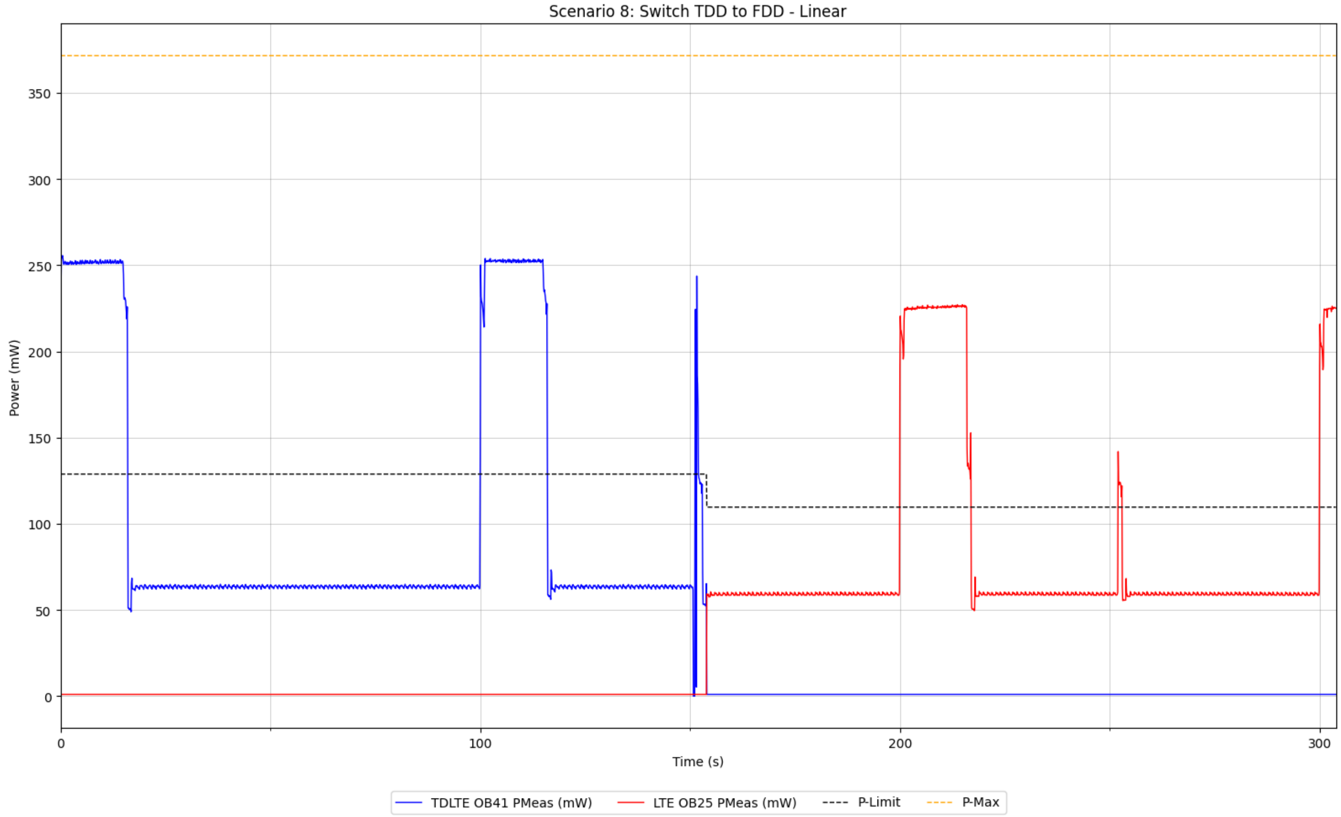
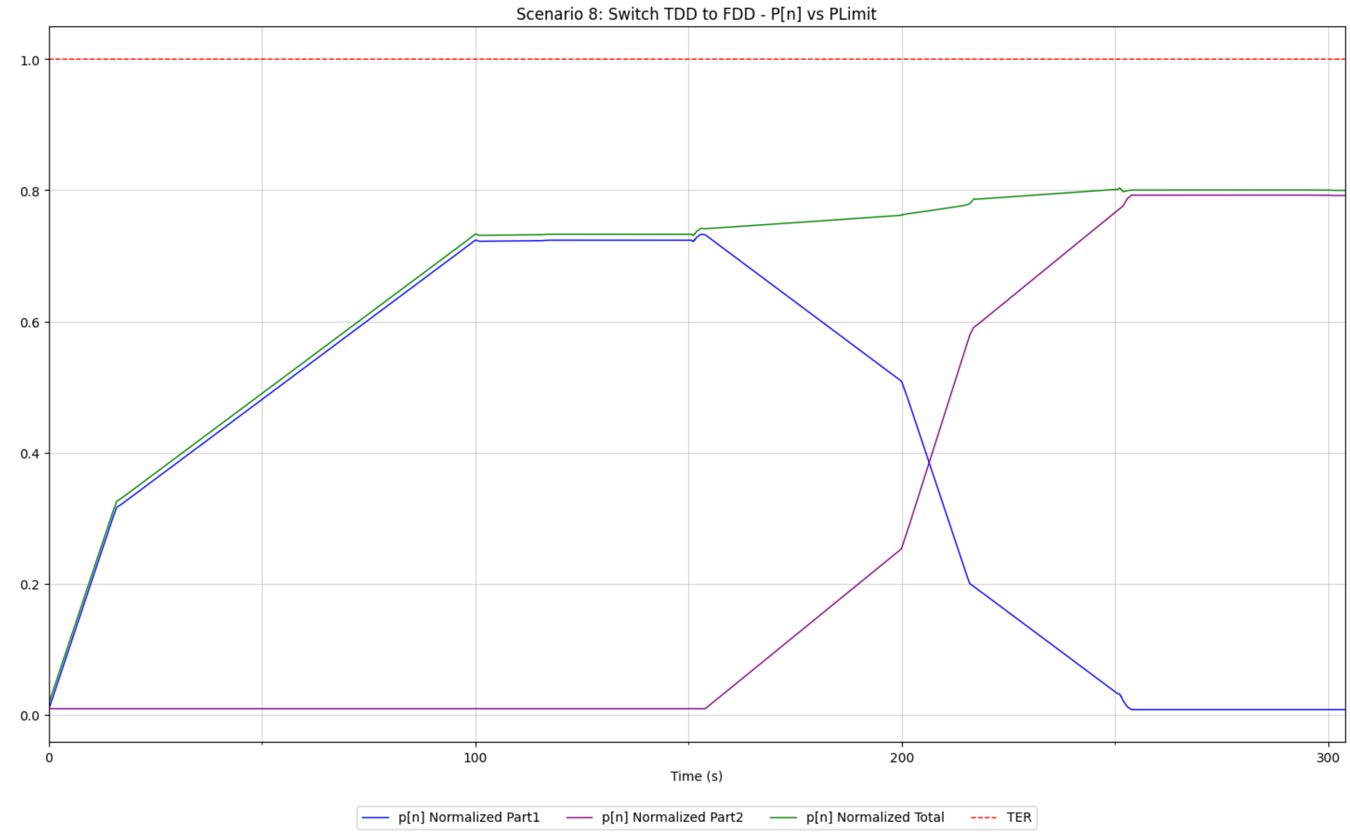


Figure 6-29: Switching Between Duplexes Test Case Validation (Conducted)



p[n] was calculated using the sum of LTE TDD's and LTE FDD's 100 second time-averaging duration.

6.1.9 Test Case 17: Dropped Connection

Figure 6-30: Call Drop Plot (Conducted)

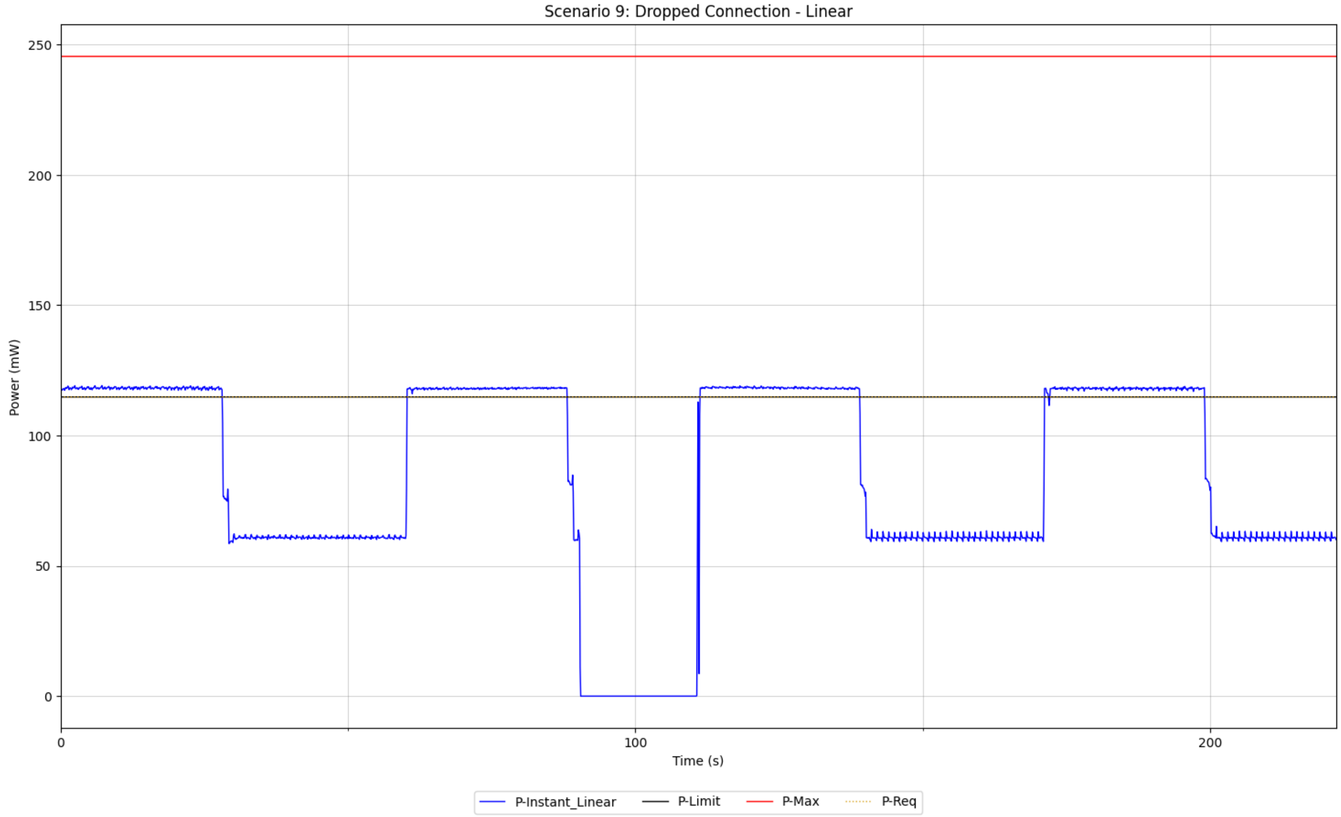
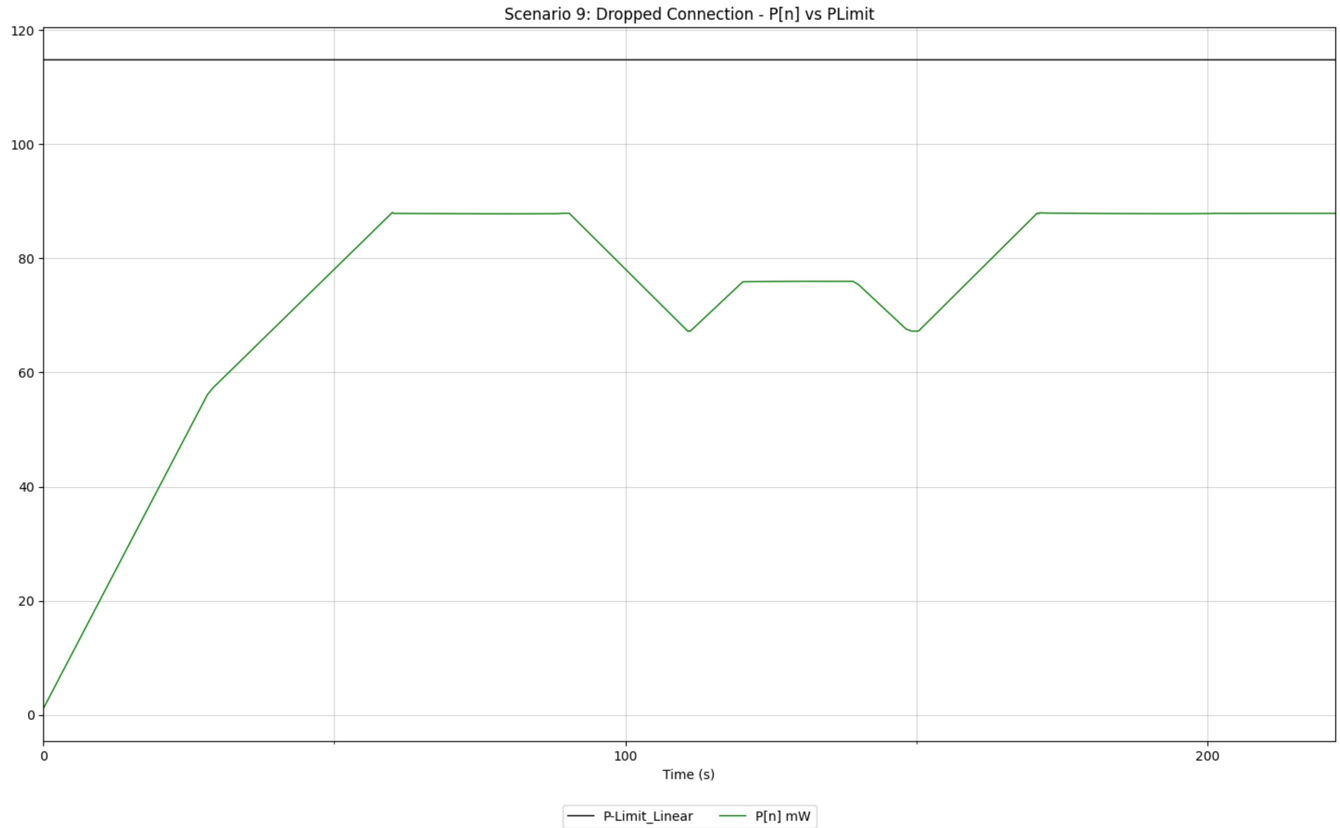


Figure 6-31: Call Drop Validation (Conducted)

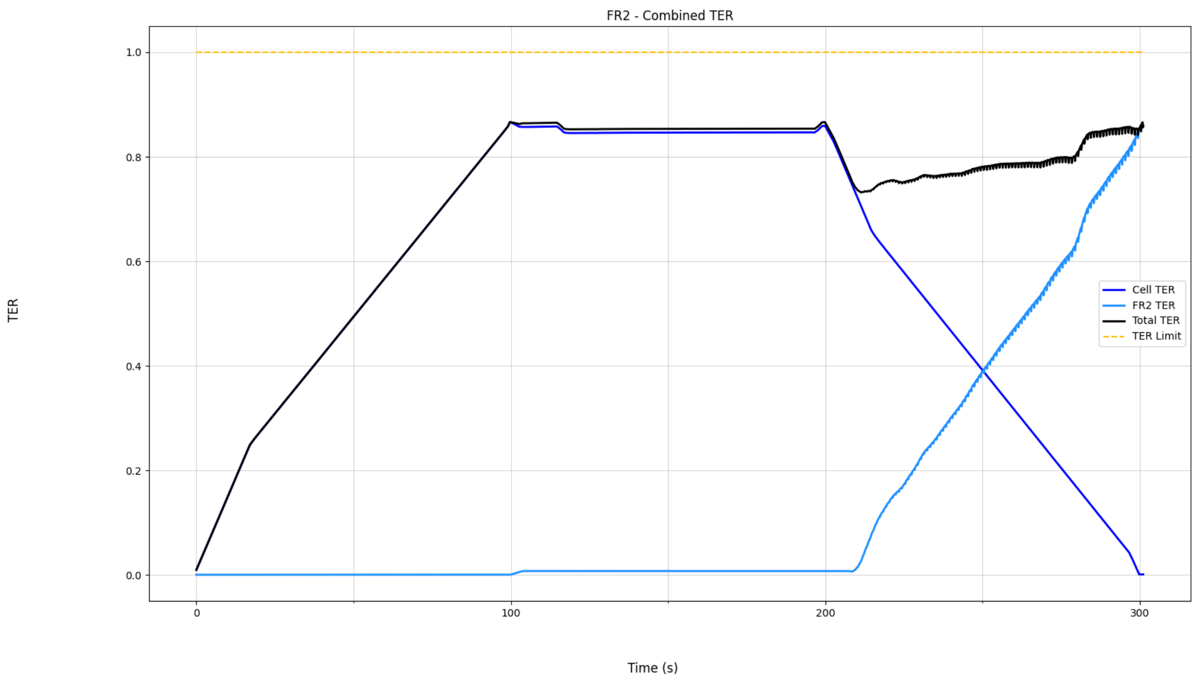


P[n] was calculated using the 60 second time-averaging duration.

6.2 PD (mmWave)

6.2.1 SAR to MPE Switch

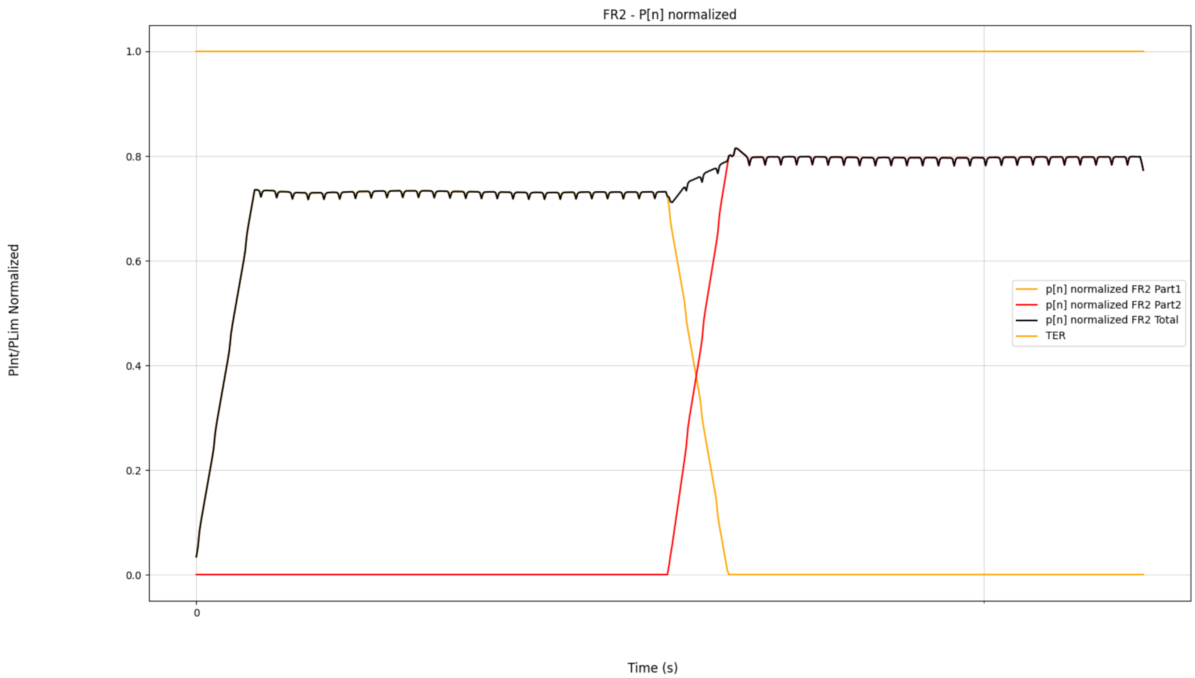
Figure 6-32: SAR to MPE Switch Validation



Combined TER was calculated using the 4 second time-averaging duration for FR-2 and 100 second time-averaging duration for Cellular.

6.2.2 Beam Switch

Figure 6-33: Beam Switch Validation



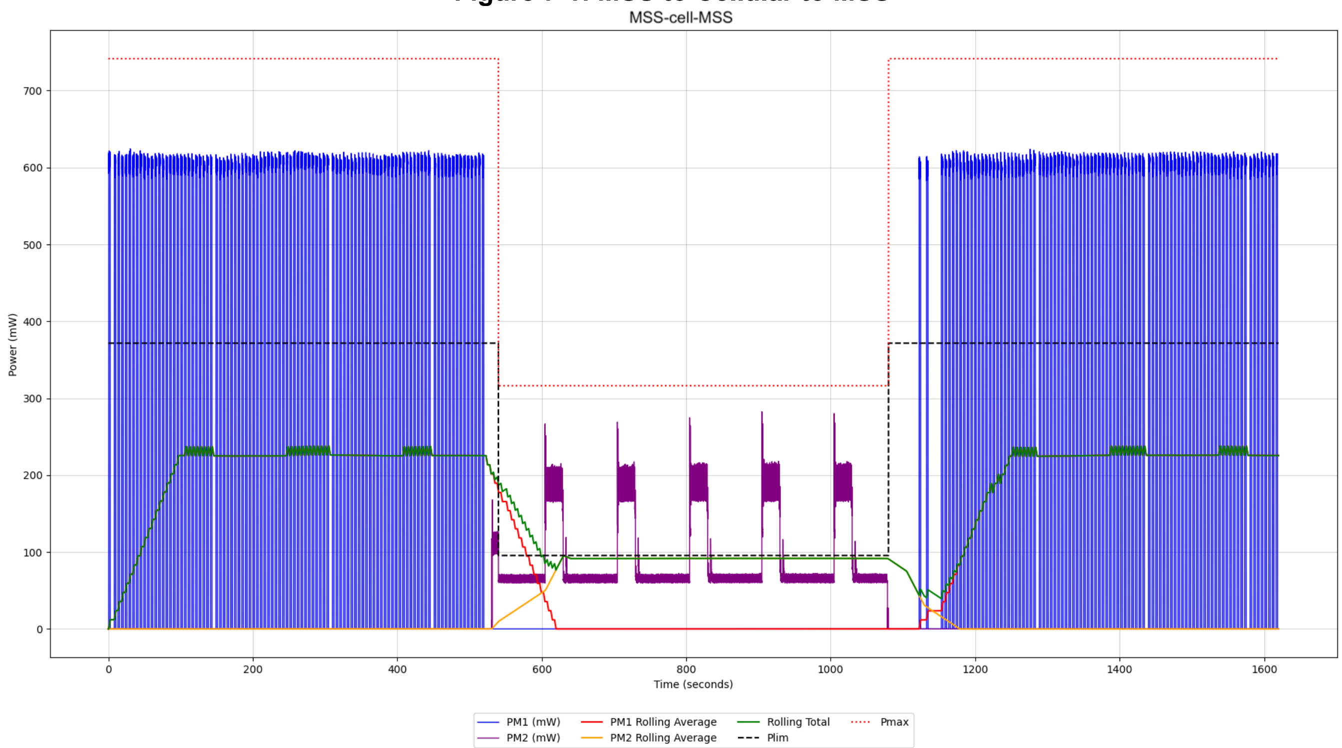
p[n] normalized was calculated using the 4 second time-averaging duration.

7. MSS[5]

7.1 Conducted

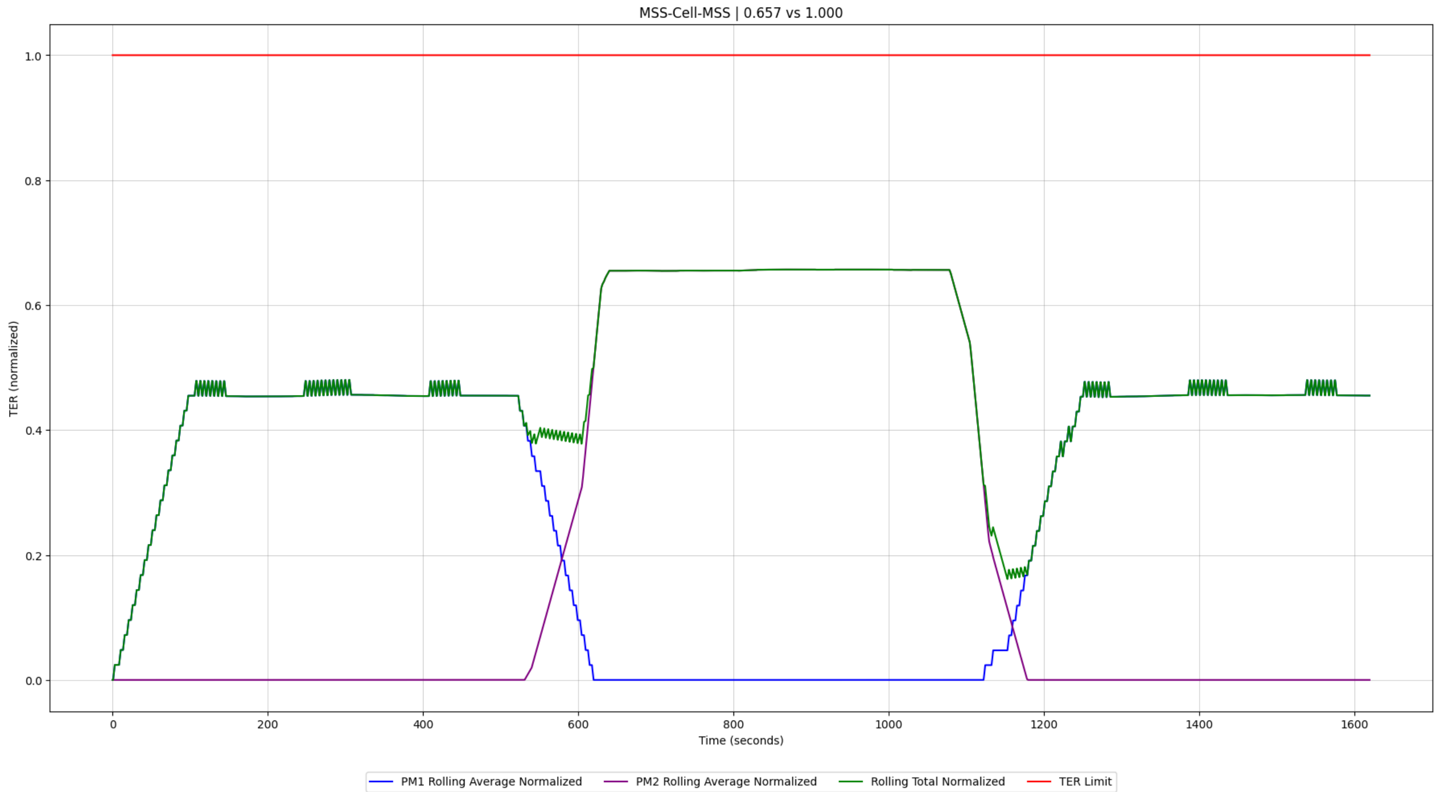
7.1.1 Technology Hand-off MSS to Cellular to MSS

Figure 7-1: MSS to Cellular to MSS



[5] Data in this section was collected and provided by the OEM; the test lab did not conduct any of these measurements within this section.

Figure 7-2: MSS to Cellular to MSS Validation



p[n] was calculated using the sum of MSS 99.84 second time-averaging duration and WWAN's 100 second time-averaging duration.

8. Dynamic Budget Algorithm Validation

This DUT supports dynamic budget sharing for Cellular, MSS, Wi-Fi, Bluetooth, NB U-NII, and 802.15.4 technologies. The budgeting algorithm dynamically controls the SAR and MPE budgets assigned to radios over time depending on use conditions and power demands.

This dynamic budgeting algorithm ensures simultaneous compliance through management of overall device TER. With this implementation, it is no longer relevant to asses simultaneous SAR, or TER, in a static manner using fixed simultaneous budgets. The validation of this dynamic budgeting algorithm is sufficient to prove simultaneous compliance.

To validate the dynamic budgeting algorithm, the following configurations will be assessed:

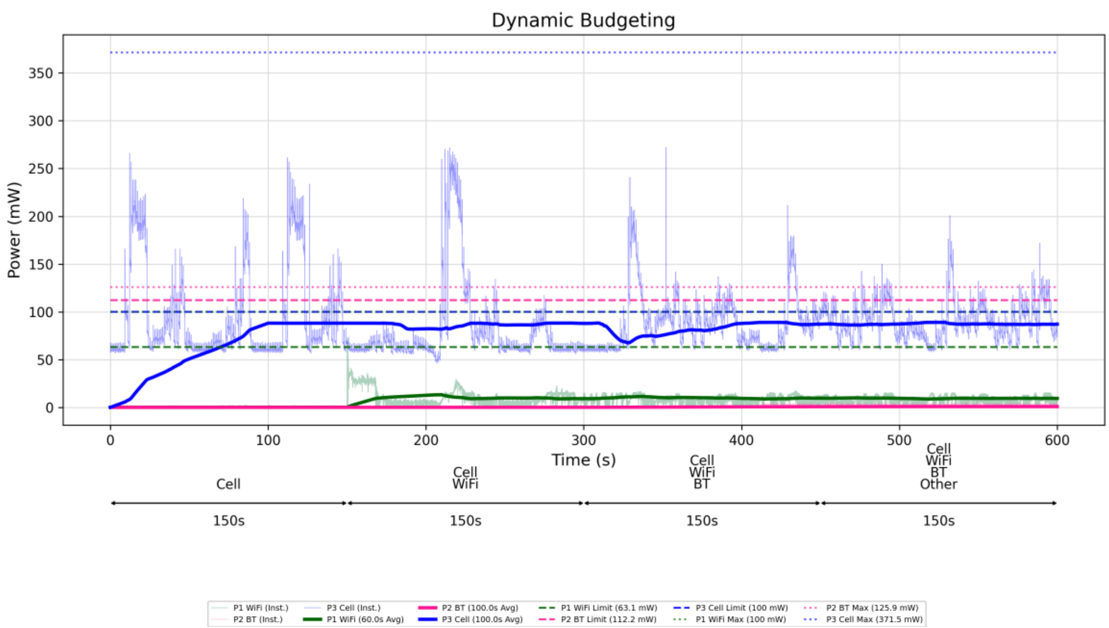
1. Cellular Standalone
2. Cellular + Wi-Fi
3. Cellular + Wi-Fi + Bluetooth
4. Cellular + Wi-Fi + Bluetooth + Static Budget Radios[6]

Table 8-1: Selected Technologies for Dynamic Budget Algorithm Validation

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Limit} (dBm)	P_{Max} (mW)	P_{Limit} (mW)
21	Dynamic Budgeting	LTE	B7	QPSK	N/A	N/A	20	Port A	ANT 14	Body	25.7	20.0	371.5	100.0
		Wi-Fi	U-NII 2C	BPSK	N/A	N/A	80	N/A	ANT 6	Body	20.0	18.0	100.0	63.1
		Bluetooth	2.4 GHz	LE	N/A	N/A	N/A	N/A	ANT 4	Body	21.0	20.5	125.9	112.2
		Static Budget Radios												

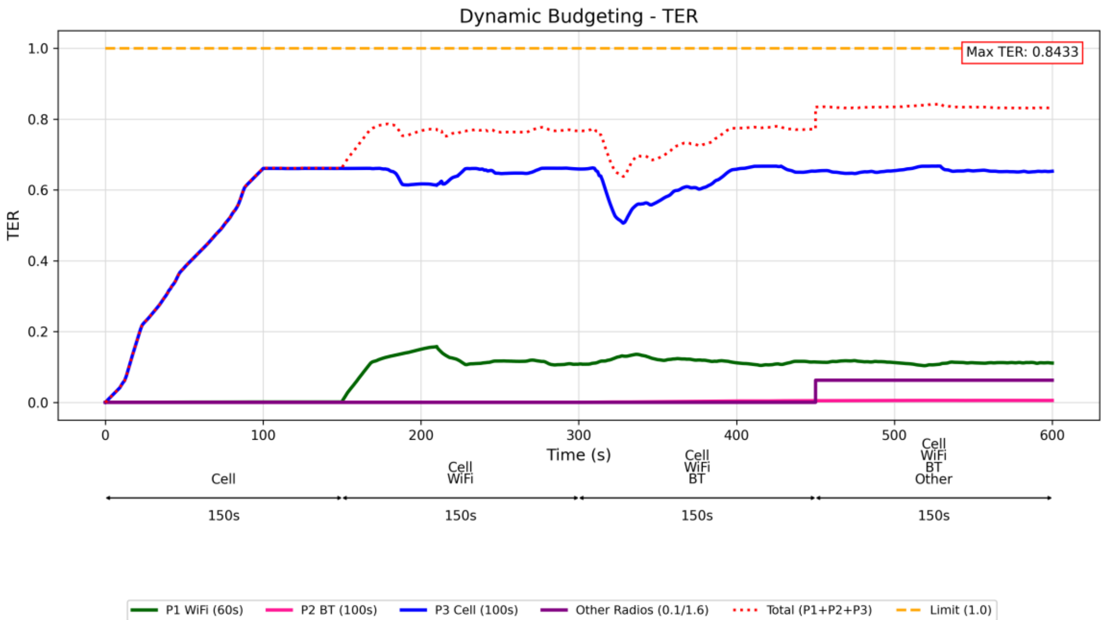
The test time per sequence will be sufficient to allow steady state to be reached. Static budget radios should capture the maximum transmission budget of any technology that does not have time-averaging or dynamic budgeting support.

Figure 8-1: Cellular + Wi-Fi to Cellular + Wi-Fi + Bluetooth to Cellular + Wi-Fi + Bluetooth + Static Radios



[6] Static Budget Radios include: WPT, UWB, 802.15.4ab – NB (Narrow Band), and NFC.

Figure 8-2: Cellular + Wi-Fi to Cellular + Wi-Fi + Bluetooth to Cellular + Wi-Fi + Bluetooth + Static Radios Validation



9. Conclusion

Table 9-1: Summary of Results for sub-7.2 GHz Conducted

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Duty Cycle (%)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Max} Corr. (dBm)	P_{Limit} (dBm)	P_{Limit} Corr. (dBm)	Validation (dBm)	P_{Max} (mW)	P_{Max} Corr. (mW)	P_{Limit} (mW)	P_{Limit} Corr. (mW)	Validation (mW)
1	Sequence A	FR-1 TDD	n77 (Block C)	DFT-s π/2 BPSK	N/A	PC3	100	67.0%	Port D	ANT 8	Body	26.0	27.7	20.2	21.9	21.0 < 21.9	398.1	594.2	104.7	156.3	125.9 > 104.7
2	Sequence B	GSM	1900	GMSK	2 Slot(s)	N/A	N/A	25.0%	Port D	ANT 4	Body	29.5	29.5	26.2	26.2	25.9 < 26.2	891.3	891.3	416.9	416.9	390.8 < 416.9
3		W-CDMA	B2	QPSK	N/A	N/A	N/A	100.0%	Port A	ANT 14	Body	25.7	25.7	21.1	21.1	20.8 < 21.1	371.5	371.5	128.8	128.8	119.9 < 128.8
4		LTE FDD	B30	QPSK	N/A	N/A	10	100.0%	Port D	ANT 4	Body	24.2	24.2	20.7	20.7	19.7 < 20.7	263.0	263.0	117.5	117.5	93.1 < 117.5
5		LTE TDD	B41	QPSK	N/A	PC3	20	63.3%	Port A	ANT 14	Body	25.7	25.7	22.3	22.3	21.9 < 22.3	371.5	371.5	169.8	169.8	155.2 < 169.8
6		FR-1 FDD	n70	DFT-s π/2 BPSK	N/A	N/A	15	90.0%	Port A	ANT 14	Body	25.7	26.2	22.0	22.5	21.6 < 22.5	371.5	412.8	158.5	176.1	144.5 < 158.5
7		FR-1 TDD	n77 (Block A)	DFT-s π/2 BPSK	N/A	PC3	100	67.0%	Port A	ANT 7	Body	26.0	27.7	24.6	26.3	24.8 < 26.3	398.1	594.2	288.4	430.5	302.0 > 288.4
8		Wi-Fi	U-NII 3	BPSK	N/A	N/A	80	N/A	N/A	ANT 16	Body	20.0	20.0	16.0	16.0	13.9 < 16.0	100.0	100.0	39.8	39.8	24.7 < 39.8
9		Wi-Fi	U-NII 5	BPSK	N/A	N/A	160	N/A	N/A	ANT 16	Body	19.0	19.0	14.0	14.0	12.8 < 14.0	79.4	79.4	25.1	25.1	19.2 < 25.1
10		Bluetooth	2.4 GHz	LE	N/A	N/A	N/A	N/A	N/A	ANT 4	Head	21.0	21.0	20.5	20.5	8.6 < 20.5	125.9	125.9	112.2	112.2	7.2 < 112.2
11	Pseudo-random	LTE FDD	B7	QPSK	N/A	N/A	20	100.0%	Port A	ANT 14	Body	25.7	25.7	20.0	20.0	19.4 < 20.0	371.5	371.5	100.0	100.0	86.3 < 100.0
17	Dropped Connection	LTE	B48	QPSK	N/A	N/A	20	63.3%	Port D	ANT 8	Body	23.9	23.9	20.6	20.6	19.5 < 20.6	245.5	245.5	114.8	114.8	88.1 < 114.8

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Duty Cycle (%)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Max} Corr. (dBm)	P_{Limit} (dBm)	P_{Limit} Corr. (dBm)	P_{Max} (mW)	P_{Max} Corr. (mW)	P_{Limit} (mW)	P_{Limit} Corr. (mW)	Validation
12	Antenna Switching	Wi-Fi	2.4 GHz	DSSS	N/A	N/A	20	N/A	N/A	ANT 4	Head	21.5	21.5	21.5	21.5	141.3	141.3	141.3	141.3	0.420 < 1.000
		Wi-Fi	U-NII 2C	BPSK	N/A	N/A	80	N/A	N/A	ANT 6	Body	20.0	20.0	18.0	18.0	100.0	100.0	63.1	63.1	
13	Change in Operating State	NB U-NII	U-NII 3	GFSK	N/A	N/A	N/A	N/A	N/A	ANT 16	Head	19.0	19.0	19.0	19.0	79.4	79.4	79.4	79.4	0.091 < 1.000
		NB U-NII	U-NII 3	GFSK	N/A	N/A	N/A	N/A	N/A	ANT 16	Body	19.0	19.0	16.0	16.0	79.4	79.4	39.8	39.8	
16	Switching Between Duplexes	LTE	B41	QPSK	N/A	PC3	20	63.3%	Port D	ANT 4	Head	25.7	25.7	21.1	21.1	371.5	371.5	128.8	128.8	0.804 < 1.000
		LTE	B25	QPSK	N/A	N/A	20	100.0%	Port D	ANT 4	Head	24.9	24.9	20.4	20.4	309.0	309.0	109.6	109.6	
14	Technology Hand-off (ULCA)	LTE	B5	QPSK	N/A	N/A	10	100.0%	Port B	ANT 2	Head	25.7	25.7	25.3	25.3	371.5	371.5	338.8	338.8	0.947 < 1.000
		LTE	B66	QPSK	N/A	N/A	20	100.0%	Port A	ANT 14	Head	25.7	25.7	23.0	23.0	371.5	371.5	199.5	199.5	
15	Technology Hand-off (ENDC)	LTE	B66	QPSK	N/A	N/A	20	100.0%	Port B	ANT 1	Body	25.7	25.7	25.4	25.4	371.5	371.5	346.7	346.7	0.857 < 1.000
		FR-1	n25	DFT-s π/2 BPSK	N/A	N/A	40	90.0%	Port C	ANT 3	Body	25.7	26.2	23.6	24.1	371.5	412.8	229.1	254.5	
18	MSS Switch Case	MSS	N/A	N/A	N/A	N/A	N/A	N/A	Port D	ANT 4	Extremity	28.7	28.7	26.7	26.7	741.3	741.3	467.7	467.7	0.657 < 1.000
		LTE	B66	QPSK	N/A	N/A	20	100.0%	Port B	ANT 1	Body	25.7	25.7	25.4	25.4	371.5	371.5	346.7	346.7	

Table 9-2: Summary of Results for PD

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Port	Transmitter	Polarity	Beam ID	P_{Max} (dBm)	P_{Limit} (dBm)	P_{Max} (mW)	P_{Limit} (mW)	Validation
19	SAR to MPE	LTE	B25	QPSK	N/A	N/A	20	Port A	ANT 14	N/A	N/A	25.7	18.8	371.5	75.9	0.867 < 1.000
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	3	20.3	-0.8	108.1	0.8	
20	Beam Switch	LTE	B25/2	QPSK	N/A	N/A	20	Port D	ANT 4	N/A	N/A	25.7	18.8	371.5	75.9	0.815 < 1.000
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	3	20.3	-0.8	108.1	0.8	
		FR-2	n258	QPSK	N/A	N/A	100	N/A	M1	Horizontal	5	14.2	1.3	26.4	1.3	

Table 9-3: Summary of Results for Dynamic Budget Algorithm Validation

Test Case No.	Test Case	Technology	Band	Modulation	Slot	Power Class	Bandwidth (MHz)	Port	Transmitter	RF Exposure Condition	P_{Max} (dBm)	P_{Limit} (dBm)	P_{Max} (mW)	P_{Limit} (mW)	Validation (dBm)
21	Dynamic Budgeting	LTE	B7	QPSK	N/A	N/A	20	Port A	ANT 14	Body	25.7	20.0	371.5	100.0	0.843 < 1.000
		Wi-Fi	U-NII 2C	BPSK	N/A	N/A	80	N/A	ANT 6	Body	20.0	18.0	100.0	63.1	
		Bluetooth	2.4 GHz	LE	N/A	N/A	N/A	N/A	ANT 4	Body	21.0	20.5	125.9	112.2	
		Static Budget Radios													

The data collected herein is sufficient in displaying the validation of the TAS algorithm(s). As demonstrated, the power limiting enforcement is effective and the total normalized time-averaged conducted power does not exceed 1 nor does P[n] exceed P_{Limit}.

Appendices

Appendix A: Test Setup Photos

Appendix B: cSAR3D Calibration Certificate

Appendix C: Dipole Certification Certificates

Appendix D: Fast SAR Measurement System & Test Equipment

D.1. Fast SAR Measurement System

The cSAR3D Fast SAR measurement system used for performing compliance tests consists of the following items:

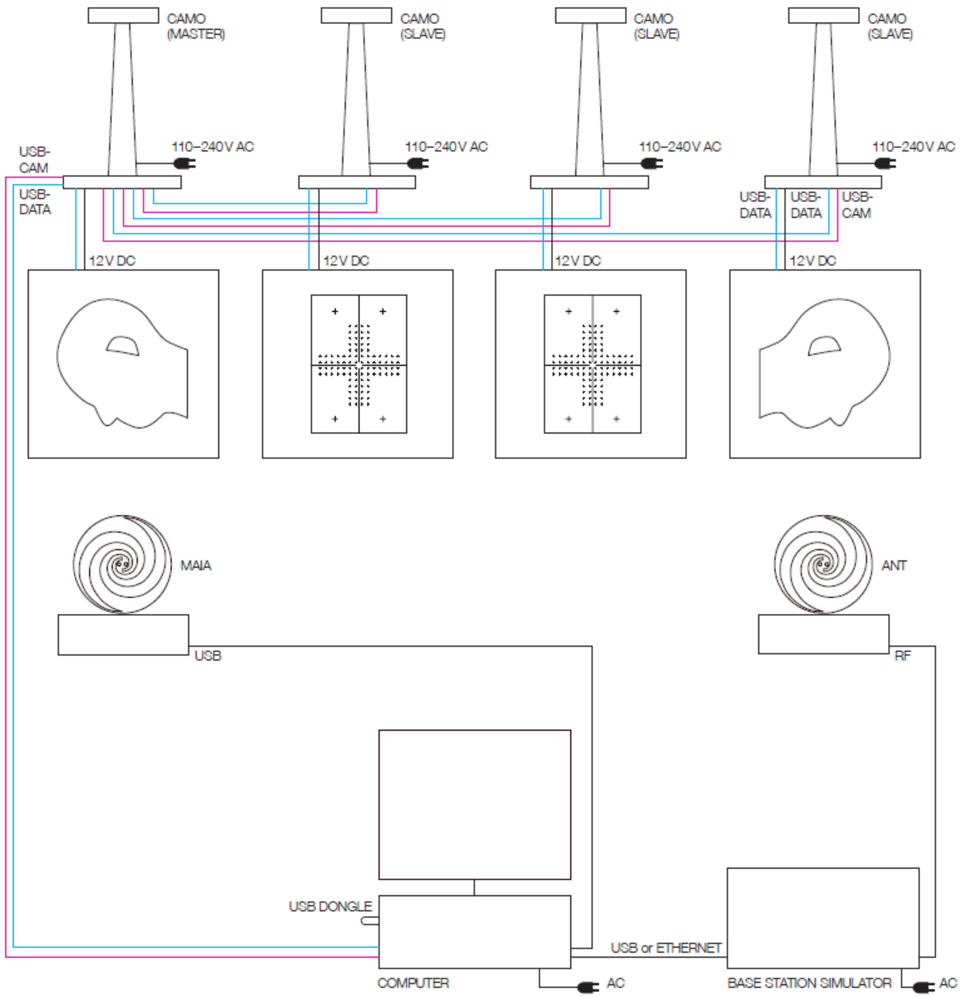


Figure D.1-1: cSAR3D System Block Diagram

- cSAR3D Flat Phantom containing:
  - A Head-Simulating Liquid medium within ±10% of the permittivity and conductivity requirements declared by IEC/IEEE 62209-1528.
  - An array of 3-D sensors embedded within the liquid utilizing mixed-sensor technology.
- “CAMO” arm-mounted positioning cameras and USB hubs.
- A test PC utilizing the cSAR3D Application Version 5.10.6.3469 for measurement control.
- A Base Station Simulator for call processing.
  - A CMW500 Wireless Communications Tester for GSM, W-CDMA, and LTE tests.
  - A UXM 5G Test Platform for 5G NR tests.
- The cSAR3D Left Head, cSAR3D Right Head, and cSAR3D Flat phantom containing Muscle-Simulating Liquid are also pictured in Figure D.1-1: cSAR3D System Block Diagram as a complete cSAR3D Fast SAR System but were not used for measurements in this test report.

D.2. Test Equipment

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

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
POWERSOURCE1	SPEAG	SE UMS 160 CC	4394	1/18/2026

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Fast SAR Measurement Platform - Flat	SPEAG	cSARDV2-FHSL	5014	10/28/2026
Fast SAR Measurement Platform - Flat	SPEAG	cSARDV2-FHSL	5279	3/10/2027
System Validation Dipole	SPEAG	D835V2	4d117	11/5/2026
System Validation Dipole	SPEAG	D1950V3	1136	4/14/2027
System Validation Dipole	SPEAG	D2450V2	706	1/9/2027
System Validation Dipole	SPEAG	D5GHz	1138	2/13/2027

Other

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Wideband Radio Communication Tester	R&S	CMW500	135384-PJ	3/31/2027
Wideband Radio Communication Tester	R&S	CMW500	171873-PW	2/11/2027
Wideband Radio Communication Tester	R&S	CMW500	137873-WG	3/31/2027
Radio Communication Tester	R&S	CMX500	103011	2/28/2027
Wideband Radio Communication Tester	Keysight	E7515B UXM 5G	MY58460103	1/31/2027
Wideband Radio Communication Tester	Keysight	E7515B UXM 5G	MY58291246	2/28/2027
Power Sensor	R&S	NRP8S	115089-GV	2/28/2027
Power Sensor	R&S	NRP8S	115090-HV	2/28/2027
Power Sensor	R&S	NRP8S	115095-QK	2/28/2027
Power Sensor	R&S	NRP18S	104134-bP	2/28/2027
Power Sensor	R&S	NRP18S	104136-JZ	2/28/2027
Power Sensor	R&S	NRP8S	115091-ZA	2/28/2027
Power Sensor	R&S	NRP8S	115093-GT	2/28/2027
Power Sensor	R&S	NRP8S	110667-vC	2/28/2027
Power Sensor	R&S	NRP8S	109115-nc	2/28/2027
Power Sensor	R&S	NRP8S	115094-Yy	2/28/2027
Power Sensor	R&S	NRP8S	115088-rq	2/28/2027
Power Sensor	R&S	NRP8S	115092-rn	2/28/2027

Appendix E: Fast SAR System Verification

A system verification was performed weekly before measurements were made as defined in *cSAR3D Application Note: System Check or Verification, April 2024* per IEC 62209-3 standards.

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	8-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA A
Operator	Pwint San
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5279

											Verification Against Absolute Targets									Verification Against Measured Reference Values								
Dipole Type	Dipole Serial Number	frequency (MHz)	Location (Orientation)	Power (dBm)	Measured SAR (W/kg)		Reported Uncertainty (k = 2) (dB)		Measured SAR Normalized to 1 W (W/kg)		Numerical Target (W/kg)		Deviation from Target (dB)		Total Uncertainty (k = 2) (%)	Total Uncertainty (k = 2) (dB)	Verified Against Numerical Targets?		SAR from cSAR3D Certificate (W/kg)		Deviation from Cal. Cert. (dB)		Tolerance -(dB)	Tolerance +(dB)	Verified Against Measured Values?	
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g			1g	10g	1g	10g	1g	10g			1g	10g
D835V2	4d117	835	A0 (0°)	17	0.432	0.271	1.01	1.01	8.62	5.41	9.56	6.22	-0.4	-0.6	30.7%	1.2	Yes	Yes	8.71	5.46	0.0	0.0	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.941	0.972	1.01	1.01	38.73	19.39	40.5	20.9	-0.2	-0.3	30.7%	1.2	Yes	Yes	39.50	19.50	-0.1	0.0	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.427	1.108	1.13	1.13	48.43	22.11	51.4	23.8	-0.3	-0.3	33.8%	1.3	Yes	Yes	51.80	23.10	-0.3	-0.2	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.760	1.082	1.13	1.13	75.02	21.59	75.8	21.4	0.0	0.0	33.8%	1.3	Yes	Yes	86.40	24.00	-0.6	-0.5	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	3.980	1.105	1.13	1.13	79.41	22.05	78.0	21.9	0.1	0.0	33.8%	1.3	Yes	Yes	86.50	23.70	-0.4	-0.3	-1.0	0.4	Yes	Yes

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	14-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA A
Operator	Pwint San
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5279

											Verification Against Absolute Targets								Verification Against Measured Reference Values							
Dipole Type	Dipole Serial Number	frequency	Location (Orientation)	Power	Measured SAR		Reported Uncertainty (k = 2)		Measured SAR Normalized to 1 W		Numerical Target		Deviation from Target		Total Uncertainty (k = 2)		Verified Against Numerical Targets?		SAR from cSAR3D Certificate		Deviation from Cal. Cert.		Tolerance		Verified Against Measured Values?	
		(MHz)		(dBm)	(W/kg)		(dB)		(W/kg)		(W/kg)		(dB)		(%)	(dB)			(W/kg)		(dB)		-(dB)	+(dB)		
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g			1g	10g	1g	10g	1g	10g			1g	10g
D835V2	4d117	835	A0 (0°)	17	0.431	0.270	1.01	1.01	8.61	5.38	9.56	6.22	-0.5	-0.6	30.7%	1.2	Yes	Yes	8.71	5.46	-0.1	-0.1	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.932	0.968	1.01	1.01	38.55	19.32	40.5	20.9	-0.2	-0.3	30.7%	1.2	Yes	Yes	39.50	19.50	-0.1	0.0	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.483	1.132	1.13	1.13	49.54	22.59	51.4	23.8	-0.2	-0.2	33.8%	1.3	Yes	Yes	51.80	23.10	-0.2	-0.1	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.909	1.119	1.13	1.13	77.99	22.33	75.8	21.4	0.1	0.2	33.8%	1.3	Yes	Yes	86.40	24.00	-0.4	-0.3	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	4.057	1.130	1.13	1.13	80.95	22.55	78.0	21.9	0.2	0.1	33.8%	1.3	Yes	Yes	86.50	23.70	-0.3	-0.2	-1.0	0.4	Yes	Yes

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	21-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA A
Operator	Pwint San
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5279

											Verification Against Absolute Targets									Verification Against Measured Reference Values								
Dipole Type	Dipole Serial Number	frequency (MHz)	Location (Orientation)	Power (dBm)	Measured SAR (W/kg)		Reported Uncertainty (k = 2) (dB)		Measured SAR Normalized to 1 W (W/kg)		Numerical Target (W/kg)		Deviation from Target (dB)		Total Uncertainty (k = 2)		Verified Against Numerical Targets?		SAR from cSAR3D Certificate (W/kg)		Deviation from Cal. Cert. (dB)		Tolerance		Verified Against Measured Values?	
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g	(%)	(dB)	1g	10g	1g	10g	1g	10g	-(dB)	+(dB)	1g	10g
D835V2	4d117	835	A0 (0°)	17	0.440	0.275	1.01	1.01	8.77	5.48	9.56	6.22	-0.4	-0.5	30.7%	1.2	Yes	Yes	8.71	5.46	0.0	0.0	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.939	0.970	1.01	1.01	38.69	19.36	40.5	20.9	-0.2	-0.3	30.7%	1.2	Yes	Yes	39.50	19.50	-0.1	0.0	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.484	1.134	1.13	1.13	49.56	22.63	51.4	23.8	-0.2	-0.2	33.8%	1.3	Yes	Yes	51.80	23.10	-0.2	-0.1	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.777	1.089	1.13	1.13	75.36	21.73	75.8	21.4	0.0	0.1	33.8%	1.3	Yes	Yes	86.40	24.00	-0.6	-0.4	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	4.015	1.123	1.13	1.13	80.11	22.41	78.0	21.9	0.1	0.1	33.8%	1.3	Yes	Yes	86.50	23.70	-0.3	-0.2	-1.0	0.4	Yes	Yes

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	28-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA A
Operator	Pwint San
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5279

Dipole Type	Dipole Serial Number	frequency (MHz)	Location (Orientation)	Power (dBm)	Measured SAR (W/kg)		Reported Uncertainty (k = 2) (dB)		Measured SAR Normalized to 1 W (W/kg)		Verification Against Absolute Targets: Numerical Target (W/kg)		Deviation from Target (dB)		Total Uncertainty (k = 2)		Verified Against Numerical Targets?		Verification Against Measured Reference Values: SAR from cSAR3D Certificate (W/kg)		Deviation from Cal. Cert. (dB)		Tolerance		Verified Against Measured Values?	
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g	(%)	(dB)	1g	10g	1g	10g	1g	10g	-(dB)	+(dB)	1g	10g
D835V2	4d117	835	A0 (0°)	17	0.437	0.275	0.27	1.01	8.71	5.48	9.56	6.22	-0.4	-0.5	30.2%	1.1	Yes	Yes	8.71	5.46	0.0	0.0	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.930	0.970	0.97	1.01	38.51	19.36	40.5	20.9	-0.2	-0.3	30.2%	1.1	Yes	Yes	39.50	19.50	-0.1	0.0	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.493	1.134	1.14	1.13	49.74	22.63	51.4	23.8	-0.1	-0.2	33.9%	1.3	Yes	Yes	51.80	23.10	-0.2	-0.1	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.693	1.089	1.07	1.13	73.69	21.73	75.8	21.4	-0.1	0.1	32.1%	1.2	Yes	Yes	86.40	24.00	-0.7	-0.4	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	3.870	1.123	1.08	1.13	77.22	22.41	78.0	21.9	0.0	0.1	32.3%	1.2	Yes	Yes	86.50	23.70	-0.5	-0.2	-1.0	0.4	Yes	Yes

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	4-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA B
Operator	Remi Rodberg
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5014

											Verification Against Absolute Targets								Verification Against Measured Reference Values								
Dipole Type	Dipole Serial Number	frequency (MHz)	Location (Orientation)	Power (dBm)	Measured SAR (W/kg)		Reported Uncertainty (k = 2) (dB)		Measured SAR Normalized to 1 W (W/kg)		Numerical Target (W/kg)		Deviation from Target (dB)		Total Uncertainty (k = 2)		Verified Against Numerical Targets?		SAR from cSAR3D Certificate (W/kg)		Deviation from Cal. Cert. (dB)		Tolerance		Verified Against Measured Values?	
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g	(%)	(dB)	1g	10g	1g	10g	1g	10g	-(dB)	+(dB)	1g	10g
D835V2	4d117	835	A0 (0°)	17	0.466	0.292	1.01	1.01	9.30	5.82	9.56	6.22	-0.1	-0.3	30.7%	1.2	Yes	Yes	9.27	5.82	0.0	0.0	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.951	0.985	1.01	1.01	38.93	19.65	40.5	20.9	-0.2	-0.3	30.7%	1.2	Yes	Yes	40.73	20.20	-0.2	-0.1	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.502	1.147	1.13	1.13	49.92	22.89	51.4	23.8	-0.1	-0.2	33.8%	1.3	Yes	Yes	53.27	23.90	-0.3	-0.2	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.782	1.096	1.13	1.13	75.46	21.87	75.8	21.4	0.0	0.1	33.8%	1.3	Yes	Yes	84.00	23.60	-0.5	-0.3	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	4.035	1.127	1.13	1.13	80.51	22.49	78.0	21.9	0.1	0.1	33.8%	1.3	Yes	Yes	83.87	23.20	-0.2	-0.1	-1.0	0.4	Yes	Yes

cSAR3D Verification Test - Flat Phantom

Version date: May 6, 2024

This spreadsheet is to be used for the System Verification Test described in the Application Note "System Check or Verification" that is part of the cSAR3D System Handbook

Please follow the Application Note "System Check or Verification" and fill the data in the yellow cells.

Date of Tests	26-Jun-2026
Software version	5.10.6.3469
Laboratory	OTA B
Operator	Remi Rodberg
Ambient Temp.	22

Notes

Location (Orientation)	Antenna location and orientation as described in the cSAR3D System Handbook
Reported uncertainty (k = 2)	The expanded measurement uncertainty as reported by the cSAR3D software. In the cSAR3D Handbook, this is ΔSAR_meas = √(MM^2 + MN^2 + MD^2 + ME^2)
Total uncertainty (k = 2)	The expanded uncertainty that combines the reported uncertainty with the uncertainty for system validation antenna. In the cSAR3D Handbook, this is ΔSAR_syscheck = √(ΔSAR_meas^2 + MV^2) = √(MM^2 + MN^2 + MD^2 + ME^2 + MV^2)
Numerical target	The absolute target values as tabulated in IEC 62209-3, known as SAR_1g,cal and SAR_10g,cal
SAR from cSAR3D Certificate	The cSAR3D measured SAR values reported by the SPEAG calibration lab, located in the cSAR3D calibration certificate. These are known in IEC 62209-3 as SAR_1g,sys and SAR_10g,sys
Tolerance	The allowable repeatability tolerance, which is stated as 10% in IEC 62209-3 for the same setup. For different positions and orientations, this is -20% to +10% as explained in the Application Note.

cSAR3D Type Flat HSL

Serial Number 5014

											Verification Against Absolute Targets								Verification Against Measured Reference Values							
Dipole Type	Dipole Serial Number	frequency (MHz)	Location (Orientation)	Power (dBm)	Measured SAR (W/kg)		Reported Uncertainty (k = 2) (dB)		Measured SAR Normalized to 1 W (W/kg)		Numerical Target (W/kg)		Deviation from Target (dB)		Total Uncertainty (k = 2) (%)	Total Uncertainty (k = 2) (dB)	Verified Against Numerical Targets?		SAR from cSAR3D Certificate (W/kg)		Deviation from Cal. Cert. (dB)		Tolerance -(dB)	Tolerance +(dB)	Verified Against Measured Values?	
					1g	10g	1g	10g	1g	10g	1g	10g	1g	10g			1g	10g	1g	10g	1g	10g			1g	10g
D835V2	4d117	835	A0 (0°)	17	0.457	0.285	1.01	1.01	9.13	5.69	9.56	6.22	-0.2	-0.4	30.7%	1.2	Yes	Yes	9.27	5.82	-0.1	-0.1	-1.0	0.4	Yes	Yes
D1950V3	1136	1950	A0 (0°)	17	1.908	0.963	1.01	1.01	38.07	19.22	40.5	20.9	-0.3	-0.4	30.7%	1.2	Yes	Yes	40.73	20.20	-0.3	-0.2	-1.0	0.4	Yes	Yes
D2450V2	706	2450	A0 (0°)	17	2.466	1.134	1.13	1.13	49.20	22.63	51.4	23.8	-0.2	-0.2	33.8%	1.3	Yes	Yes	53.27	23.90	-0.3	-0.2	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5200	A0 (0°)	17	3.663	1.055	1.13	1.13	73.09	21.05	75.8	21.4	-0.2	-0.1	33.8%	1.3	Yes	Yes	84.00	23.60	-0.6	-0.5	-1.0	0.4	Yes	Yes
D5GHzV2	1138	5800	A0 (0°)	17	3.898	1.086	1.13	1.13	77.78	21.67	78.0	21.9	0.0	0.0	33.8%	1.3	Yes	Yes	83.87	23.20	-0.3	-0.3	-1.0	0.4	Yes	Yes

Appendix F: Measurement Uncertainty

F.1. Fast SAR

The cSAR3D Measurement Platform performs on-the-fly calculation of the uncertainty of each measurement from the measured SAR distribution and other parameters. The calculated uncertainties for each Fast SAR measurement performed is reported with the Fast SAR Test results.

The uncertainty calculations are performed in accordance with IEC 62209-3 and the draft IEC Technical Report for 5G NR FR-1.

The combined expanded uncertainties for $psSAR1g$ and $psSAR10g$ are calculated as follows:

$$U_{1g} = k \cdot u_{c,1g}$$

$$U_{10g} = k \cdot u_{c,10g}$$

A coverage factor of $k = 2$ is used, corresponding to a 95% confidence interval. The combined standard uncertainties, $u_{c,1g}$ [dB] and $u_{c,10g}$ [dB], having log normal distributions, are calculated as follows:

$$u_{c,1g} = \sqrt{\sum_{i=1}^{N} \left(a_{i,1g} \cdot c_i / q_i\right)^2} = \sqrt{\sum_{i=1}^{N} {u_{i,1g}}^2}$$

$$u_{c,10g} = \sqrt{\sum_{i=1}^{N} \left(a_{i,10g} \cdot c_i / q_i\right)^2} = \sqrt{\sum_{i=1}^{N} {u_{i,10g}}^2}$$

where

- $a_{i,1g}$ and $a_{i,10g}$ are the uncertainty values of the i^{th} uncertainty component having a probability density function PDF_i. These are determined from the measured SAR distribution, other measurement parameters, phantom type, and system characteristics
- q_i is the divisor corresponding to the probability density function PDF_i.
- c_i is the sensitivity coefficient associated with the i^{th} uncertainty component. It describes how the total uncertainty varies with small changes in the uncertainty component.
- $u_{i,1g} = a_{i,1g} \cdot c_i / q_i$is standard uncertainty of the i^{th} uncertainty component. It is normalized so that it has a lognormal distribution.

F.1.1 Fast SAR Combined Expanded Uncertainty

The general combined expanded uncertainty declared by the Fast SAR system manufacturer is shown below in both percentages and decibel offsets.

Phantom Type	Distance (mm)	psSAR	$2 \cdot u_c$ (±%)				$2 \cdot u_c$ (±dB)			
			0.69 - 1 GHz	1 - 3 GHz	3 - 5 GHz	5 - 6 GHz	0.69 - 1 GHz	1 - 3 GHz	3 - 5 GHz	5 - 6 GHz
Flat	< 5	1g / 10g	27.5	27.5	29.0	29.0	1.5	1.5	1.6	1.6
Flat	≥ 5	1g / 10g	26.4	26.4	28.5	28.5	1.5	1.5	1.6	1.6
Head	≥ 0	1g / 10g	35.8	35.8	36.9	36.9	1.8	1.8	1.8	1.8

Note(s):

*: Measurement uncertainty declarations for Fast SAR systems are referenced from *Schmid & Partner Engineering AG, cSAR3D V5.10 Manual, October 2025.*

F.2. Conducted

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{Lab}
RF Power Measurement Direct Method Using Power Meter	1.300 dB Peak 0.450 dB Avg

Uncertainty figures are valid to a confidence level of 95%.

END OF REPORT