# RF Exposure Report

The following samples were submitted and identified on behalf of the client as:

| | |
|---|---|
| **Equipment Under Test** | Notebook Computer |
| **Brand Name** | HP |
| **Model No.** | HSN-I41C-4 |
| **Company Name** | HP Inc. |
| **Company Address** | 1501 Page Mill Road, Palo Alto CA 94304 USA |
| **FCC ID** | B94HNI41C4TKR |
| **Date of Receipt** | Sep. 01, 2020 |
| **Date of Test(s)** | Oct. 10, 2020 |
| **Date of Issue** | Oct. 21, 2020 |

In the configuration tested, the EUT complied with the standards specified above.

**Remarks:**

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS Taiwan Ltd. Central RF Lab or testing done by SGS Taiwan Ltd. Central RF Lab in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Ltd. Central RF Lab in writing.

**Signed on behalf of SGS**

| Clerk / Ruby Ou | Engineer / Jay Tseng | Asst. Manager / John Yeh |
|---|---|---|
| Ruby Ou | Jay Tseng | John Yeh |

**Date: Oct. 21, 2020**

# Revision History

| Report Number | Revision | Description | Issue Date |
|---|---|---|---|
| ES/2020/80024 | Rev.00 | Initial creation of document | Oct. 21, 2020 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## Contents

# 1.General Information

## 1.1 Testing Laboratory

| | |
|---|---|
| SGS Taiwan Ltd. Central RF Lab | |
| No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan | |
| FCC Designation Number | TW0027 |
| Tel | +886-2-2299-3279 |
| Fax | +886-2-2298-0488 |
| Internet | http://www.tw.sgs.com/ |

## 1.2 Details of Applicant

| | |
|---|---|
| Company Name | HP Inc. |
| Company Address | 1501 Page Mill Road, Palo Alto CA 94304 USA |

# 2. Introduction

The equipment under test (EUT) is a Notebook Computer (FCC ID: B94HNI41C4TKR), it contains supports 3G/4G/5G bands. These modems are enabled with Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement.

This purpose of the Part 2 report is to demonstrate the EUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Qualcomm Smart Transmit feature for FCC equipment authorization


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

# 3. Qualcomm Smart Transmit Operation Description

## 3.1 Feature description

The FCC RF exposure limit is defined based on time-averaged RF exposure. When running in a wireless device, Qualcomm Smart Transmit feature enables more elegant power control mechanisms for RF exposure management.

It ensures at all times the wireless device is in compliance with the FCC limit of RF exposure averaged over a defined time window:

Denoted as $T_{SAR}$ for specific absorption rate (SAR for Tx frequency < 6 GHz)

The Smart Transmit feature not only ensures the wireless device complies with RF exposure requirement, but also improves the user experience and network performance.

For a given wireless device, RF exposure is proportional to the transmitting power.

Once the SAR of the wireless device is characterized at a transmit power level by SAR measurements, RF exposure at a different power level for the characterized configurations can be scaled by the change in the corresponding power level.

Therefore, for a characterized device, RF exposure compliance is achieved through transmit power control and management.

The Smart Transmit feature incorporated in Qualcomm modems reliably controls the transmit power of the wireless device in real time to maintain the time-averaged transmit power, in turn, time-averaged RF exposure, below the threshold predefined for a given technology and band.

This predefined average power limit, denoted as Plimit, is determined, so the wireless device continuously transmitting at Plimit level complies with the FCC RF exposure limit.


SGS Taiwan Ltd. 台灣檢驗科技股份有限公司
No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

### 3.2 Basic concept of the feature

The Smart Transmit feature is configured to manage the instantaneous transmit power (Tx) to keep the time-averaged power and not exceed Plimit.

If time-averaged transmit power approaches the Plimit, then the modem needs to limit instantaneous transmit power to ensure the time-averaged transmit power does not exceed the Plimit in any $T_{SAR}$ time windows (i.e., the time-averaged RF exposure complies with the FCC RF exposure limit in any time window).

The wireless device can instantaneously transmit at high transmit powers and exceed the Plimit for a short duration before limiting the power to maintain the time-averaged transmit power under the Plimit.

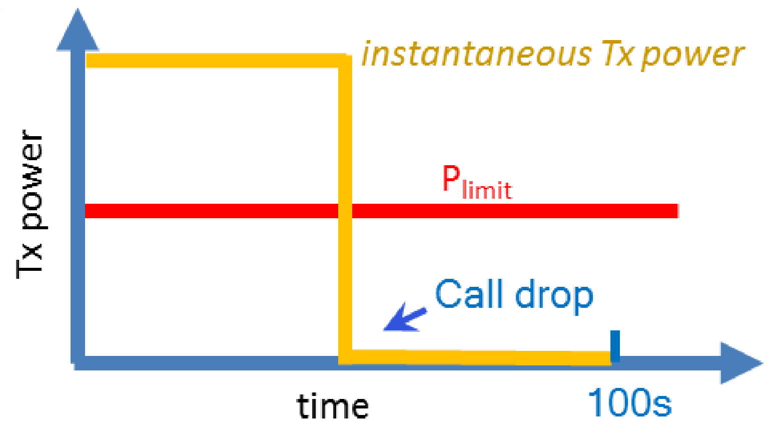
If the wireless device transmits at high power for a long duration, then the radio link needs to be dropped to be compliant with time-averaged Tx power requirement (see Figure 3-1).

To avoid dropping the radio link, Smart Transmit feature starts the power limiting enforcement earlier in time to back off the Tx power to a reserve level (denoted as Preserve), so the wireless device can maintain the radio link at a minimum reserve power level for as long as needed, and at the same time ensure the time-averaged Tx power over any predefined time window is less than Plimit at all times (see Figure 3-2). At all times, Smart Transmit meets the below equation (1):

$$time\ avg.Tx\ power = \frac{1}{T}\int_{t}^{t+T} inst.Tx\ power(t)\,dt \le P_{limit} \qquad (1)$$

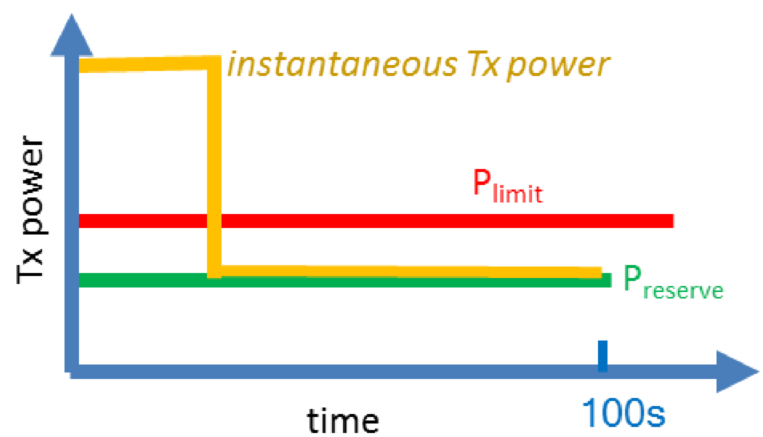
where, time avg. Tx power is the power averaged between t and t+T time period;

T is predefined time window defined by the regulator for time-averaging RF exposure; inst. Tx power (t) is the instantaneous transmit power at t time instant; Plimit is the predefined time averaged power limit.




(a)

Figure 3-1 Transmit at high power when needed and permitted




(b)

Figure 3-2 Transmit with reserve power to support continuous transmission at a minimum power level (Preserve)

# 4. Validation strategy

The following scenarios cover validation of time-averaging algorithm.
1. During a time-varying Tx power transmission: To prove that the Smart Transmit feature accounts for Tx power variations in time accurately.

2. During a call disconnect and re-establish scenario: To prove that the Smart Transmit feature accounts for history of past Tx power transmissions accurately.

3. During technology/band handover: To prove that the Smart Transmit feature functions correctly during transitions in technology/band.

4. During antenna switch: To prove that the Smart Transmit feature functions correctly during transitions in antenna (AsDiv scenario).

5. During change in device state: To prove that the Smart Transmit feature functions correctly during transitions in device state.

6. During time window switch: To prove that the Smart Transmit feature correctly handles the transition from one time window to another specified by FCC, and maintains the normalized time-averaged RF exposure to be less than FCC limit of 1.0 at all times.

7. SAR vs. PD exposure switching during sub-6+mmW transmission: To prove that the Smart Transmit feature functions correctly and ensures total RF exposure compliance during transitions in SAR only exposure, SAR+PD exposure, and PD only exposure scenarios.

8. SAR exposure switching between two active radios (radio1 and radio2): To prove that the Smart Transmit feature functions correctly and ensures total RF exposure compliance when exposure varies among SAR_radio1 only, SAR_radio1 + SAR_radio2, and SAR_radio2 only scenarios.

As described in Part 0 SAR Char report, the RF exposure is proportional to the Tx power for a SAR-characterized wireless device. Thus, time-averaging algorithm validation can be effectively performed through conducted power measurement.
To have high confidence in this validation, but also be practical, the strategy for the validation including both power measurement and RF exposure measurement is outlined as follows:

**Conducted power measurement**:

■ Measure conducted Tx power for $f < 6$GHz

Convert it into RF exposure and divide by respective FCC limits to get normalized exposure

■ Perform time-averaging over predefined time windows


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

■ Demonstrate that the total normalized time-averaged RF exposure is less than 1 for all transmission scenarios (i.e., previous scenarios 1 to 8); For sub-6 transmission only:

$$1g\_or\_10gSAR(t) = \frac{conducted\_Tx\_power(t)}{conducted\_Tx\_power\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (3a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR(t)dt}{FCC\ SAR_{limit}} \leq 1 \quad (3b)$$

where, conducted_Tx_power(t), conducted_Tx_power(t)_Plimit, and 1g_SAR_Plimit correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at Plimit, and measured 1g_SAR values at Plimit for the worst-case radio configuration within the tested technology/band/Antenna/DSI. **RF Exposure measurement:** ■ Demonstrate the total RF exposure averaged over predefined time windows does not exceed FCC's SAR limit, through time-averaged SAR measurements for only scenario 1 to add confidence in the Smart Transmit feature validation, while avoiding the complexity in SAR measurement (in particular, for scenario 3 requiring change in SAR probe calibration file to accommodate different bands and/or tissue simulating liquid). □ For *f* < 6 transmission only (Scenario 1): measure instantaneous SAR versus time and demonstrate total time-averaged RF exposure is less than 1.0 at all times.

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR_{P\ limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (5a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR(t)dt}{FCC\ SAR_{limit}} \leq 1 \quad (5b)$$

# 5. Sub-6 Validation Test Plan

This chapter provides the test plan for validating Qualcomm Smart Transmit feature for sub-6 transmission. The 100 seconds time window for operating f < 3GHz is used as an example to detail the test procedures. The same test plan and test procedures described in this chapter apply to 60 seconds time window for 3GHz ≤ f < 6GHz.

## 5.1 Test sequence determination for validation

Following the FCC recommendation, two test sequences having time-variation in Tx power are predefined for sub-6 (f < 6 GHz) validation:

Test sequence 1: Requesting EUT to transmit at maximum power, measured Pmax†, for 80s, then requesting for half of the maximum power, i.e., measured Pmax/2, for the rest of the time.

Test sequence 2: requesting EUT to transmit at time-varying Tx power levels. This sequence is generated relative to measured Pmax, measured Plimit and calculated Preserve (= measured Plimit - Reserve_power_margin) of EUT based on measured Plimit.

For an easier computation of the 100s running average, 0 dBm for 100s is added at the beginning of the test sequences, so the 100s running average can be directly performed starting with the first 100-seconds data using excel spreadsheet.

The details for generating these two test sequences is described and listed in Appendix A.

## 5.2 Test configuration selection criteria for validating Smart Transmit feature

For validating Smart Transmit feature, this section provides a general guidance to select test cases. In practice, an adjustment can be made in test case selection. The justification/clarification may be provided.

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

The Smart Transmit time averaging operation is independent of bands, modes, and channels for a given technology. Hence, validation of Smart Transmit in one band/mode/channel per technology is sufficient. Two bands per technology are proposed and selected for this testing to provide high confidence in this validation.

Note this test is designed for single radio transmission scenario. If UE supports sub6 NR in both non-standalone (NSA) and standalone (SA) modes, then validation in time-varying Tx power transmission scenario described in this section needs to be performed in SA mode. Otherwise, it needs to be performed in NSA mode with LTE anchor set to low power. The choice between SA and NSA mode needs to also take into account the seletion criteria described below. In general, one mode out of the two modes (NSA or SA) is sufficient for this test.

The criteria for the selection is based on the Plimit values determined in Part 0 SAR Char report, select two bands* in each supported technology that correspond to least** and highest*** Plimit values for validating Smart Transmit, where Plimit < Pmax.

Note:

1. Pmax refers to maximum Tx power configured for this device in this technology/band (not rated Pmax). This Pmax definition applies throughout this Part 2 report.

2. If Plimit > Pmax, the validation test with time-varying test sequences is not needed as no power enformance will be required in this condition.

* If one Plimit level applies to all the bands within a technology or if only one band within a technology has Plimit < Pmax, then only one band needs to be tested. In this case, select one band/radio configuration for this test. Use the highest measured 1g_SAR shown in Part 1 SAR Test Report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR.

** In case of multiple bands having the same least Plimit within the technology, then select any one band out of these bands.

*** The band having a higher Plimit (meaning lower SAR at Pmax) needs to be properly selected so that the power limiting enforced by Smart Transmit can be validated using the pre-defined test sequences. If the highest Plimit in a technology is too high (i.e., > Pmax) where the power limiting enforcement is not needed when testing with the pre-defined test sequences, then the next highest level should be checked. This process should be continued within the technology until the second band for validation testing is determined.

Note if possible for this selection, delta (Pmax - Plimit) should be 1dB or higher.

### 5.2.2 Test configuration selection for change in call

The criteria to select a test configuration for call-drop measurement is:

Select technology/band with least Plimit among all supported technologies/bands and Plimit < Pmax, then select one radio configuration within the selected band for this test. Use the highest measured 1g_SAR listed in Part 1 SAR Test Report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR.

In case of multiple bands having same least Plimit, then select one band/radio configuration for this test.

Test for change in call is not required if all Plimit > Pmax

This test is performed with the EUT being requested to transmit at maximum power, the above band selection will result in Tx power enforcement (i.e., EUT forced to transmit at Preserve) for longest duration, at that time, call change (call drop/reestablish) is performed. One test is sufficient as the feature operation is independent of technology and band.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

### 5.2.3 Test configuration selection for change in technology/band

The selection criteria for this measurement is to have EUT switch from a technology/band with lowest (or highest) Plimit within the technology group to a technology/band with highest (or lowest) Plimit within the technology group, or vice versa.

The selection order is:

First select both technology/band configurations having Plimit < Pmax. In case of multiple bands having the same Plimit, select one band/radio configuration for this test. If this can not be found, then,

Select at least one technology/band configuration having Plimit < Pmax. If all Plimit > Pmax, then, test for change in technology/band is not required.

Use the highest measured 1g_SAR at Plimit (Plimit < Pmax) shown in Part 1 SAR Test Report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR. However, in the case of Plimit > Pmax, the SAR measured in Part 1 report for the corresponding radio configuration selected and tested in Part 2 should be applied in Equation (3a), (4a), (5a) and (6a).

This test is performed with the EUT being requested to transmit at maximum power, the technology/band switch is performed during Tx power enforcement (i.e., EUT forced to transmit at Preserve). One test is sufficient as the feature operation is independent of technology and band.



SGS Taiwan Ltd. 台灣檢驗科技股份有限公司
No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

### 5.2.4 Test configuration selection for change in antenna

The criteria to select a test configuration for antenna switch (between primary and diversity antennas) measurement is:

Whenever possible and supported by the EUT, first select antenna switch configuration within the same technology/band/DSI (i.e., same technology, band and DSI combination), and having different Plimit, and having both Plimit < Pmax where possible. Otherwise, select at least one antenna having Plimit < Pmax.

If the EUT does not support antenna switch within the same technology/band, but has multiple transmitting antennas to support different frequency bands, then antenna switch test should be performed in combination with technology and/or band switch. Note in this case, if possible, antenna switch test may be included as part of either change in technology and band (Section 5.2.3) or change in time window (Section 5.2.6).

Test for change in antenna is not required if all Plimit > Pmax

Use the highest measured 1g_SAR at Plimit (Plimit < Pmax) shown in Part 1 SAR Test report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR. However, in the case of Plimit > Pmax, the SAR measured in Part 1 report for the corresponding radio configuration selected and tested in Part 2 should be applied in Equation (3a), (4a), (5a) and (6a).

This test is performed with the EUT being requested to transmit in selected technology/band at maximum power out of antenna, the antenna switch is performed during Tx power enforcement (i.e., EUT forced to transmit at Preserve). One test is sufficient as the feature operation is independent of technology and band.

### 5.2.5 Test configuration selection for change in device state

The criteria to select a test configuration for device state switch measurement is:

Select a technology/band having the Plimit < Pmax within any technology and DSI group, and for the same technology/band having a different Plimit (Plimit < Pmax) and in any other DSI group. Both the selected DSIs should have Plimit < Pmax where possible. Otherwise, select at least one DSI having Plimit < Pmax. Note that the selected DSI transition need to be supported by the device.

Test for change in device state is not required if all Plimit > Pmax.

Use the highest measured 1g_SAR at Plimit (Plimit < Pmax) shown in Part 1 report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR. However, in the case of Plimit > Pmax, the SAR measured in Part 1 report for the corresponding radio configuration selected and tested in Part 2 should be applied in Equation (3a), (4a), (5a) and (6a).

This test is performed with the EUT being requested to transmit at maximum power in selected technology/band/antenna/device-state. The change in device state is performed during Tx power enforcement (i.e., EUT forced to transmit at Preserve). One test is sufficient as the feature operation is independent of technology, band, antenna and device state.

### 5.2.6 Test configuration selection for change in time window

FCC specifies different time window for time averaging based on operation frequency. The criteria to select a test configuration for validating Smart Transmit feature and demonstrating the compliance during the change in time window is

Select any technology/band that has operation frequency classified in one time window defined by FCC (such as 100s time window), and its corresponding $P_{limit}$ is less than $P_{max}$ if possible.

Select the 2nd technology/band that has operation frequency classified in a different time window defined by FCC (such as 60s time window), and its corresponding $P_{limit}$ is less than $P_{max}$ if possible.

It is preferred both $P_{limit}$ values of two selected technology/bands are less than corresponding $P_{max}$, but if not possible or due to limitation of test setup, then at least one of technologies/bands has its $P_{limit}$ less than $P_{max}$.

Else, if all $P_{limit} > P_{max}$, then,
first select both technologies/bands (one is in 100s time window, another is in 60s time window) having ($P_{limit} – P_{max}$) < 2.2dB; if it is not available, then

select at least one technology/band in 60s time window having ($P_{limit} – P_{max}$) < 2.2dB; if it it not available, then

Test for change in time window is not required.

Use the highest measured 1g_SAR at Plimit (Plimit < Pmax) shown in Part 1 report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR. However, in the case of Plimit > Pmax, the SAR measured in Part 1 report for the corresponding radio configuration selected and tested in Part 2 should be applied in Equation (3a), (4a), (5a) and (6a).

This test is performed with the EUT being requested to transmit at maximum power in selected technology/band. Test for one pair of time windows selected is sufficient as the feature operation is the same.

### 5.2.7 Test configuration selection for SAR exposure switching

If supported, the test configuration for SAR exposure switching should cover

1.SAR exposure switch when two active radios are in the same time window. The following radio configurations need to be covered if the device supports:

a. LTE + sub6 NR: LTE is protected as it is anchor in NR call. However, Sub6 NR can sustain the link if LTE is at low power

b. Interband ULCA: PCC is protected as it is primary in interband ULCA call. SCC will drop the link if SCC is requested to transmit continuously at or above $P_{limit}$ regardless of PCC transmitting power level.

Note that Smart Transmit treats intraband ULCA as single Tx, so, this test is not needed for intraband ULCA.

2.SAR exposure switch when two active radios are in different time windows. Note that one test with two active radios in any two different time windows is sufficient as Smart Transmit operation is the same for RF exposure switch in any combination of two different time windows. For device supporting LTE + mmW NR, this test (i.e., Scenario 2) is covered in SAR vs PD exposure switch validation.

The Smart Transmit time averaging operation ensures total time-averaged RF exposure compliance independent of the source of SAR exposure (for example, LTE vs. Sub6 NR). Hence, validation of Smart Transmit in any one band combination for each simultaneous SAR transmission scenario (i.e., one band combination for LTE + Sub6 NR transmission, and one band combination for interband ULCA) is sufficient, where the SAR exposure varies among SARradio1 only, SARradio1 + SARradio2, and SARradio2 only scenarios.

The criteria to select a test configuration for validating Smart Transmit feature during SAR exposure switching scenarios is

Following the above two test requirements, select the required configuration(s) for the EUT supported simultaneous transmission scenario(s).

Among all supported simultaneous transmission configurations, the selection order is

1. Select one configuration where both $P_{limit}$ of radio1 and radio2 is less than their corresponding $P_{max}$, preferably, with different $P_{limits}$. If this configuration is not available, then,

2. Select one configuration that has $P_{limit}$ less than its $P_{max}$ for at least one radio. If this can not be found, then,

3. The test for SAR exposure switch when two active radios are in the same time window is not required. For SAR exposure switch when two active radios are in the different time windows, the selection order is:

Select both configurations that has $P_{limit}$ of radio1 and radio2 greater than $P_{max}$ but having ($P_{limit} – P_{max}$) < 2.2dB.

If this can't be found, then,

Select at least one configuration in 60s window that has ($P_{limit} – P_{max}$) < 2.2dB.

If all ($P_{limit} – P_{max}$) > 2.2dB, then,

Test for SAR exposure switch when two active radios are in the different time windows is not required.

Use the highest *measured* 1g_ SAR at $P_{limit}$ ($P_{limit} < P_{max}$) shown in Part 1 report for the selected tech/band/antenna/DSI out of all radio configurations and device positions in Equation (3a), (4a), (5a) and (6a) to calculate time-varying SAR. However, in the case of $P_{limit} > P_{max}$, the SAR measured in Part 1 report for the corresponding radio configuration selected and tested in Part 2 should be applied in Equation (3a), (4a), (5a) and (6a).

Test for one band combination per each simultaneous transmission technology is sufficient as the feature operation is the same. Additional details for testing LTE+Sub6 NR non-standalone are provided in Appendix B.



SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## 5.3 Test procedures for conducted power measurements

This section provides general conducted power measurement procedures to perform compliance test under dynamic transmission scenarios described in Section 2. In practice, an adjustment can be made in these procedures. The justification/clarification may be provided. Perform conducted power measurement to validate Smart Transmit time averaging feature in the transmission scenarios described in Section 4.2. Refer to Appendix B for detailed test procedures for LTE+Sub6 NR transmission.

### 5.3.1 Time-varying Tx power transmission scenario

This test is performed with the two pre-defined test sequences described in Section 5.1 for all the technologies and bands selected in Section 5.2.1. The purpose of the test is to demonstrate the effectiveness of power limiting enforcement and that the time averaged transmit power when converted into 1gSAR values does not exceed the regulatory limit at all times (see Eq. (3a) and (3b)).

**Test procedure**

1. Measure $P_{max}$, measure $P_{limit}$ and calculate $P_{reserve}$ (= measured $P_{limit}$ in dBm – *Reserve_power_margin* in dB) and follow Section 5.1 to generate the test sequences for all the technologies and bands selected in Section 5.2.1. Both test sequence 1 and test sequence 2 are created based on measured Pmax and measured Plimit of the EUT. Test condition to measure Pmax and Plimit is:

Measure $P_{max}$ with Smart Transmit disabled and callbox set to request maximum power.

Measure $P_{limit}$ with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.

2. Set *Reserve_power_margin* to actual (intended) value, with callbox requesting the EUT to transmit at pre-defined test sequence 1 (generated in Step 1), measure and record Tx power versus time. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1g_SAR value (see Eq. (3a)) using Step 1.b result, and then perform 100s running average to determine time-averaged 1g_SAR versus time as illustrated in below Figure 5-1.

| Time | Power/SAR |
|---|---|
| $t_1$ | $P_{t1}$ or $SAR_{t1}$ |
| $t_2$ | $P_{t2}$ or $SAR_{t2}$ |
| : | : |
| : | : |
| $t_n$ ($t_1$+100s) | $P_{tn}$ or $SAR_{tn}$ |
| $t_{n+1}$ ($t_2$+100s) | $P_{tn+1}$ or $SAR_{tn+1}$ |
| : | : |

1st 100s time window

$$time\ averaged\ P1\ or\ SAR1 = \frac{\sum_{i=1}^{n} P_{ti} or\ SAR_{ti}}{n}$$

2nd 100s time window

$$time\ averaged\ P2\ or\ SAR2 = \frac{\sum_{i=2}^{n+1} P_{ti}\ or\ SAR_{ti}}{n}$$

**Figure 5-1 100s running average illustration**

**NOTE:**

In Eq.(3a), instantaneous Tx power is converted into instantaneous 1g_ SAR value by applying the worst-case 1g_or_10gSAR value for each technology/band at $P_{limit}$ as reported in *Part 1 SAR test report*.

3. Make one plot containing:

a. Instantaneous Tx power versus time measured in Step 2, and

b. Requested transmit power used in Step 2 (test sequence 1).

4. Make another plot containing:

a. Instantaneous 1g_SAR versus time determined in Step 2

b. Computed time-averaged 1g_SAR versus time determined in Step 2

c. Corresponding regulatory 1g_*SAR* limit.

5. Repeat Steps 2~4 for pre-defined test sequence 2 and replace the requested Tx power (test sequence 1) in Step 3b with test sequence 2.

6. Repeat Steps 2~5 for all the selected technologies and bands.

The validation criteria is, at all times, the time-averaged 1g_SAR versus time determined in Step 2 (and plotted in Step 4) shall not exceed the regulatory *1g_SAR* limit.

### 5.3.2 Change in call scenario

This test is to demonstrate that Smart Transmit feature accurately accounts for the past Tx powers during time-averaging when a new call is established.

The call drop and re-establishment needs to be performed during power limit enforcement, i.e., when the EUT transmits at Preserve level (i.e., during Tx power enforcement) to demonstrate the continuity of RF exposure management and limiting in call change scenario. In other words, the RF exposure averaged over any 100s-time window (including the time windows containing the call change) doesn’t exceed the corresponding regulatory 1g_SAR limit.

Test procedure

1. Measure Plimit for the technology/band selected in Section 5.2.2. Measure Plimit with Smart Transmit enabled and Reserve_power_margin set to 0 dB, callbox set to request maximum power.

2. Set Reserve_power_margin to actual (intended) value and enable Smart Transmit

3. Establish radio link with callbox in technology/band selected in Section 5.2.2.

4. Request EUT to transmit at 0 dBm for at least 100 seconds, followed by requesting EUT to transmit at maximum Tx power for about ~60 seconds, and then drop the call for ~10 seconds. Afterwards, reestablish another call in the same radio configuration (i.e., same technology/band/channel) and continue callbox requesting EUT to transmit at maximum Tx power for the remaining time for a total test time of 500 seconds. Measure and record Tx power versus time.

5. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1g_SAR value (see Eq. (3a)) using Step 1 result, and then perform 100s running average to determine time-averaged 1g_SAR versus time as illustrated in Figure 5-1.

NOTE: In Eq.(3a), instantaneous Tx power is converted into instantaneous 1g_SAR value by applying the worst-case 1g_SAR value of the technology/band at Plimit as reported in Part 1 SAR Test Report.

6. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 3.

7. Make another plot containing: (a) instantaneous 1g_SAR versus time determined in Step 4, (b) computed time-averaged 1g_SAR versus time determined in Step 4, and (c) corresponding regulatory 1g_SAR limit.

The validation criteria is, at all times, the time-averaged 1g_SAR versus time determined in Step 4 (and plotted in Step 6) shall not exceed the regulatory 1g_SAR limit.

### 5.3.3 Change in technology and band

This test is to demonstrate the correct power control by Smart Transmit during technology switches and/or band handovers.

Similar to the change in call test in Section 5.3.2, to validate the continuity of RF exposure limiting during the transition, the technology and band handover needs to be performed when EUT's Tx power is at Preserve level (i.e., during Tx power enforcement) to make sure that the EUT's Tx power from previous Preserve level to the new Preserve level (corresponding to new technology/band). Since the Plimit could vary with technology and band, Eq. (1a) can be written as follows to convert the instantaneous Tx power in 1gSAR exposure for the two given radios, respectively:

$$1g\_or\_10gSAR_1(t) = \frac{conducted\_Tx\_power\_1(t)}{conducted\_Tx\_power\_P_{limit\_1}} * 1g\_or\_10gSAR\_P_{limit\_1} \quad (7a)$$

$$1g\_or\_10gSAR_2(t) = \frac{conducted\_Tx\_power\_2(t)}{conducted\_Tx\_power\_P_{limit\_2}} * 1g\_or\_10gSAR\_P_{limit\_2} \quad (7b)$$

$$\frac{\frac{1}{T_{SAR}}\left[\int_{t-T_{SAR}}^{t_1} 1g\_or\_10gSAR_1(t)dt + \int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR_2(t)dt\right]}{1g\_or\_10gSAR_{limit}} \leq 1 \quad (7c)$$

where, conducted_Tx_power_1(t), conducted_Tx_power_Plimit_1, and 1g_SAR_Plimit_1 correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at Plimit, and measured 1gSAR SAR value at Plimit of technology1/band1; conducted_Tx_power_2(t), conducted_Tx_power_Plimit_2(t), and 1g_SAR_Plimit_2 correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at Plimit, and measured 1gSAR value at Plimit of technology2/band2. Transition from technology1/band1 to the technology2/band2 happens at time-instant 't1'.

### Test procedure

1. Measure $P_{limit}$ for both the technologies and bands selected in Section 5.2.3. Measure $P_{limit}$ with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.

2. Set *Reserve_power_margin* to actual (intended) value and reset power on EUT to enable Smart Transmit

3. Establish radio link with callbox in first technology/band selected in Section 5.2.3.

4. Request EUT to transmit at 0 dBm for at least 100 seconds, followed by requesting EUT to transmit at maximum Tx power for about ~60 seconds, and then switch to second technology/band selected in Section 5.2.3. Continue with callbox requesting EUT to transmit at maximum Tx power for the remaining time for a total test time of 500 seconds. Measure and record Tx power versus time for the entire duration of the test.

5. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into 1g_SAR value (see Eq. (7a) and (7b)) using corresponding technology/band Step 1 result, and then perform 100s running average to determine time-averaged 1gSAR versus time as illustrated in Figure 5-1. Note that in Eq.(7a) & (7b), instantaneous Tx power is converted into instantaneous 1g_SAR value by applying the worst-case 1gSAR value for the selected technologies/bands at Plimit as reported in Part 1 SAR Test Report.

6. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 4.

7. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 5, (b) computed time-averaged 1g_SAR versus time determined in Step 5, and (c) corresponding regulatory 1g_SAR limit.

The validation criteria is, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory 1g_SAR limit.

### 5.3.4 Change in antenna

This test is to demonstrate the correct power control by Smart Transmit during antenna switches from primary to diversity. The test procedure is identical to Section 5.3.3, with switching antenna instead of technology/band. The validation criteria is, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory 1g_SAR limit.

### 5.3.5 Change in DSI

This test is to demonstrate the correct power control by Smart Transmit during device state transitions from one device state to another. The test procedure is identical to Section 5.3.3, with changing device state instead of technology/band. The validation criteria is, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory 1g_SAR limit.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

### 5.3.5 Change in time window

This test is to demonstrate the correct power control by Smart Transmit during the change in averaging time window when a specific band handover occurs. FCC specifies time-averaging windows of 100s for Tx frequency < 3GHz, and 60s for Tx frequency between 3GHz and 6GHz.

Similar to the change in technology and band test in Section 5.3.3, to validate the continuity of RF exposure limiting during the transition, the band handover test needs to be performed when EUT handovers from operation band less than 3GHz to greater than 3GHz or vice versa. The equations (3a) and (3b) in Section 4.1 can be written as follows for transmission scenario having change in time window,

$$1g\_or\_10gSAR_1(t) = \frac{conducted\_Tx\_power\_1(t)}{conducted\_Tx\_power\_P_{limit\_1}} * 1g\_or\_10gSAR\_P_{limit\_1} \quad (8a)$$

$$1g\_or\_10gSAR_2(t) = \frac{conducted\_Tx\_power\_2(t)}{conducted\_Tx\_power\_P_{limit\_2}} * 1g\_or\_10gSAR\_P_{limit\_2} \quad (8b)$$

$$\frac{\frac{1}{T1_{SAR}}\left[\int_{t-T1_{SAR}}^{t_1} 1g\_or\_10gSAR_1(t)dt\right] + \frac{1}{T2_{SAR}}\left[\int_{t-T2_{SAR}}^{t} 1g\_or\_10gSAR_2(t)dt\right]}{1g\_or\_10gSAR_{limit}} \leq 1 \quad (8c)$$

where, conducted_Tx_power_1(t), conducted_Tx_power_Plimit_1, and 1g_SAR

_Plimit_1 correspond to the instantaneous Tx power, conducted Tx power at Plimit, and compliance 1g_SAR values of band1 at Plimit_1; conducted_Tx_power_2(t), conducted_Tx_power_Plimit_2, and 1g_SAR_Plimit_2 correspond to the instantaneous Tx power, conducted Tx power at Plimit, and compliance 1g_SAR values of band2 at Plimit_2. One of the two bands is less than 3GHz, another is greater than 3GHz. Transition from first band with time-averaging window ‘T1 SAR’ to the second band with time-averaging window ‘T2 SAR’ happens at time-instant ‘t1’.

**Test procedure**

1. Measure $P_{limit}$ for both the technologies and bands selected in Section 5.2.6. Measure $P_{limit}$ with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.

2. Set *Reserve_power_margin* to actual (intended) value and enable Smart Transmit

**Transition from 100s time window to 60s time window, and vice versa**

3. Establish radio link with callbox in the technology/band having 100s time window selected in Section 5.2.6.

4. Request EUT to transmit at 0 dBm for at least 100 seconds, followed by requesting EUT to transmit at maximum Tx power for about ~140 seconds, and then switch to second technology/band (having 60s time window) selected in Section 5.2.6. Continue with callbox requesting EUT to transmit at maximum Tx power for about ~60s in this second technology/band, and then switch back to the first technology/ band. Continue with callbox requesting EUT to transmit at maximum Tx power for at least another 100s. Measure and record Tx power versus time for the entire duration of the test.

5. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into *1g*_SAR value (see Eq. (8a) and (8b)) using corresponding technology/band Step 1 result, and then perform 100s running average to determine time- averaged *1g*_SAR versus time as illustrated in Figure 5-1. Note that in Eq.(8a) & (8b), instantaneous Tx power is converted into instantaneous *1g*_SAR value by applying the worst-case *1g*_SAR value for the selected technologies/bands at $P_{limit}$.

6. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 4.

7. Make another plot containing: (a) instantaneous *1g*_SAR versus time determined in Step 5, (b) computed time-averaged *1g*_SAR versus time determined in Step 5, and (c) corresponding regulatory *1g_SAR* limit.

**Transition from 60s time window to 100s time window, and vice versa**

8. Establish radio link with callbox in the technology/band having 60s time window selected in Section 5.2.6.

9. Request EUT to transmit at 0 dBm for at least 60 seconds, followed by requesting EUT to transmit at maximum Tx power for about ~80 seconds, and then switch to second technology/band (having 100s time window) selected in Section 5.2.6. Continue with callbox requesting EUT to transmit at maximum Tx power for about ~100s in this second technology/band, and then switch back to the first technology/band. Continue with callbox requesting EUT to transmit at maximum Tx power for the remaining time for a total test time of 500 seconds. Measure and record Tx power versus time for the entire duration of the test.

10. Repeat above Step 5~7 to generate the plots

The validation criteria is, at all times, the time-averaged *1g*_SAR versus time shall not exceed the regulatory *1g_SAR* limit.

### 5.3.7 SAR exposure switching

This test is to demonstrate that Smart Transmit feature is accurately accounts for switching in exposures among SAR from radio1 only, SAR from both radio1 and radio2, and SAR from radio2 only scenarios, and ensures total time-averaged RF exposure complies with the FCC limit. The detailed test procedure for SAR exposure switching in the case of LTE+Sub6 NR non-standalone mode transmission scenario is provided in Appendix B.

**Test procedure:**

1. Measure conducted Tx power corresponding to $P_{limit}$ for radio1 and radio2 in selected band. Test condition to measure conducted $P_{limit}$ is:

Establish device in call with the callbox for radio1 technology/band. Measure conducted Tx power corresponding to radio1 $P_{limit}$ with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.

Repeat above step to measure conducted Tx power corresponding to radio2 $P_{limit}$. If radio2 is dependent on radio1 (for example, non-standalone mode of Sub6 NR requiring radio1 LTE as anchor), then establish radio1 + radio2 call with callbox, and request all down bits for radio1 LTE. In this scenario, with callbox requesting maximum power from radio2 Sub6 NR, measured conducted Tx power corresponds to radio2 $P_{limit}$ (as radio1 LTE is at all-down bits)

2. Set *Reserve_power_margin* to actual (intended) value, with EUT setup for radio1 + radio2 call. In this description, it is assumed that radio2 has lower priority than radio1. Establishd device in radio1+radio2 call, and request all-down bits or low power on radio1, with callbox requesting UE to transmit at maximum power in radio2 for at least one time window. After one time window, set callbox to request UE to transmit at maximum power on radio1, i.e., all-up bits. Continue radio1+radio2 call with both radios at maximum power for at least one time window, and drop (or request all-down bits) radio2. Continue radio1 at maximum power for at least one time window. Record the conducted Tx power for both radio1 and radio2 for the entire duration of this test.

3. Once the measurement is done, extract instantaneous Tx power versus time for both radio1 and radio2 links. Similar to technology/band switch test in Section 5.3.3, convert the conducted Tx power for both these radios into *1g_*SAR value (see Eq. (7a) and (7b)) using corresponding technology/band $P_{limit}$ measured in Step 1, and then perform 100s running average to determine time-averaged *1g_*SAR versus time as illustrated in Figure 5-1. Note that here it is assumed both radios have Tx frequencies < 3GHz, otherwise, 60s running average should be performed for radios having Tx frequency between 3GHz and 6GHz.

4. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 2.

5. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 3, (b) computed time-averaged 1gSAR versus time determined in Step 3, and (c) corresponding regulatory *1g_SAR* limit.

The validation criteria is, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory 1g_SAR limit.

### 5.4 Test procedure for SAR measurements

This section provides general conducted power measurement procedures to perform compliance test under dynamic transmission scenarios described in Section 2. In practice, an adjustment can be made in these procedures. The justification/clarification may be provided.

To validate time averaging algorithm through SAR measurement, the “path loss” between callbox antenna and EUT needs to be calibrated to ensure that the EUT Tx power reacts to the requested power from callbox in a radiated call. It should be noted that when signaling in closed loop mode, protocol-level power control is in play, resulting in EUT not solely following callbox TPC (transmit power control) commands. In other words, EUT response has many dependencies (RSSI, quality of signal, path loss variation, fading, etc.,) other than just TPC commands. These dependencies have less impact in conducted setup (as it is a controlled environment and the path loss can be very well calibrated) but have significant impact on radiated testing in an uncontrolled environment, such as SAR test setup. Therefore, the deviation in EUT Tx power from callbox requested power is expected.

The following steps are for time averaging algorithm validation through SAR measurement:

1. “Path Loss” calibration: Place the EUT against the flat section of the SAM Twin phantom in the worst-case position determined based on Section 5.2.1. For each band selected, prior to SAR measurement, perform “path loss” calibration between callbox antenna and EUT. Since the SAR test environment is not controlled, extreme care needs to be taken to avoid the influence from reflections.
2. Time averaging algorithm validation:

i For a given radio configuration (technology/band) selected in Section 5.2.1, enable Smart Transmit and set Reserve_power_margin to 0 dB, with callbox to request maximum power, perform area scan, conduct pointSAR measurement at peak location of the area scan. This pointSAR value, pointSAR_Plimit corresponds to pointSAR at the measured Plimit obtained in Step 1 of Section 5.3.1.

ii Set Reserve_power_margin to actual (intended) value, with callbox requesting the EUT to transmit at power levels described by test sequence 1 in Step 1 of Section 5.3.1, conduct pointSAR measurement versus time at peak location of the area scan determined in this section Step 2.i. Once the measurement is done, extract instantaneous pointSAR vs time data, pointSAR(t), and convert it into instantaneous 1gSAR vs. time by using equation (5a):

$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \qquad (5a)$$

where, pointSAR_Plimit corresponds to the value determined in Step 2.i, and pointSAR(t) corresponds to instantaneous pointSAR determined in Step 2.ii.

iii Perform 100s running average to determine time-averaged 1gSAR versus time.

iv Make one plot containing (a) instantaneous pointSAR versus time measured in this section Step 2.ii, and (b) requested Tx power (test sequence 1 using secondary Y-axis scale) versus time.

v Make another plot containing (a) 1g_SAR versus time determined in this section Step 2.ii, (b) time-averaged 1g_SAR versus time determined in this section Step 2.iii, (c) regulatory 1g_ SAR limit.

vi Repeat 2.ii ~ 2.v for test sequence 2 generated in Step 1 of Section 5.3.1

vii Repeat 2.i ~ 2.vi for all the technologies and bands selected in Section 5.2.1.

The time-averaging validation criteria for SAR measurement is that, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory 1g_SAR limit.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

# 6. Test Configurations

### 6.1 WWAN (sub-6) transmission

The Plimit values, corresponding to 0.445 W/kg (1gSAR) of SAR_design_target, for technologies and bands supported by EUT are derived in Part 0 report and summarized in Table 6-1. Note all Plimit power levels entered in Table 6-1 correspond to average power levels after accounting for duty cycle in the case of TDD modulation schemes (for e.g., LTE TDD).

**Table 6-1: $P_{limit}$ for supported technologies and bands ($P_{limit}$ in EFS file)**

| Antenna | Band | Plimit** (dBm) | Pmax* (dBm) |
|---|---|---|---|
| Tx5 | WCDMA B II | 36.7 | 23.5 |
| Tx5 | WCDMA B IV | 34.4 | 23.5 |
| Tx5 | WCDMA B V | 40.1 | 23.5 |
| Tx5 | LTE B2 | 36.4 | 23 |
| Tx5 | LTE B4 | 36.0 | 23 |
| Tx5 | LTE B5 | 38.0 | 23.5 |
| Tx5 | LTE B7 | 38.2 | 23 |
| Tx5 | LTE B12 | 40.7 | 23.5 |
| Tx5 | LTE B13 | 36.1 | 23.5 |
| Tx5 | LTE B14 | 37.6 | 23.5 |
| Tx5 | LTE B17 | 39.8 | 23.5 |
| Tx5 | LTE B25 | 36.1 | 23 |
| Tx5 | LTE B26 | 37.9 | 23.5 |
| Tx5 | LTE B30 | 37.5 | 22 |
| Tx5 | LTE B38 | 34.8 | 21 |
| Tx5 | LTE B41 PC3 | 34.3 | 21 |
| Tx5 | LTE B41 PC2 | 33.9 | 22.4 |
| Tx5 | LTE B66 | 35.2 | 23 |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

| | | | |
|---|---|---|---|
| Tx5 | 5G n2 | 36.5 | 23 |
| Tx5 | 5G n5 | 39.8 | 23 |
| Tx5 | 5G n12 | 38.0 | 23 |
| Tx5 | 5G n66 | 34.8 | 23 |
| Tx8 | LTE B2 | 20.9 | 23 |
| Tx8 | LTE B7 | 19.5 | 23 |
| Tx8 | LTE B42 | 17.5 | 21 |
| Tx8 | LTE B48 | 16.8 | 19 |
| Tx8 | LTE B66 | 20.6 | 23 |
| Tx8 | 5G n2 | 19.8 | 23 |
| Tx8 | 5G n7 | 19.1 | 23 |
| Tx8 | 5G n41 PC2 | 18.4 | 26 |
| Tx8 | 5G n41 PC3 | 17.3 | 23 |
| Tx8 | 5G n66 | 19.6 | 23 |

*Pmax is used for RF tune up procedure. The maximum allowed output power is equal to Pmax + device uncertainty.

*All Plimit power levels entered in the Table correspond to average power levels after accounting for duty cycle in the case TDD modulation schemes (for e.g., LTE TDD).

Based on selection criteria described in Section 3.2.1, the selected technologies/bands for testing time-varying test sequences are listed in Table 5-2, the *Reserve_power_margin* (dB) for B94HNI41C4TKR is set to 2dB in EFS, and is used in Part 2 test.

The radio configurations used in Part 2 test for selected technologies, bands, DSIs and antennas are listed in Table 6-2. The corresponding worst-case radio configuration 1gSAR values for selected technology/band are extracted from Part 1 report and are listed in the last column of Table 6-2.
Based on equations (1a), (2a), (3a) and (4a), it is clear that Part 2 testing outcome is normalized quantity, which implies that it can be applied to any radio configuration within a selected technology/band. Thus, as long as applying the

worst-case SAR obtained from the worst radio configuration in Part 1 testing to calculate time-varying SAR exposure in equations (1a), (2a), (3a) and (4a), the accuracy in compliance demonstration remains the same.

## Table 6-2: Radio configurations selected for Part 2 test

.

| Radio configurations selected for Part 2 test | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Part 2 test configurations | | | | | | | | | | | Part 1 worst-case radio config 1g SAR measured at $P_{limit}$ (W/kg) |
| Test case# | Test scenario | Tech | Band | Ant | Channel | Freq (MHz) | RB/RB offset | mode | position | Position details | |
| 1 | time-varying Tx power transmission | LTE | 42 | 8 | 43490 | 3590 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.32 |
| 2 | | LTE | 48 | 8 | 56640 | 3690 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.417 |
| 3 | | sub6 NR | n2 | 8 | 376000 | 1880 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 0.381 |
| 4 | | sub6 NR | n41 | 8 | 528000 | 2640 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 0.216 |
| 5 | change in call | LTE | 48 | 8 | 56640 | 3690 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.417 |
| 6 | Teah/band switch | LTE | 48 | 8 | 56640 | 3690 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.417 |
| | | WCDMA | V | 5 | 4183 | 836.6 | 1/25 | RMC | Bottom | Laptop, 0mm | 0.011 |
| 7 | Change in Time Window (100-60-100s) | LTE | 14 | 5 | 23330 | 793 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.0178 |
| | | LTE | 42 | 8 | 43490 | 3590 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.32 |
| 8 | Change in Time Window (60-100-60s) | LTE | 42 | 8 | 43490 | 3590 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.32 |
| | | LTE | 14 | 5 | 23330 | 793 | 1/25 | QPSK | Bottom | Laptop, 0mm | 0.0178 |
| 9 | SAR1 vs SAR2 | LTE | 5 | 5 | 20600 | 844 | 1/0 | QPSK | Bottom | Laptop, 0mm | 0.0174 |
| | | sub6 NR | n2 | 8 | 380000 | 1900 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 0.381 |

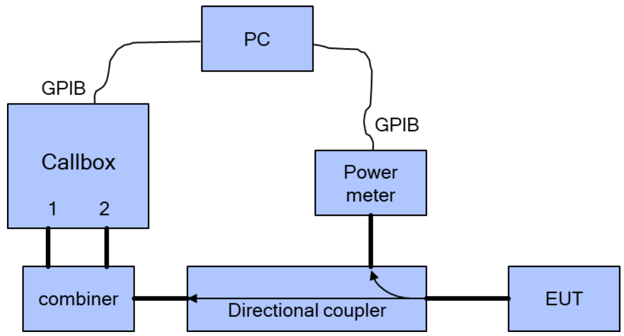
Based on the selection criteria described before, the radio configurations for the Tx varying transmission test cases listed in Section 4 are:

1. Technologies and bands for time-varying Tx power transmission: The test case 1~4 listed in Table 6-2 are selected to test with the test sequences 1/2 in both time-varying conducted power measurement and time-varying SAR measurement.(WCDMA is not required due to Plimit > Pmax)
2. Technology and band for change in call test: The test case 5 listed in Table 6-2 are selected for performing the call drop test in conducted power setup. LTE B48 having the lowest $P_{limit}$ among all technologies and bands
3. Technologies and bands for change in technology/band test: The test case 6 listed in Table 6-2 is selected for handover test from a technology/band to another technology/band, in conducted power setup.
4. Technologies and bands for change in DSI: This is not required because the device supports laptop mode only. (one DSI)
5. Technologies and bands for change in time-window/antenna: The test case 7~8 listed in Table 6-2 is selected for time window switch between 60s window (LTE B42) and 100s window (LTE B14) in conducted power setup.
6. Technologies and bands for switch in SAR exposure: The test case 9 listed in Table 6-2 are selected for SAR exposure switching test in one of the supported simultaneous WWAN transmission scenario, i.e., LTE + Sub6 NR active in the same 100s time window, in conducted power setup.

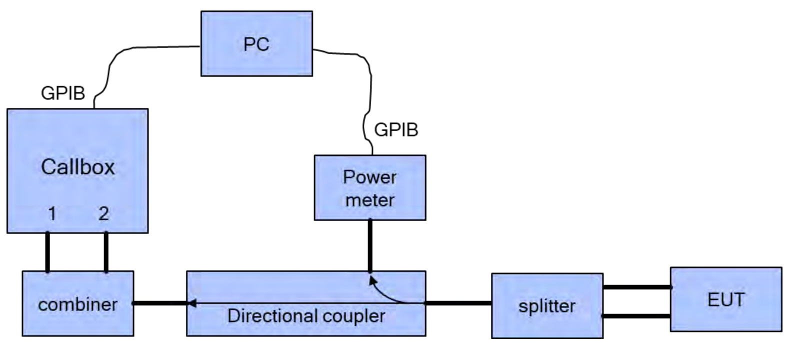
# 7. Conducted Power Test Results for Sub-6 Smart Transmit Feature Validation

## 7.1 Measurement setup

The Rohde & Schwarz CMW500 callbox is used in this test. The test setup schematic are shown in Figures 7-1. For single antenna measurement, one port (RF1 COM) of the callbox is connected to the RF port of the EUT using a directional coupler. For antenna & technology switch measurement, two ports (RF1 COM and RF3 COM) of the callbox used for signaling two different technologies are 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 EUT corresponding to the two antennas of interest. In both the setups, power meter is used to tap the directional coupler for measuring the conducted output power of the EUT. For time averaging validation test, call drop test, and DSI switch test, only RF1 COM port of the callbox is used to communicate with the EUT. For technology/band switch measurement, both RF1 COM and RF3 COM port of callbox are used to switch from one technology communicating on RF1 COM port to another technology communicating on RF3 COM port. All the path losses from RF port of EUT 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.

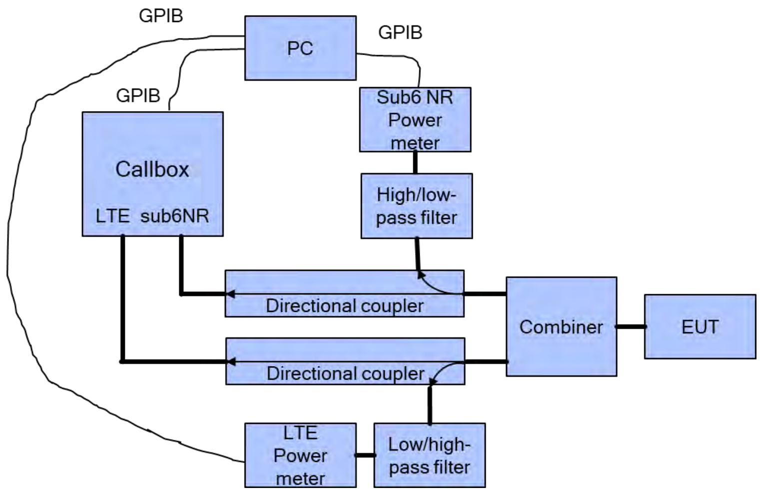



**(a)**




**(b)**


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group




**(c)**

**Figure 7-1 Conducted power measurement setup**

Both the callbox and power meter are connected to the PC using GPIB cables. Two 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 EUT RF port using the power meter. The commands sent to the callbox to request power are:

- 0dBm for 100 seconds
- test sequence 1 or test sequence 2, for 360 seconds
- stay at the last power level of test sequence 1 or test sequence 2 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 DSI switch tests, after the call is established, the callbox is set to request the EUT'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 EUT 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 EUT for the rest of the test. Note that the call drop/re-establish, or technology/band/antenna switch or DSI switch is manually performed when the Tx power of EUT is at Preserve level.

## 7.2 Plimit and Pmax measurement results

The measured Plimit for all the selected radio configurations given in Table 6-2 are listed in below Table 7-1. Pmax was also measured for radio configurations selected for testing time-varying Tx power transmission scenarios in order to generate test sequences following the test procedures.

## Table 7-1: Measured $P_{limit}$ and $P_{max}$ of selected radio configurations

| Measured $P_{limit}$ and $P_{max}$ of selected radio configurations | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test case# | Test scenario | Tech | Band | Ant | Channel | Freq (MHz) | RB/RB offset | mode | position | Position details | Plimit EFS setting (dBm) | Pmax (dBm) | measured Plimit (dBm) | measured Pmax (dBm) |
| 1 | time-varying Tx power transmission | LTE | 42 | 8 | 43190 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 17.5 | 21 | 17.399 | 21.98 |
| 2 | | LTE | 48 | 8 | 55340 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 16.8 | 19 | 16.555 | 19.97 |
| 3 | | sub6 NR | n2 | 8 | 380000 | 1900 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 19.8 | 23 | 19.81 | 23.89 |
| 4 | | sub6 NR | n41 | 8 | 509202 | 2546.01 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 17.3 | 23 | 17.34 | 23.24 |
| 5 | Call Drop | LTE | 48 | 8 | 55340 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 16.8 | 19 | 16.555 | 19.97 |
| 6 | Teah/band switch | LTE | 48 | 8 | 55340 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 16.8 | 19 | 16.555 | 19.97 |
| | | WCDMA | V | 5 | 4183 | 836.6 | | RMC | Bottom | Laptop, 0mm | 40.1 | 23.5 | 24.01 | 24.08 |
| 7 | Change in Time Window (100-60-100s) | LTE | 14 | 5 | 23330 | 793 | 1/0 | QPSK | Bottom | Laptop, 0mm | 37.6 | 23.5 | 23.66 | 23.69 |
| | | LTE | 42 | 8 | 43190 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 17.5 | 21 | 17.399 | 21.98 |
| 8 | Change in Time Window (60-100-60s) | LTE | 42 | 8 | 43190 | 3560 | 1/0 | QPSK | Bottom | Laptop, 0mm | 17.5 | 21 | 17.399 | 21.98 |
| | | LTE | 14 | 5 | 23330 | 793 | 1/0 | QPSK | Bottom | Laptop, 0mm | 37.6 | 23.5 | 23.66 | 23.69 |
| 9 | SAR1 vs SAR2 | LTE | 5 | 5 | 20600 | 844 | 1/0 | QPSK | Bottom | Laptop, 0mm | 38 | 23.5 | 23.92 | 23.95 |
| | | sub6 NR | n2 | 8 | 380000 | 1900 | 1/1 | DFT-s-OFDM, BPSK | Bottom | Laptop, 0mm | 19.8 | 23 | 19.81 | 23.89 |

Note: the device uncertainty of $P_{max}$ is +1.0dB/-1.0dB as provided by manufacturer.

.

### 7.3 Time-varying Tx power measurement results

The measurement setup is shown in Figures 7-1(a) and 7-1(c). The purpose of the time-varying Tx power measurement is to demonstrate the effectiveness of power limiting enforcement and that the time-averaged Tx power when represented in time-averaged 1gSAR values does not exceed FCC limit as shown in Eq. (3a) and (3b), rewritten below:

$$1g\_or\_10gSAR(t) = \frac{conducted\_Tx\_power(t)}{conducted\_Tx\_power\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (3a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 1g\_or\_10gSAR(t)dt}{FCC\ SAR_{limit}} \leq 1 \quad (3b)$$

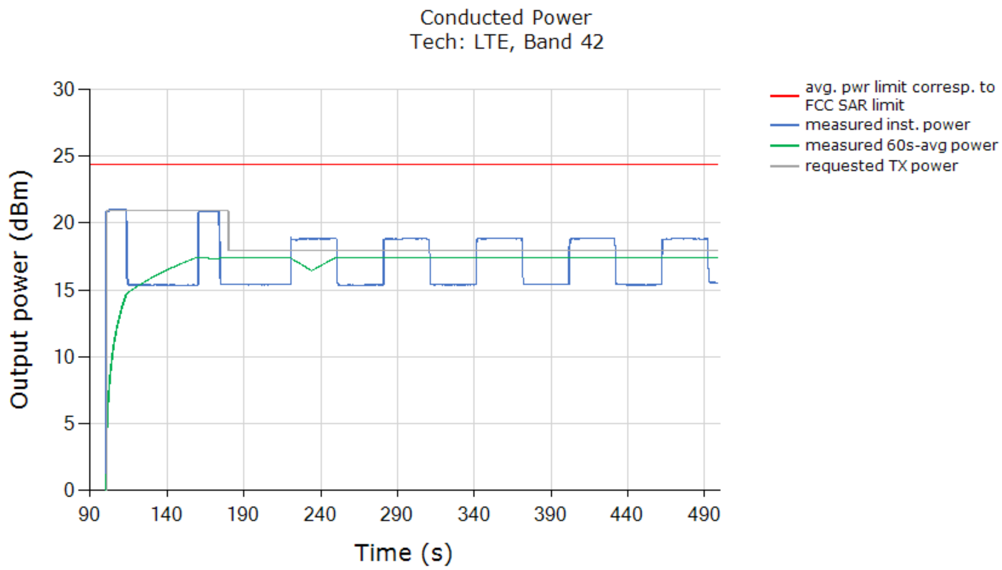
where, $conducted\_Tx\_power(t)$, $conducted\_Tx\_power\_Plimit$, and $1g\_SAR\_Plimit$ correspond to the measured instantaneous conducted Tx power, measured conducted Tx power at Plimit, and measured 1gSAR values at Plimit reported in Part 1 test (listed in Table 6-2 of this report as well).

Following the test procedure, the conducted Tx power measurement for all selected configurations are reported in this section. In all the conducted Tx power plots, the dotted line represents the requested power by callbox (test sequence 1 or test sequence 2), the blue curve represents the instantaneous conducted Tx power measured using power meter, the green curve represents time-averaged power and red line represents the conducted power limit that corresponds to FCC limit of 1.6 W/kg for 1gSAR.

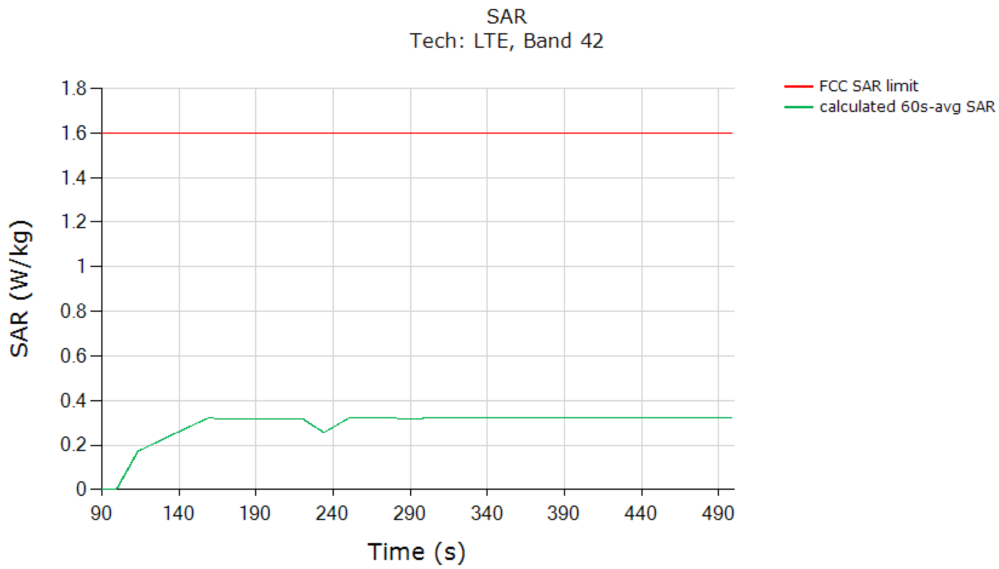
Similarly, in all the 1g SAR plots (when converted using Eq. (3a)), the green curve represents the 100s/60s-time averaged 1gSAR value calculated based on instantaneous 1gSAR; and the red line limit represents the FCC limit of 1.6 W/kg for 1gSAR.

7.3.1 LTE Band 42

Test result for test sequence 1:



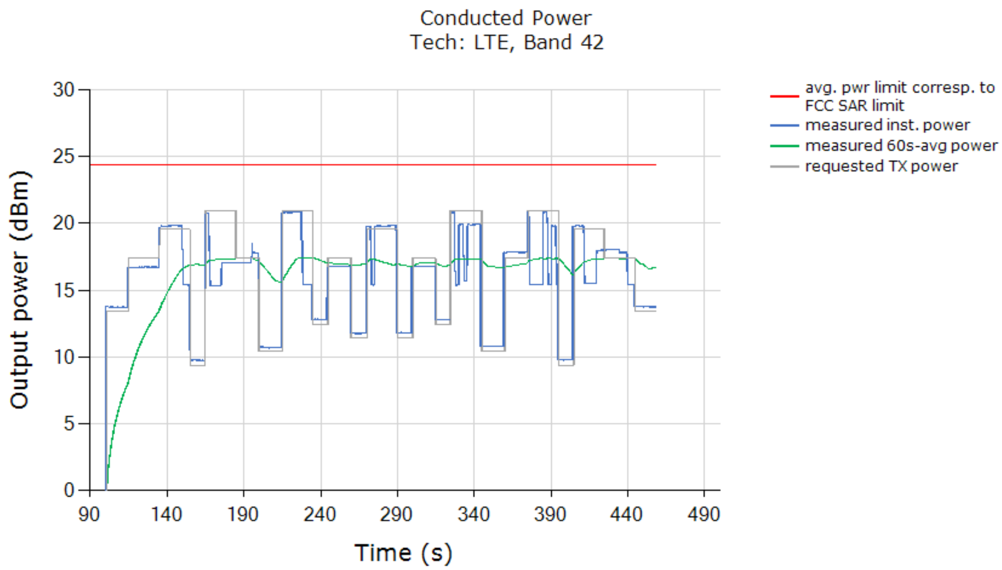

Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 10gSAR (green curve) | 0.324 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

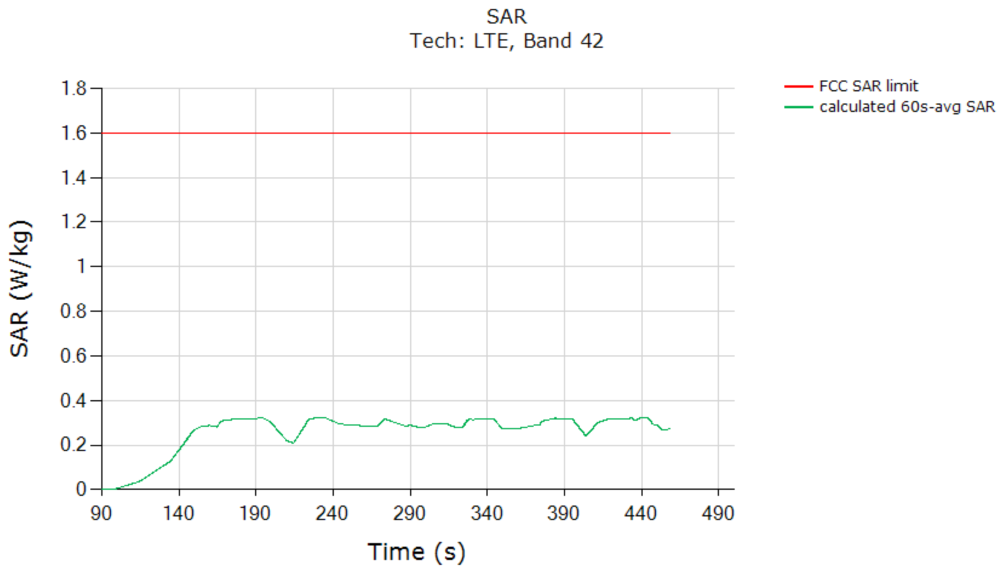

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

Test result for test sequence 2:




Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

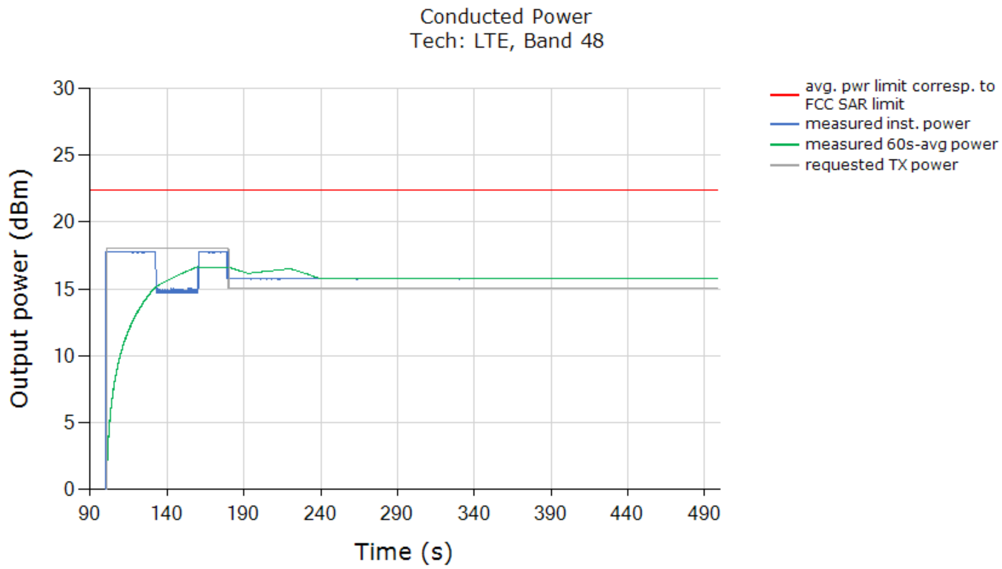



| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.322 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

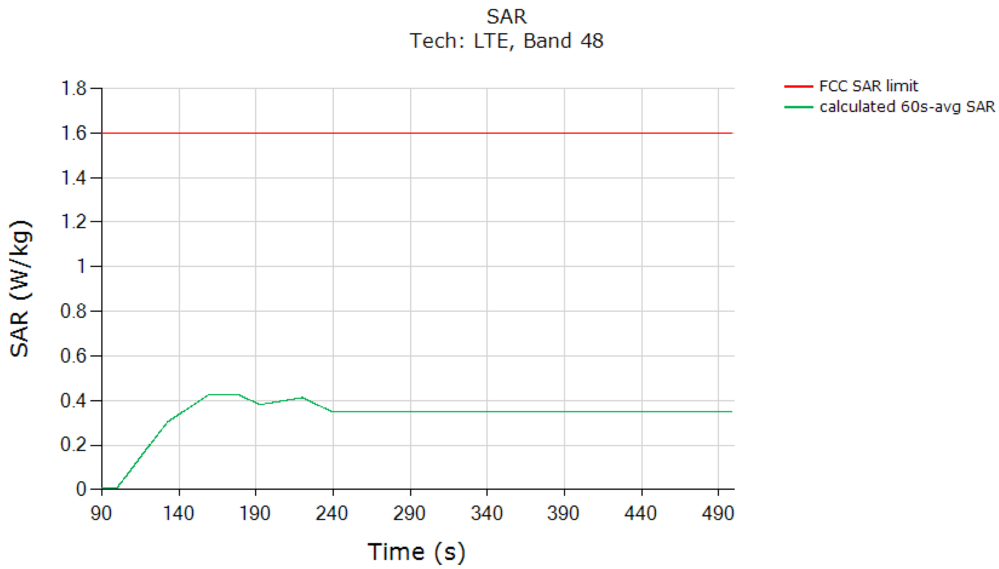
## 7.3.2 LTE Band 48

Test result for test sequence 1:




Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

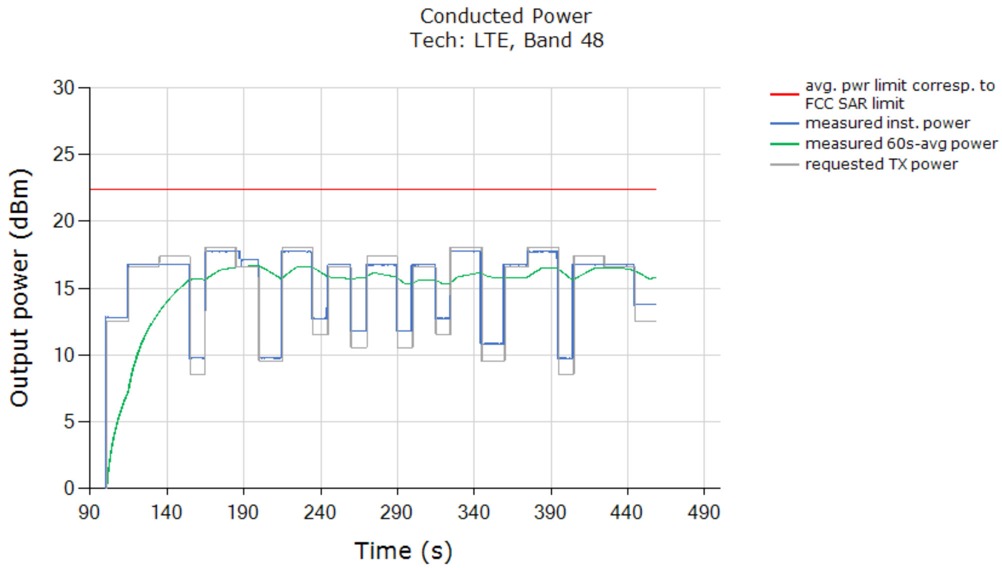

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group



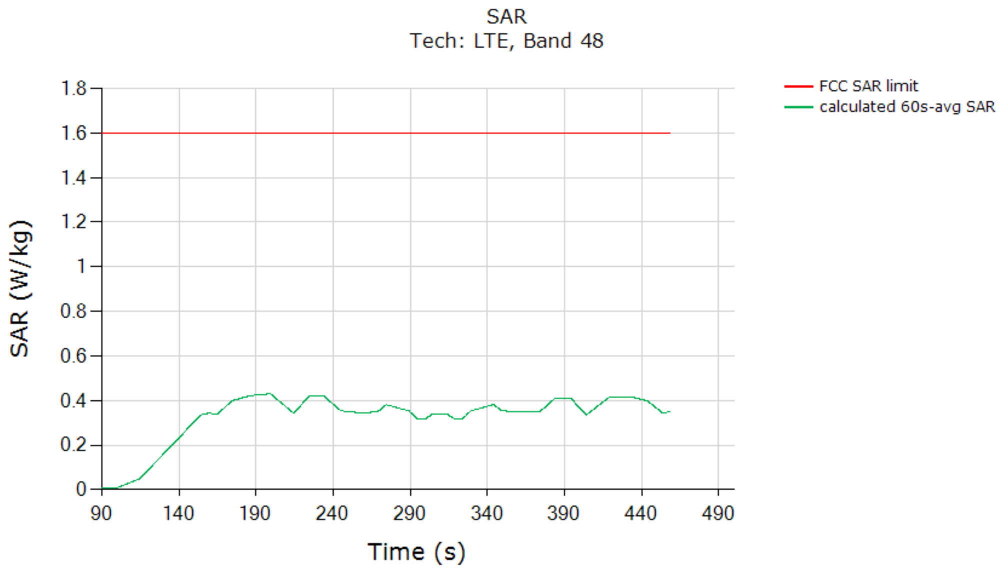

| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 10gSAR (green curve) | 0.427 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

Test result for test sequence 2:




Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

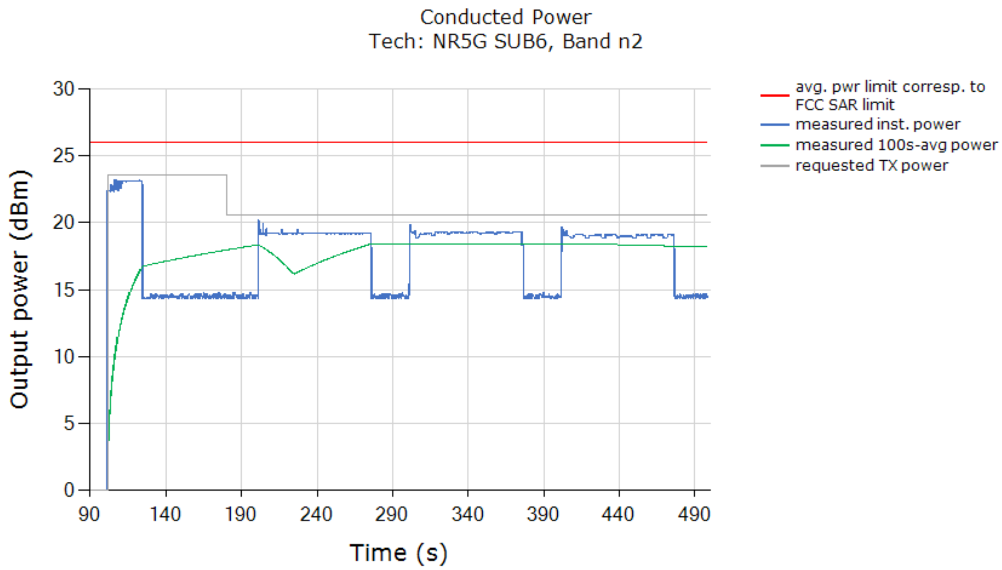



| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.430 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

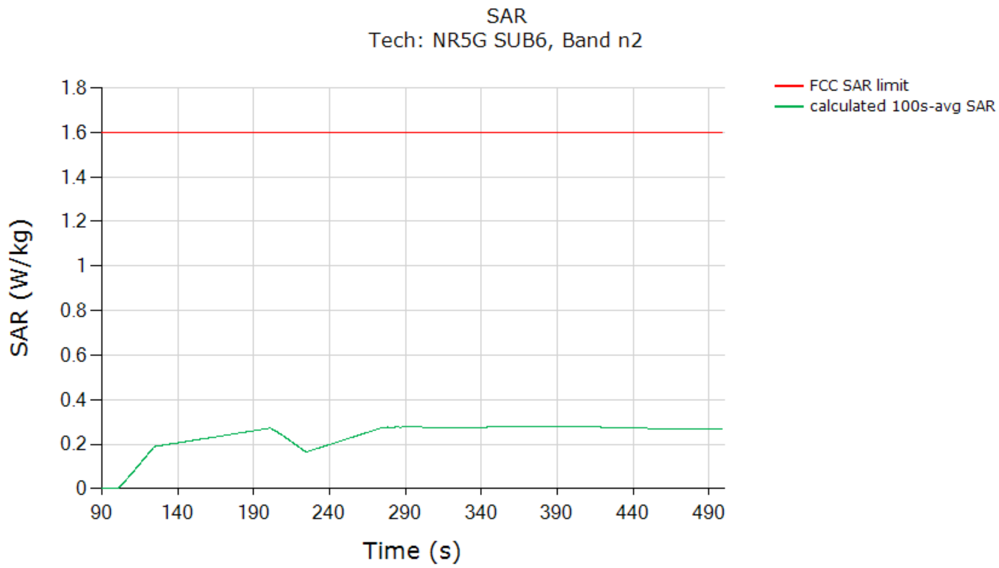

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

7.3.3 Sub6 NR Band 2

Test result for test sequence 1:

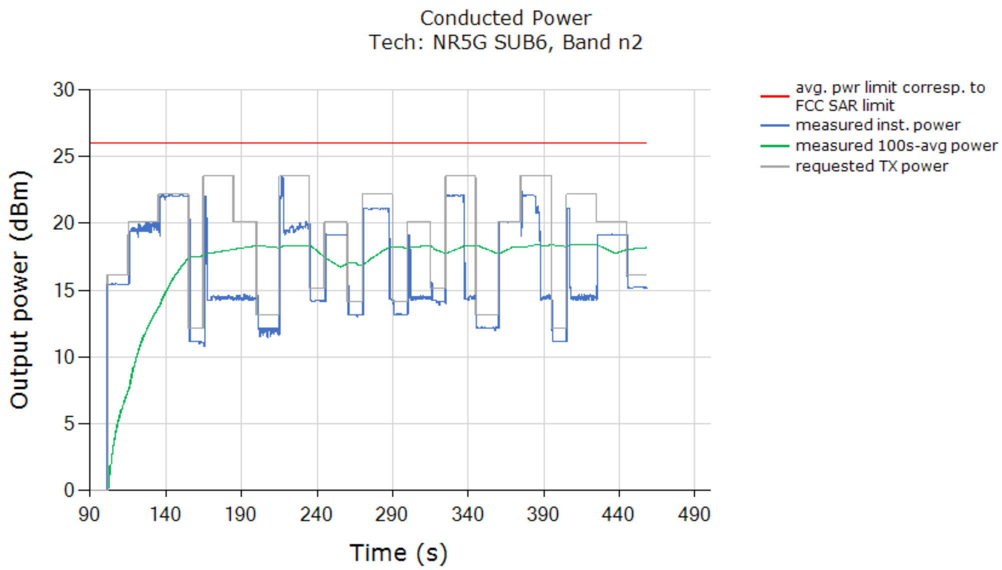



Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

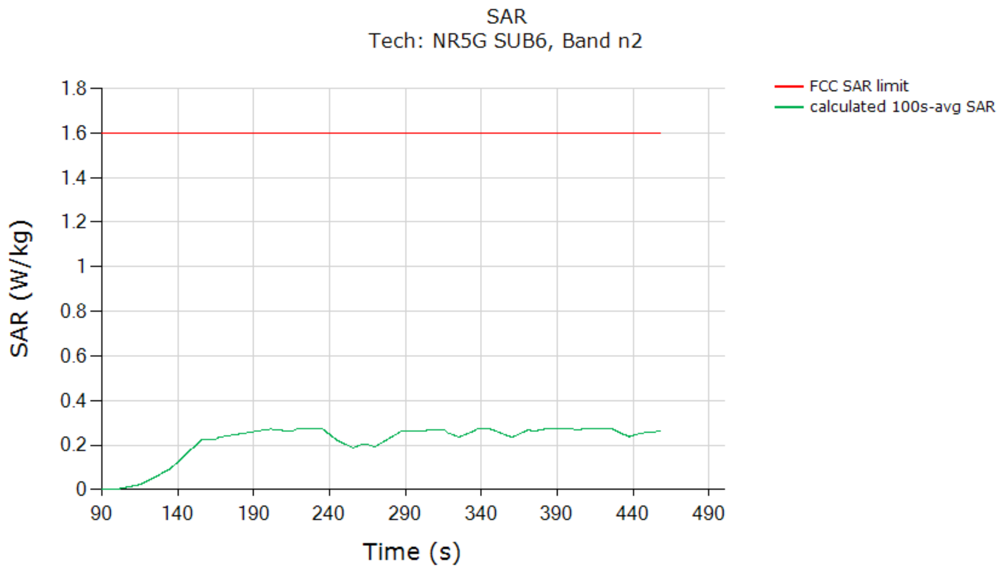



| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.278 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

Test result for test sequence 2:



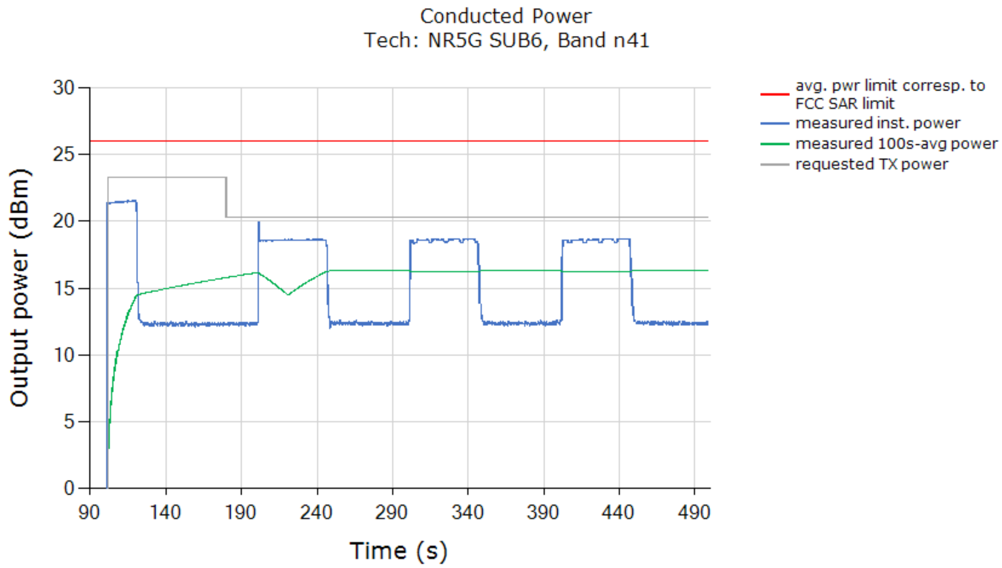

Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



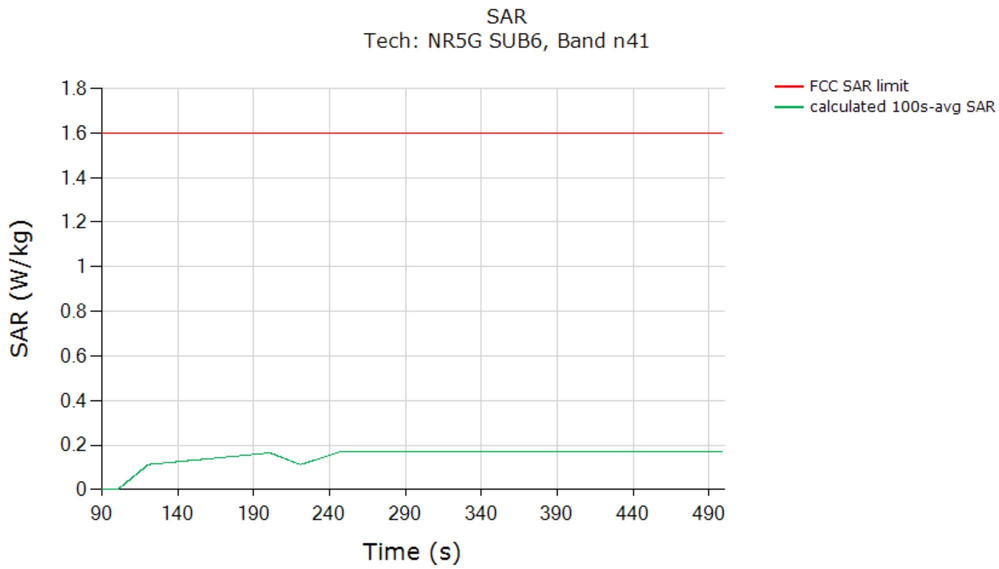

| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.275 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

7.3.4 Sub6 NR Band 41

Test result for test sequence 1:

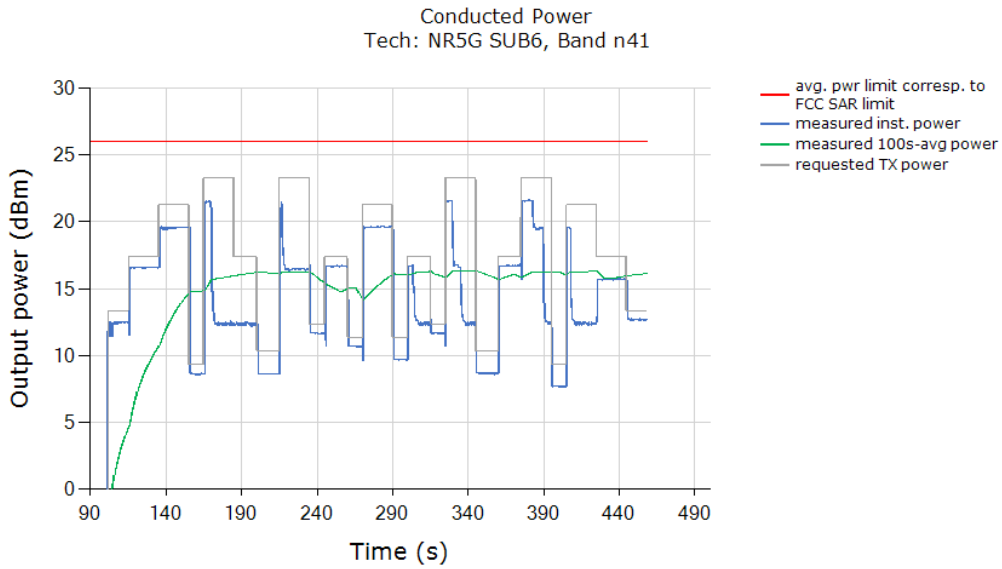



Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:

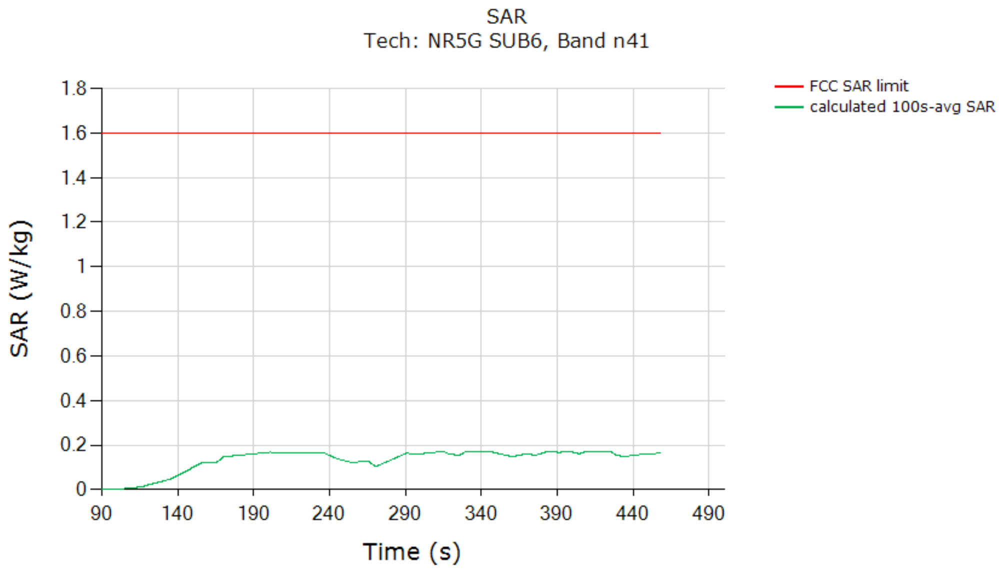



| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.170 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

Test result for test sequence 2:




Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time-averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



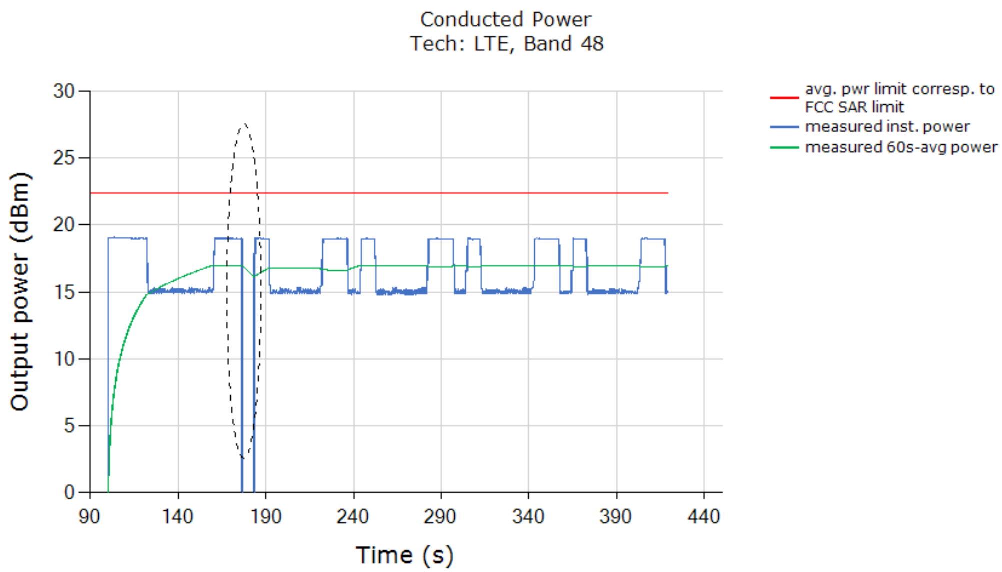

| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.171 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

## 7.4 Change in Call Test Results

This test was measured with LTE B48, and with callbox requesting maximum power. The call drop was manually performed when the EUT is transmitting at Preserve level as shown in the plot below (dotted black region). The measurement setup is shown in Figure 7-1.

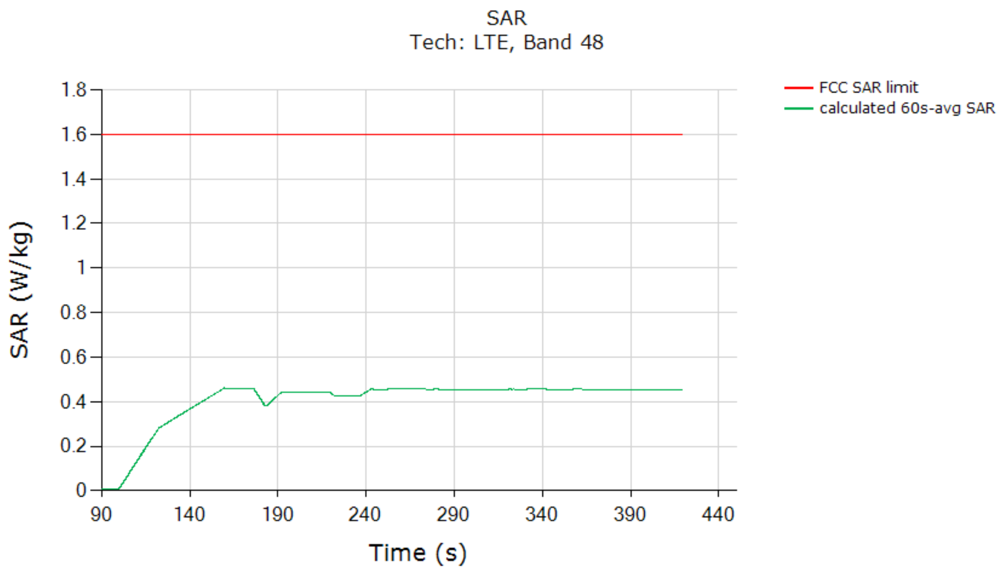
Call drop test result:

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power kept the same $P_{reserve}$ level of LTE Band 48 after the call was re-established:




Plot Notes: The conducted power plot shows expected Tx transition.

Plot 2: Above time-averaged conducted Tx power is converted/calculated into time-averaged 1gSAR using Equation (3a) and plotted below to demonstrate that the time- averaged 1gSAR versus time does not exceed the FCC limit of 1.6 W/kg for 1gSAR:



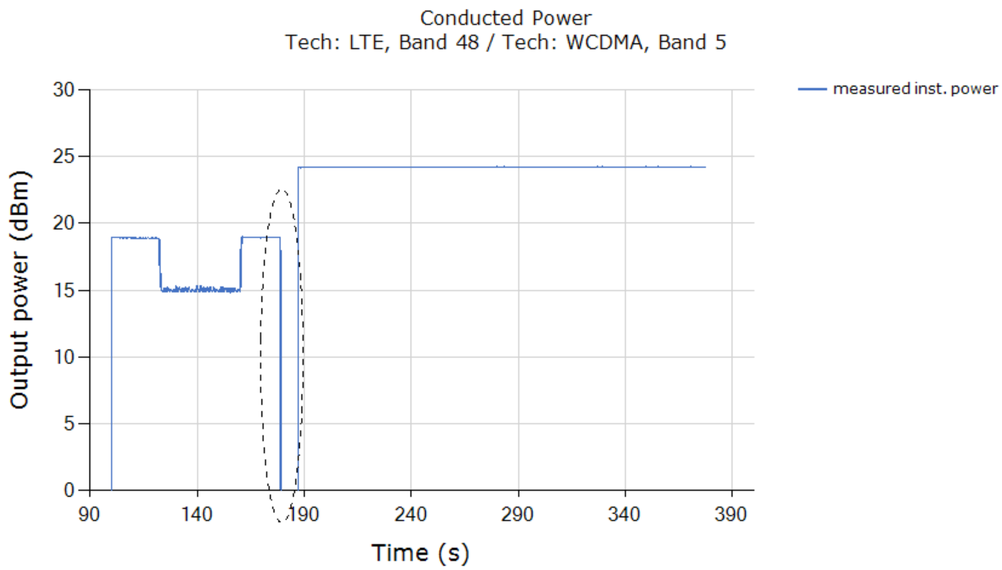

| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.461 |
| Validated | |

The test result validated the continuity of power limiting in change in call scenario.

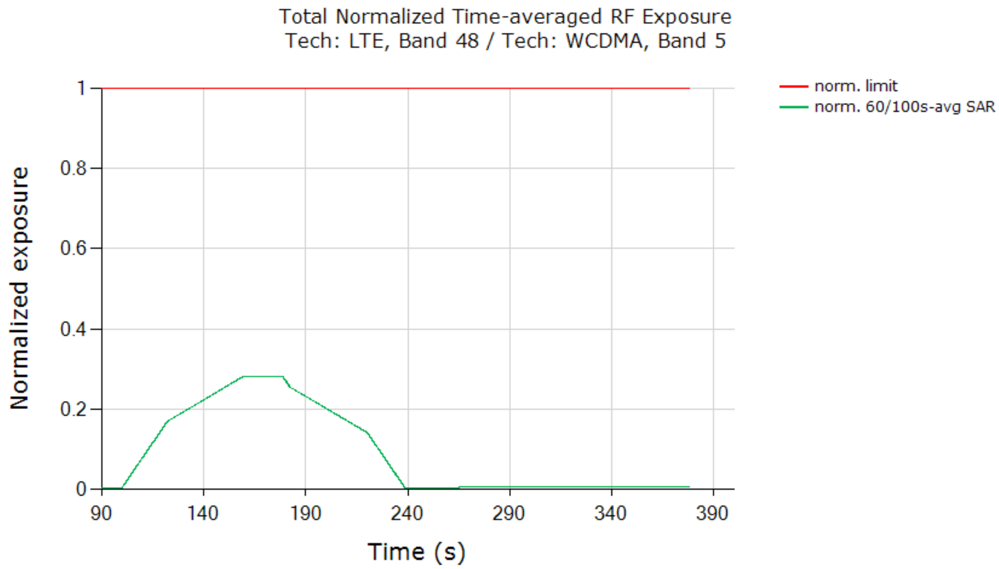
### 7.5 Change in technology/band test results

This test was conducted with callbox requesting maximum power, and with technology switch from LTE B48 to WCDMA B5. Following procedure, and using the measurement setup shown in Figure 7-1(a) and (c), the technology/band switch was performed when the EUT is transmitting at Preserve level as shown in the plot below (dotted black region).

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed from LTE B48, Preserve level to WCDMA B5.




Plot 2: All the time-averaged conducted Tx power measurement results were converted into time-averaged normalized SAR values, and plotted below to demonstrate that the time-averaged normalized exposure versus time does not exceed the normalized FCC limit of 1.0:




| | Exposure Ratio |
|---|---|
| FCC normalized Exposure Ratio limit | 1.0 |
| Max total time averaged normalized Exposure Ratio (green curve) | 0.283 |
| Validated | |

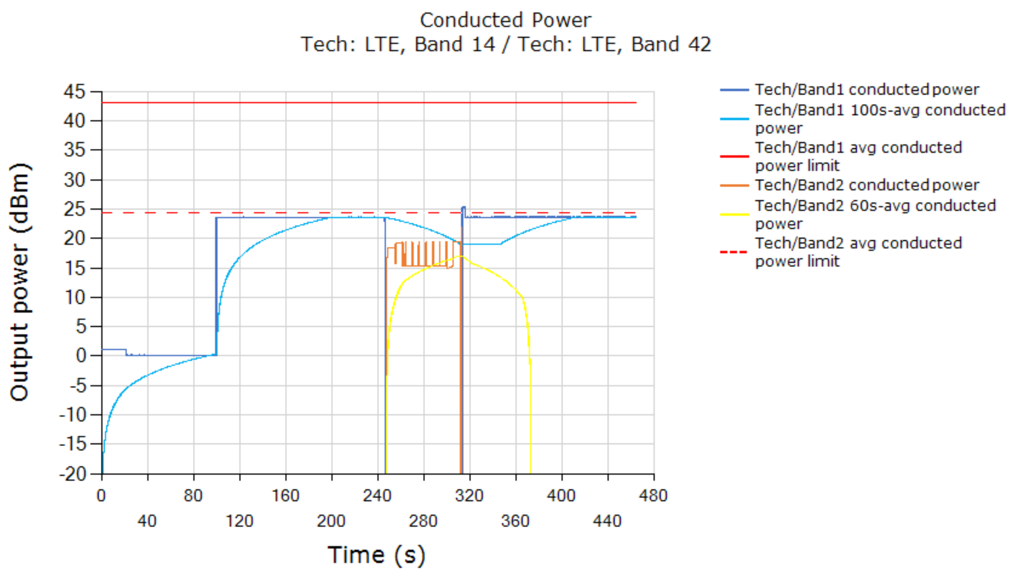
The test result validated the continuity of power limiting in technology/band switch scenario.

## 7.6 Change in Time window / antenna switch test results

7.6.1 Test case 1: transition from LTE B14 to LTE B42 (i.e., 100s to 60s), then back to LTE B14

Test result for change in time-window (from 100s to 60s to 100s):

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when LTE B14 switches to LTE Band 42 (~247 seconds timestamp) and switches back to LTE Band 14 (~313 seconds timestamp):



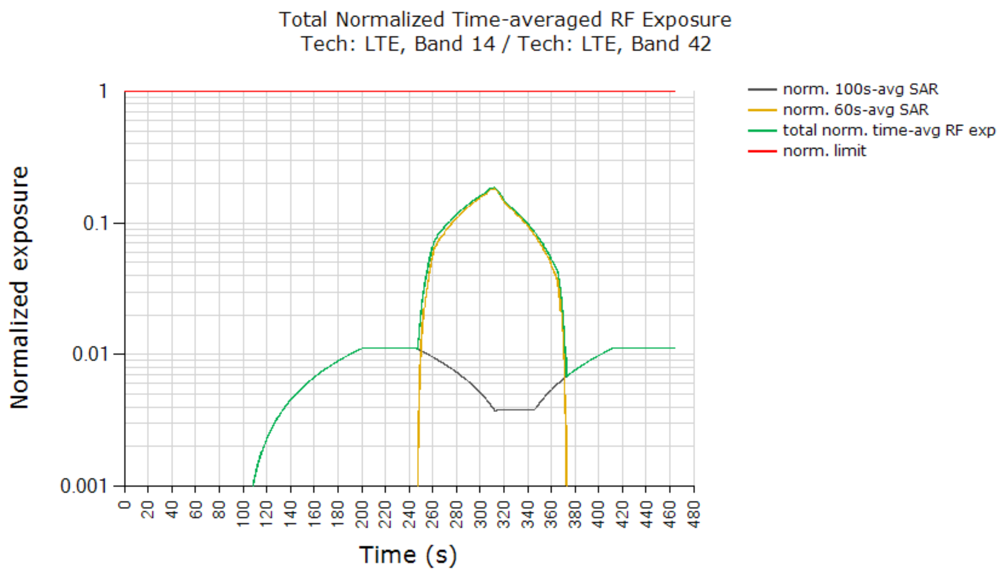

Plot Notes: The conducted power plot shows expected transitions in Tx power at ~247 seconds (100s-to-60s transition) and at ~313 seconds (60s-to-100s transition) in order to maintain total time-averaged RF exposure compliance across time windows, as show in next plot.



SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values, and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (8a) is used to convert the Tx power of device to obtain 100s- averaged normalized SAR in LTE B14 as shown in black curve. Similarly, equation (8b) is used to obtain 60s-averaged normalized SAR in LTE Band 42 as shown in orange curve.

Equation (8c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).




| | Exposure Ratio |
|---|---|
| FCC normalized Exposure Ratio | 1.0 |
| Max total time averaged normalized Exposure Ratio (green curve) | 0.186 |
| Validated | |

Plot Notes:

Maximum power is requested by callbox for the entire duration of the test, with tech/band switches from 100s-to-60s window at ~247s time stamp, and from 60s-to-100s window at ~313s time stamp. Smart Transmit controls the Tx power during these time-window switches to ensure total time-averaged RF exposure, i.e., sum of black and orange curves given by equation (8c), is always compliant. In time-window switch test, at all times the total time averaged normalized RF exposure (green curve) should not exceed normalized SAR_design_target +1dB device uncertainty. In this test, with a maximum normalized SAR of 0.186 being ≤ 0.35 (=0.445/1.6 +1.0dB device uncertainty), the above test result validated the continuity of power limiting in time-window switch scenario.

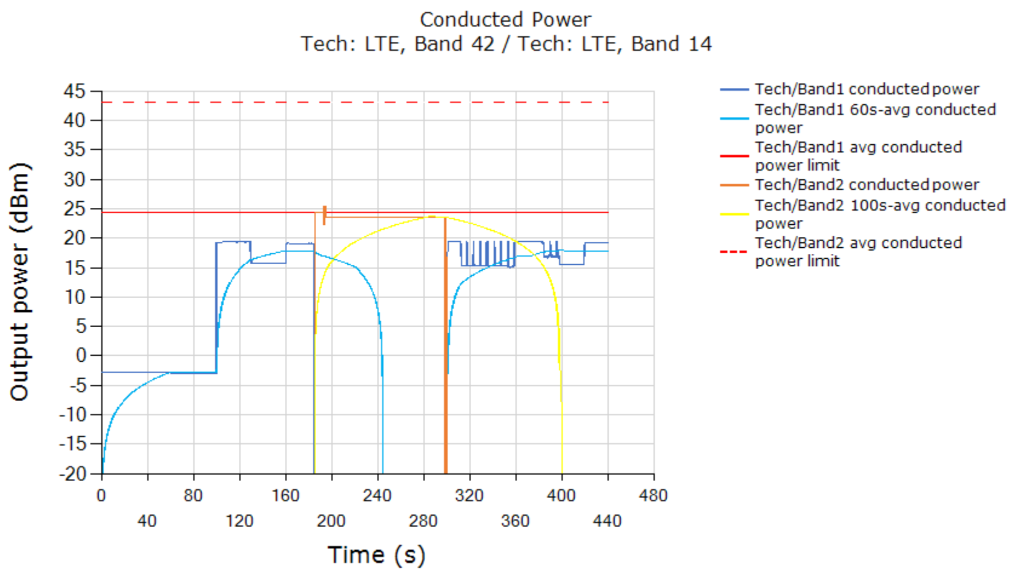


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

7.6.2 Test case 2: transition from LTE B42 to LTE B14 (i.e., 60s to 100s), then back to LTE B43

Test result for change in time-window (from 60s to 100s to 60s):

Plot 1: Measured Tx power (dBm) versus time shows that the transmitting power changed when LTE Band 42 switches to LTE B14 (~184 seconds timestamp) and switches back to LTE Band 42 (~300 seconds timestamp):

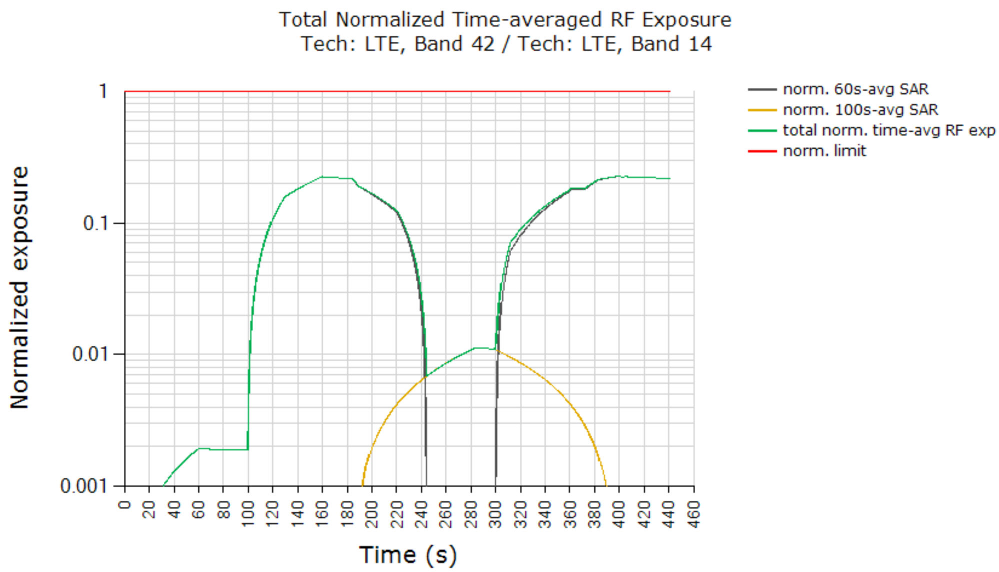



Plot Notes: The conducted power plot shows expected transitions in Tx power at ~184 seconds (60s-to-100s transition) and at ~300 seconds (100s-to-60s transition) in order to maintain total time-averaged RF exposure compliance across time windows, as show in next plot.


SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (8a), (8b) and (8c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (8a) is used to convert the Tx power of device to obtain 60s- averaged normalized SAR in LTE Band 42 as shown in black curve. Similarly, equation (8b) is used to obtain 100s-averaged normalized SAR in LTE B14 as shown in orange curve.

Equation (8c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).




| | Exposure Ratio |
|---|---|
| FCC normalized Exposure Ratio limit | 1.0 |
| Max total time averaged normalized Exposure Ratio (green curve) | 0.226 |
| Validated | |

Plot Notes:

Maximum power is requested by callbox for the entire duration of the test, with tech/band switches from 60s-to-100s window at ~184 s time stamp, and from 100s-to-60s window at ~300s time stamp. Smart Transmit controls the Tx power during these time-window switches to ensure total time-averaged RF exposure, i.e., sum of black and orange curves given by equation (8c), is always compliant. In time-window switch test, at all times the total time averaged normalized RF

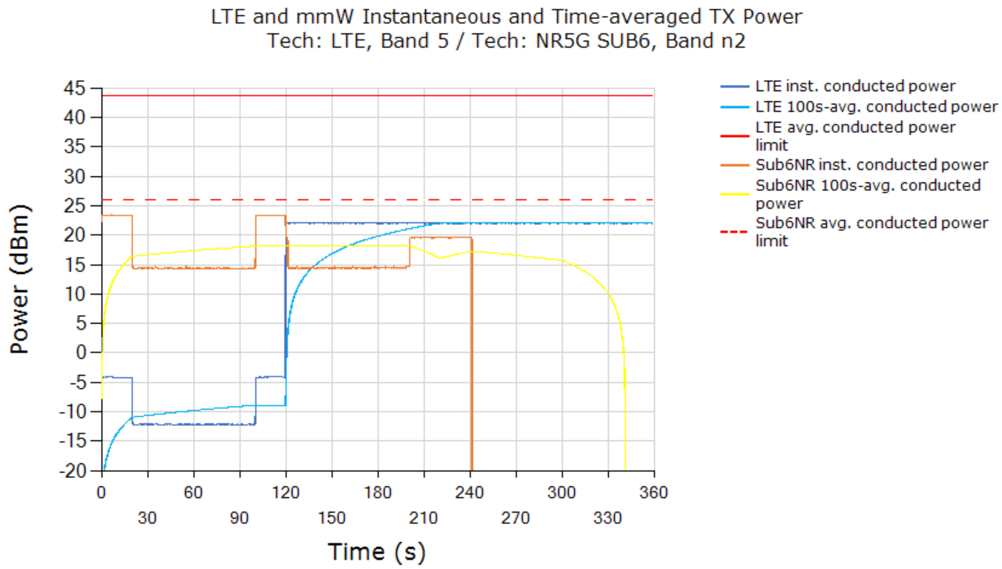

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

exposure (green curve) should not exceed normalized SAR_design_target + 1dB device uncertainty. In this test, with a maximum normalized SAR of 0.226 being ≤ 0.35 (=0.445/1.6 +1.0dB device uncertainty), the above test result validated the continuity of power limiting in time-window switch scenario.

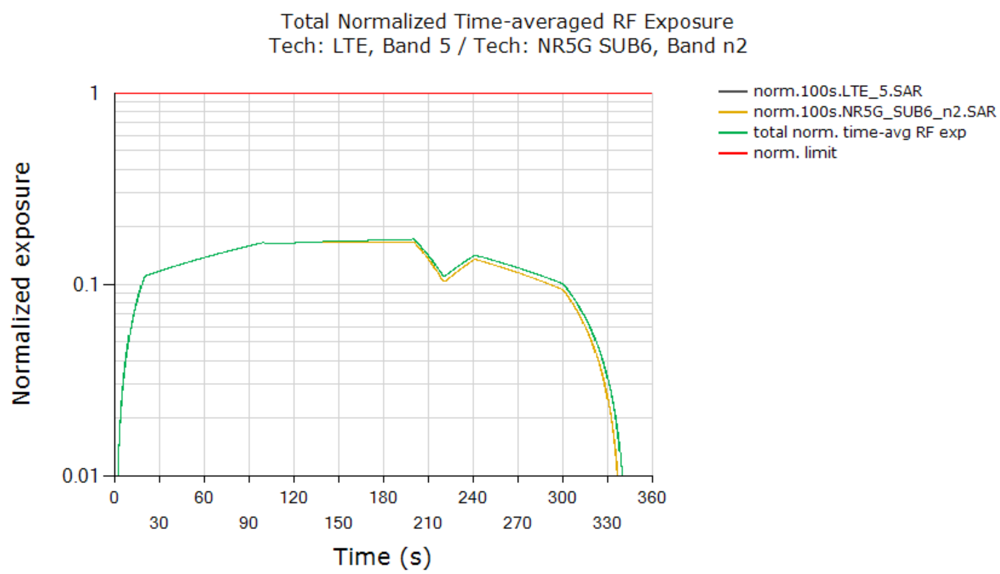

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

### 7.7 Switch in SAR exposure test results

This test was conducted with callbox requesting maximum power, and with the EUT in LTE Band 5 + Sub6 NR Band 2 call. Following procedure detailed in Section 5.3.7 and Appendix B, and using the measurement setup shown in Figure 7-1, the SAR exposure switch measurement is performed with the EUT in various SAR exposure scenarios.




Plot 2: All the conducted Tx power measurement results were converted into time-averaged normalized SAR values using Equation (8a), (8b) and (8c), and plotted below to demonstrate that the time-averaged normalized SAR versus time does not exceed the FCC limit of 1 unit. Equation (8a) is used to convert the LTE Tx power of device to obtain 100s-averaged normalized SAR in LTE B5 as shown in black curve. Similarly, equation (8b) is used to obtain 100s-averaged normalized SAR in Sub6 NR n2 as shown in orange curve. Equation (8c) is used to obtain total time-averaged normalized SAR as shown in green curve (i.e., sum of black and orange curves).




| | Exposure Ratio |
|---|---|
| FCC normalized Exposure Ratio limit | 1.0 |
| Max total time averaged normalized Exposure Ratio (green curve) | 0.172 |
| Validated | |

## Plot Notes:.

Device starts predominantly in Sub6 NR SAR exposure scenario between 5s and 125s, and in LTE SAR + Sub6 NR SAR exposure scenario between 125s and 240s, and in predominantly in LTE SAR exposure scenario after t=240s. Here, Smart Transmit allocates a maximum of 75% of exposure margin (based on 2dB reserve margin setting) for Sub6 NR. This corresponds to a normalized 1gSAR exposure value = 75% * 0.381W/kg measured SAR at Sub6 NR $P_{limit}$ / 1.6W/kg limit = 0.179 ± 1dB device related uncertainty (see orange curve between 5s~120s). For predominantly LTE SAR exposure scenario, maximum normalized 1gSAR exposure should correspond to 100% exposure margin = 0.0174W/kg measured SAR at LTE $P_{limit}$ / 1.6W/kg limit = 0.011 ± 1dB device related uncertainty (see black curve after t = 240s). Additionally, in SAR exposure switch test, at all times the total time-averaged normalized RF exposure (green curve) should not exceed normalized *SAR_design_target* + 1dB device uncertainty. In this test, with a maximum normalized SAR of 0.172 being ≤ 0.35 (= 0.445/1.6 + 1dB device uncertainty), the above test result validated the continuity of power limiting in SAR exposure switch scenario.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

# 8. SAR Test Results for Sub-6 Smart Transmit Feature Validation

## 8.1 Measurement setup

The measurement setup in Figure 7-1 is similar to normal SAR measurements. 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 GPIB so that the test script executed on PC can send GPIB 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 before, for EUT to follow TPC command sent from the callbox wirelessly, the "path loss" between callbox antenna and the EUT 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". Similarly, in the case of time-varying SAR measurements in Sub6 NR (with LTE as anchor), "path loss" between callbox antenna and the EUT needs to be carefully calibrated for both LTE link as well as for Sub6 NR link.

The EUT is placed in worst-case position according to Table 6-2.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## 8.2 SAR measurement results for time-varying Tx power transmission scenario

Following Section 5.4 procedure, time-averaged SAR measurements are conducted using EX3DV4 probe at peak location of area scan over 500 seconds. cDASY6 system verification for SAR measurement is provided in Appendix C.

SAR probe integration times depend on the communication signal being tested. Integration times used by SPEAG for their probe calibrations can be downloaded from here (integration time is listed on the bottom of the first page for each tech):

https://speag.swiss/assets/downloads/services/cs/UID-Summary-200905.pdf

Since the sampling rate used by cDASY6 for pointSAR measurements is not in user control, the number of points in 100s or 60s interval is determined from the scan duration setting in cDASY6 time-average pointSAR measurement by (100s or 60s / cDASY6_scan_duration * total number of pointSAR values recorded). Running average is performed over these number of points in excel spreadsheet to obtain 100s-/60s-averaged pointSAR.

For each of selected technology/band (listed in Table 6-2):

1. With *Reserve_power_margin* set to 0 dB, area scan is performed at $P_{limit}$, and time-averaged pointSAR measurements are conducted to determine the pointSAR at $P_{limit}$ at peak location, denoted as *point*SAR$_{Plimit}$.
2. With *Reserve_power_margin* set to actual (intended) value, two more time-averaged pointSAR measurements are performed at the same peak location for test sequences 1 and 2.

To demonstrate compliance, all the pointSAR measurements results were converted into 1gSAR value by using Equation (5a), rewritten below:

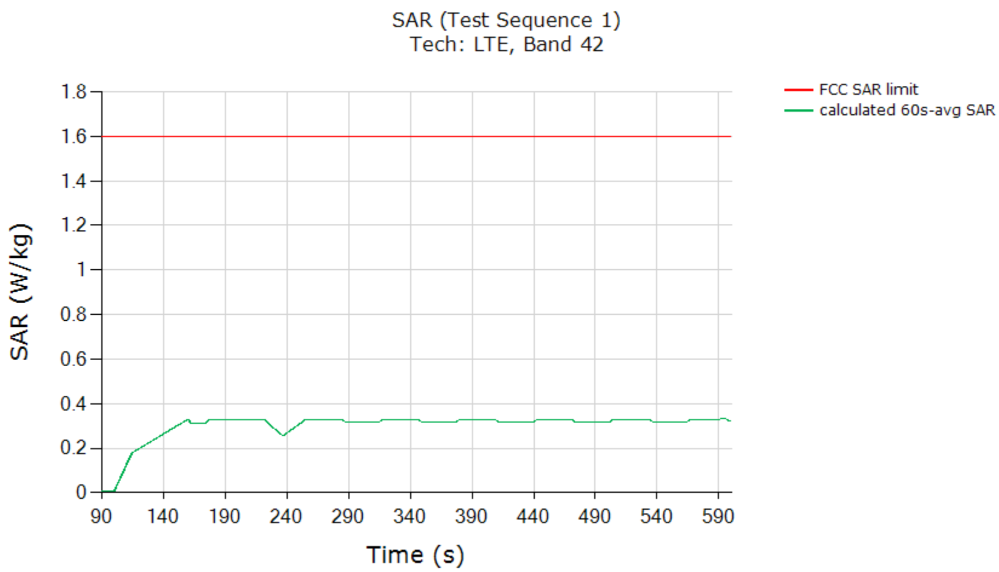
$$1g\_or\_10gSAR(t) = \frac{pointSAR(t)}{pointSAR\_P_{limit}} * 1g\_or\_10gSAR\_P_{limit} \quad (5a)$$

where, $pointSAR(t)$, $pointSAR\_Plimit$, and $1g\_SAR\_Plimit$ correspond to the measured instantaneous point SAR, measured point SAR at Plimit from above step 1 and 2, and measured 1gSAR value at Plimit obtained from Part 1 report and listed in Table 6-2 in Section 6.1 of this report.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

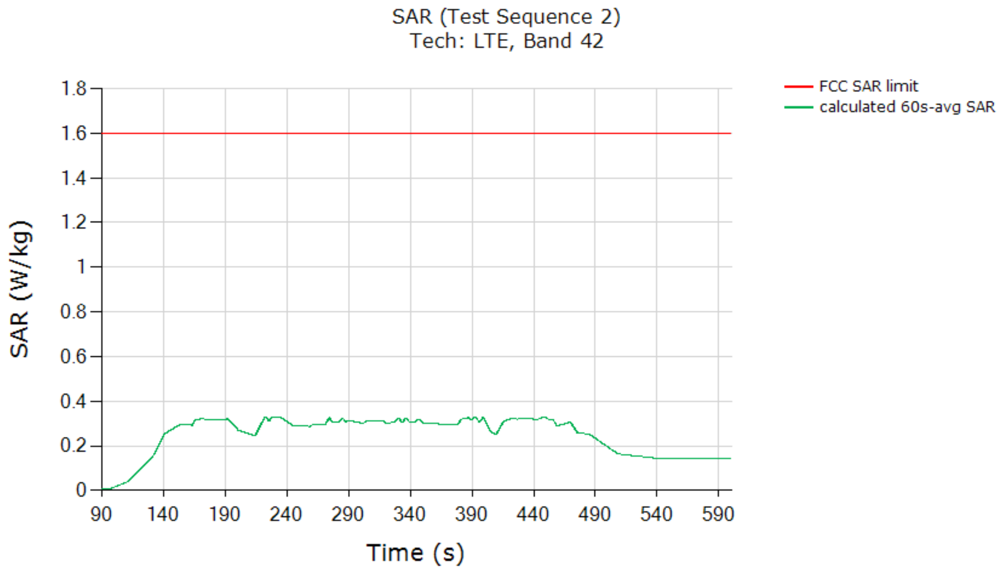
## 8.2.1 LTE Band 42 SAR test results

SAR test results for test sequence 1:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.331 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

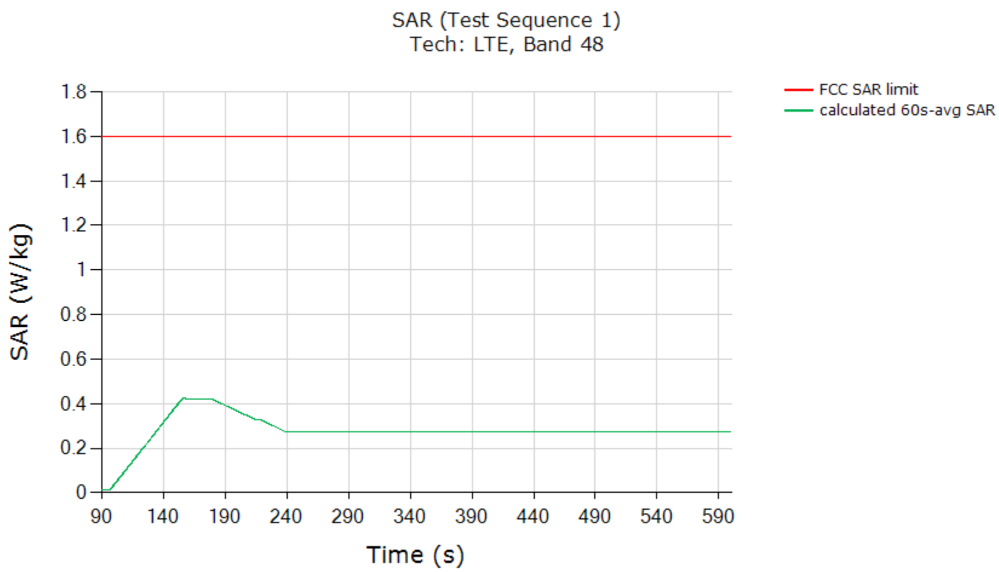
## SAR test results for test sequence 2:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.330 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

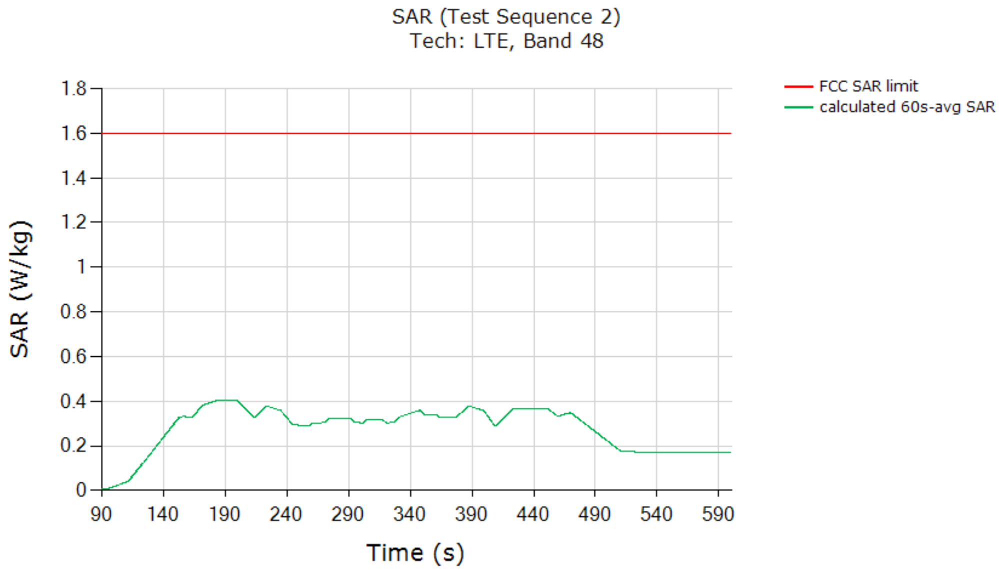
8.2.2 LTE Band 48 SAR test results

SAR test results for test sequence 1:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.427 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

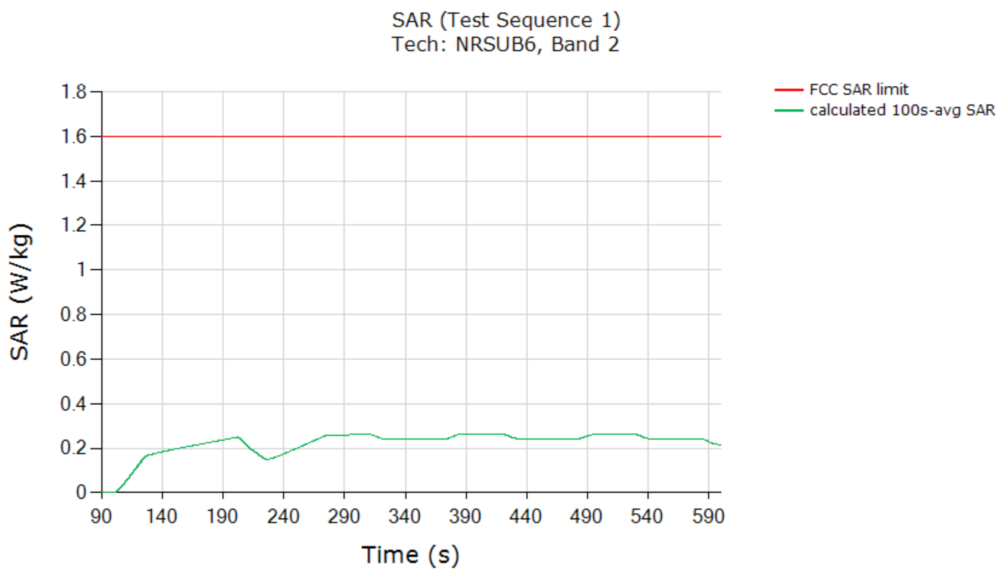
## SAR test results for test sequence 2:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 60s-time averaged 1gSAR (green curve) | 0.405 |
| Validated: Max time averaged SAR (green curve) does not exceed measured SAR at Plimit +1.0dB device uncertainty | |

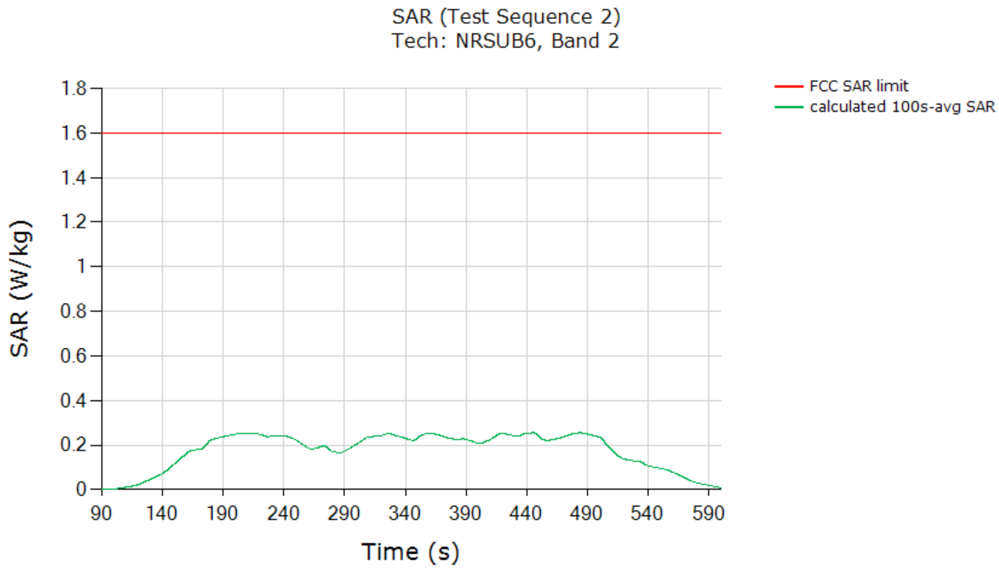
8.2.3 Sub6 NR Band 2 SAR test results

SAR test results for test sequence 1:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.264 |
| Validated: Max time averaged SAR (green curve) does not exceed "75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty" | |

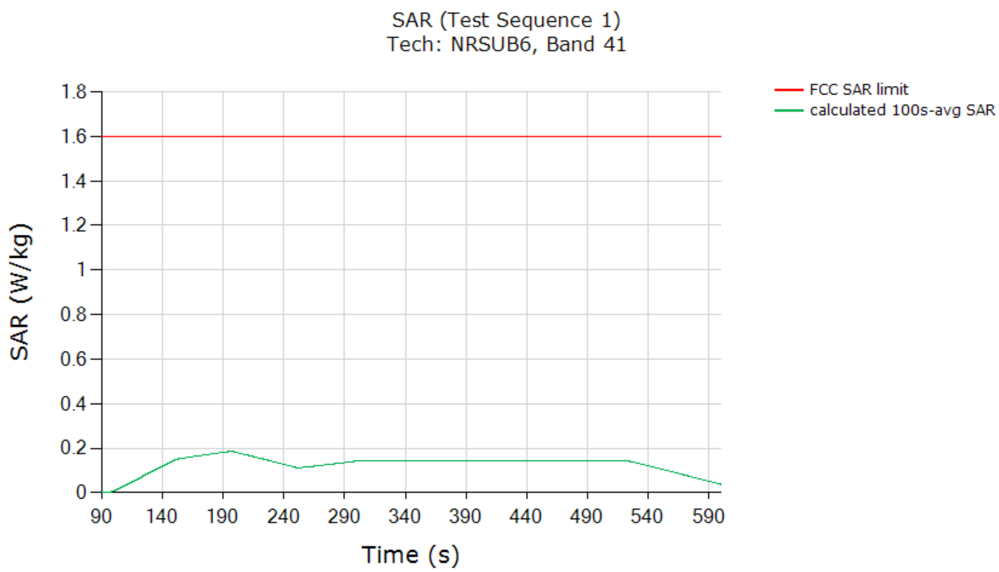
## SAR test results for test sequence 2:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.255 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

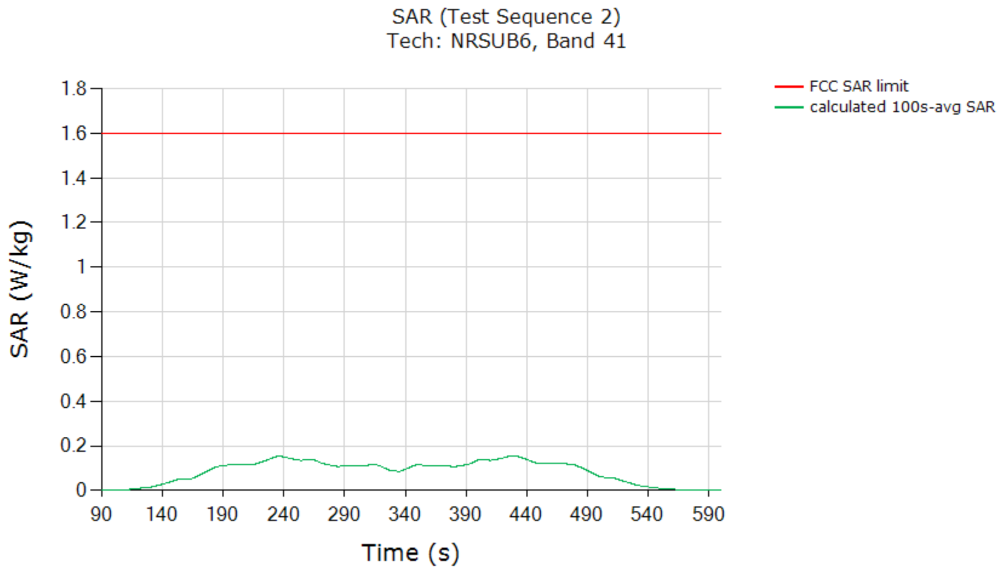
## 8.2.4 Sub6 NR Band 41 SAR test results

SAR test results for test sequence 1:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.186 |
| Validated: Max time averaged SAR (green curve) does not exceed “75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty” | |

## SAR test results for test sequence 2:




| | (W/kg) |
|---|---|
| FCC 1gSAR limit | 1.6 |
| Max 100s-time averaged 1gSAR (green curve) | 0.156 |
| Validated: Max time averaged SAR (green curve) does not exceed "75% (with 2dB Reserve_Power_Margin) of measured SAR at Plimit, +1.0dB device uncertainty" | |

# 9. Conclusions

Qualcomm Smart Transmit feature employed in B94HNI41C4TKR has been validated through the conducted power/SAR measurement.

As demonstrated in this report, the power limiting enforcement is effective and the total normalized time-averaged RF exposure does not exceed 1.0 for all the transmission scenarios described in Section 4. Therefore, the EUT complies with FCC RF exposure requirement.

## Appendix A. Test Sequences

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

   a. Measured maximum power ($P_{max}$)

   b. Measured Tx_power_at_SAR_design_target ($P_{limit}$)

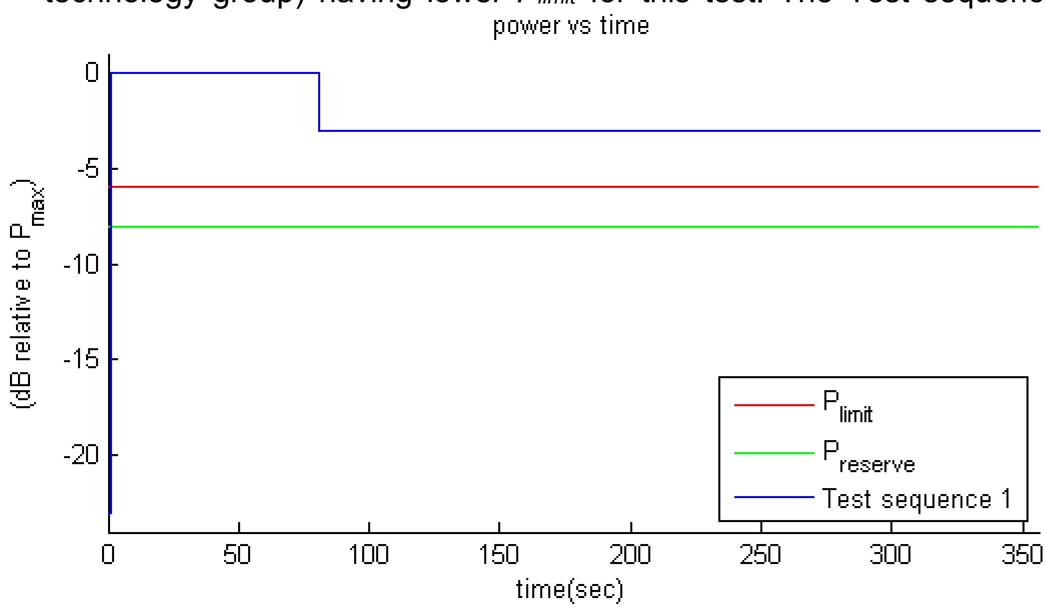
   c. Reserve_power_margin (dB)

   - $P_{reserve}$ (dBm) = measured $P_{limit}$(dBm) – Reserve_power_margin (dB)

   d. *SAR_time_window* (100s for FCC)

2. Test Sequence 1 Waveform:

Based on the parameters above, the Test Sequence 1 is generated with one transition between high and low Tx powers. Here, high power = $P_{max}$; low power
= $P_{max}/2$, and the transition occurs after 80 seconds at high power $P_{max}$. As long as the power enforcement is taking into effective during one 100s/60s time window, the validation test with this defined test sequence 1 is valid, otherwise, select other radio configuration (band/DSI within the same technology group) having lower $P_{limit}$ for this test. The Test sequence 1




waveform is shown below:

**Figure 0-1 Test sequence 1 waveform**


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

3. Test Sequence 2 Waveform:

Based on the parameters in A-1, the Test Sequence 2 is generated as described in Table 10-1, which contains two 170 second-long sequences (yellow and green highlighted rows) that are mirrored around the center row of 20s, resulting in a total duration of 360 seconds:

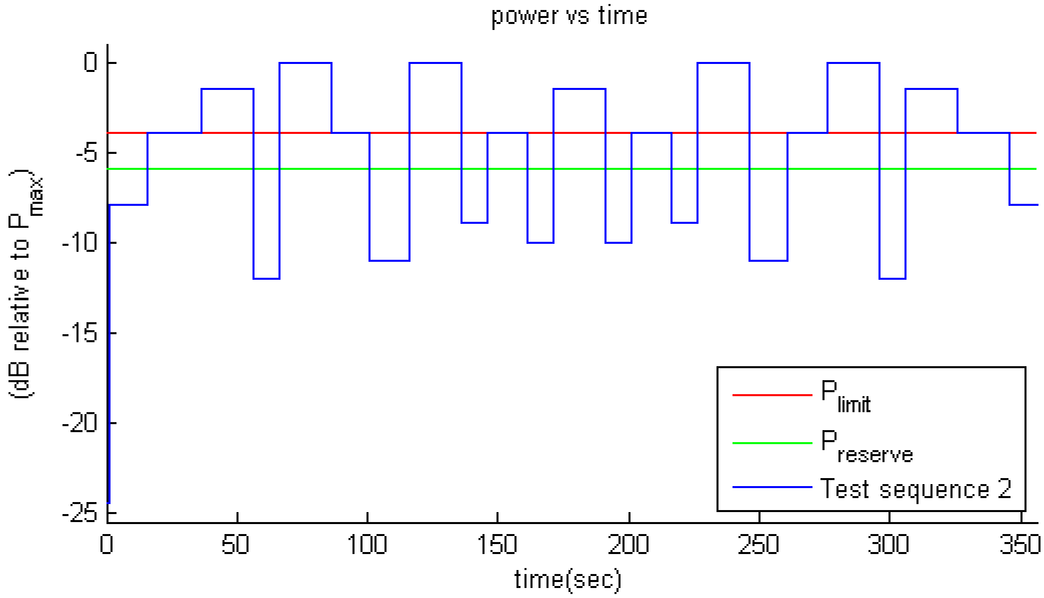
## Table 0-1 Test Sequence 2

| Time duration (seconds) | dB relative to $P_{limit}$ or $P_{reserve}$ |
|---|---|
| 15 | $P_{reserve} - 2$ |
| 20 | $P_{limit}$ |
| 20 | $(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step |
| 10 | $P_{reserve} - 6$ |
| 20 | $P_{max}$ |
| 15 | $P_{limit}$ |
| 15 | $P_{reserve} - 5$ |
| 20 | $P_{max}$ |
| 10 | $P_{reserve} - 3$ |
| 15 | $P_{limit}$ |
| 10 | $P_{reserve} - 4$ |
| 20 | $(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step |
| 10 | $P_{reserve} - 4$ |
| 15 | $P_{limit}$ |
| 10 | $P_{reserve} - 3$ |
| 20 | $P_{max}$ |
| 15 | $P_{reserve} - 5$ |
| 15 | $P_{limit}$ |
| 20 | $P_{max}$ |
| 10 | $P_{reserve} - 6$ |
| 20 | $(P_{limit} + P_{max})/2$ averaged in mW and rounded to nearest 0.1 dB step |
| 20 | $P_{limit}$ |
| 15 | $P_{reserve} - 2$ |



SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

The Test Sequence 2 waveform is shown in Figure A-2.





SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## Appendix B. Validation for sub6 simultaneous transmission scenarions

Appendix H provides the test procedures for validating Qualcomm Smart Transmit feature for LTE + Sub6 NR non-standalone (NSA) mode transmission scenario, where sub-6GHz LTE link acts as an anchor, and for validating interband ULCA transmission scenario

### B.1Time-varying Tx power test for sub6 NR in NSA mode

Follows Section 5.2.1 to select test configurations for time-varying test. This test is performed with two pre-defined test sequences (described in Section 5.1) applied to Sub6 NR (with LTE on all-down bits for the entire test after establishing the LTE+Sub6 NR call with the callbox).

Follow the test procedures described in Section 5.3.1 to demonstrate the effectiveness of power limiting enforcement and that the time averaged Tx power of Sub6 NR when converted into 1gSAR values does not exceed the regulatory limit at all times (see Eq. (3a) and (3b)). Sub6 NR response to test sequence1 and test sequence2 will be similar to other technologies (say, LTE) shown in Section 8.

### B.2 Switch in SAR exposure between LTE vs. Sub6 NR during transmission

This test is to demonstrate that Smart Transmit feature accurately accounts for switching in exposures among SAR for LTE radio only, SAR from both LTE radio and sub6 NR, and SAR from sub6 NR only scenarios, and ensures total time-averaged RF exposure compliance with FCC limit.

### Test procedure:

1. Measure conducted Tx power corresponding to $P_{limit}$ for LTE and sub6 NR in selected band. Test condition to measure conducted $P_{limit}$ is:

Establish device in call with the callbox for LTE in desired band. Measure conducted Tx power corresponding to LTE $P_{limit}$ with Smart Transmit enabled and *Reserve_power_margin* set to 0 dB, callbox set to request maximum power.

Repeat above step to measure conducted Tx power corresponding to Sub6 NR $P_{limit}$. If testing LTE+Sub6 NR in non-standalone mode, then establish LTE+Sub6 NR call with callbox and request all down bits for radio1 LTE. In this scenario, with callbox requesting maximum power from Sub6 NR, measured conducted Tx power corresponds to radio2 $P_{limit}$ (as radio1 LTE is at all-down bits)

2. Set *Reserve_power_margin* to actual (intended) value, with EUT setup for LTE + Sub6 NR call. First, establish LTE connection with the callbox, and then add Sub6 NR connection. As soon as the Sub6 NR connection is established, request all-down bits (or low power) on LTE link and then request UE to transmit at maximum power in Sub6 NR. Continue LTE (all-down bits) + Sub6 NR transmission for more than one time-window duration to test predominantly Sub6 NR SAR exposure scenario (as SAR exposure is negligible from all-down bits in LTE). After at least one time-window, request LTE to go all-up bits to test LTE SAR and Sub6 NR SAR exposure scenario. After at least one more time-window, drop (or request all-down bits) Sub6 NR transmission to test predominantly LTE SAR exposure scenario. Continue the test for at least one more time-window. Record the conducted Tx powers for both LTE and Sub6 NR for the entire duration of this test.

3. Once the measurement is done, extract instantaneous Tx power versus time for both LTE and Sub6 NR links. Similar to technology/band switch test in Section 5.3.3, convert the conducted Tx power for both these radios into 1g_SAR value (see Eq. (7a) and (7b)) using corresponding technology/band $P_{limit}$ measured in Step 1, and then perform 100s running average to determine time-averaged 1g_SAR versus time as illustrated in Figure 5-1. Note that here it is assumed both radios have Tx frequencies < 3GHz, otherwise, 60s running average should be performed for radios having Tx frequency between 3GHz and 6GHz.

4. Make one plot containing: (a) instantaneous Tx power versus time measured in Step 2.

5. Make another plot containing: (a) instantaneous 1gSAR versus time determined in Step 3, (b) computed time-averaged 1gSAR versus time determined in Step 3, and (c) corresponding regulatory *1g_SAR* limit.

The validation criteria is, at all times, the time-averaged 1g_SAR versus time shall not exceed the regulatory *1g_SAR* limit.


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## Appendix C. cDASY6 System Verification

### EX3DV4 E-Field Probe

| | | |
|---|---|---|
| Construction | Symmetrical design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., DGBE) |  |
| Calibration | Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 750/835/1750/1900/2300/2600/3500/3700MHz<br>Additional CF for other liquids and frequencies upon request | |
| Frequency | 10 MHz to > 6 GHz | |
| Directivity | ± 0.3 dB in HSL (rotation around probe axis)<br>± 0.5 dB in tissue material (rotation normal to probe axis) | |
| Dynamic Range | 10 μW/g to > 100 mW/g<br>Linearity: ± 0.2 dB (noise: typically < 1 μW/g) | |
| Dimensions | Tip diameter: 2.5 mm | |
| Application | High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%. | |



SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

**PHANTOM**

| Model | ELI | |
|---|---|---|
| Construction | The ELI phantom is used for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles. | |
| Shell Thickness | 2 ± 0.2 mm |  |
| Filling Volume | Approx. 30 liters | |
| Dimensions | Major axis: 600 mm<br>Minor axis: 400 mm | |

**DEVICE HOLDER**

| Construction | The device holder (Supporter) for Notebook is made by POM (polyoxymethylene resin ) , which is non-metal and non-conductive. The height can be adjusted to fit varies kind of notebooks. | <br>Device Holder |
|---|---|---|


SGS Taiwan Ltd. 台灣檢驗科技股份有限公司 No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## Instruments List

| Manufacturer | Device | Type | Serial number | Date of last calibration | Date of next calibration |
|---|---|---|---|---|---|
| SPEAG | Dosimetric E-Field Probe | EX3DV4 | 7466 | Feb.04,2020 | Feb.03,2021 |
| SPEAG | System Validation Dipole | D750V3 | 1015 | Aug.13,2020 | Aug.12,2021 |
| | | D835V2 | 4d063 | Aug.13,2020 | Aug.12,2021 |
| | | D1900V2 | 5d173 | Apr.22,2020 | Apr.21,2021 |
| | | D2600V2 | 1005 | Jan.29,2020 | Jan.28,2021 |
| | | D3500V2 | 1009 | Aug.12,2020 | Aug.11,2021 |
| | | D3700V2 | 1057 | Nov.04,2019 | Nov.03,2020 |
| SPEAG | Data acquisition Electronics | DAE4 | 877 | Mar.17,2020 | Mar.16,2021 |
| SPEAG | Software | DASY 52 V52.10.4 | N/A | Calibration not required | Calibration not required |
| SPEAG | Phantom | ELI | N/A | Calibration not required | Calibration not required |
| Agilent | Network Analyzer | E5071C | MY46100433 | Dec.13,2019 | Dec.12,2020 |
| Agilent | Dielectric Probe Kit | 85070E | MY44300677 | Calibration not required | Calibration not required |
| Agilent | Dual-directional coupler | 772D | MY46151242 | Aug.17,2020 | Aug.16,2021 |
| | | 778D | MY48220468 | Aug.17,2020 | Aug.16,2021 |
| Agilent | RF Signal Generator | N5181A | MY50141235 | May.04,2020 | May.03,2021 |
| Agilent | Power Meter | E4417A | MY51410006 | Mar.09,2020 | Mar.08,2021 |
| Agilent | Power Sensor | E9301H | MY51470001 | Mar.09,2020 | Mar.08,2021 |
| | | | MY51470002 | Mar.09,2020 | Mar.08,2021 |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

| Manufacturer | Device | Type | Serial number | Date of last calibration | Date of next calibration |
|---|---|---|---|---|---|
| TECPEL | Digital thermometer | DTM-303A | TP130074 | Apr.10,2020 | Apr.09,2021 |
| KEYSIGHT | UXM 5G Wireless Test Platform | E7515B | MY59321561 | Dec.16,2019 | Dec.15,2020 |
| R&S | Radio Communication Test | CMW 500 | 125470 | Dec.11,2019 | Dec.10,2020 |


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

## SAR Tissue and System Verification

### 1.1 Tissue Verification

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

The composition of the body tissue simulating liquid:

| Frequency (MHz) | Mode | Ingredient | | | | | | Total amount |
|---|---|---|---|---|---|---|---|---|
| | | DGMBE | Water | Salt | Preventol D-7 | Cellulose | Sugar | |
| 750 | Head | — | 532.98 g | 18.3 g | 2.4 g | 3.2 g | 766 g | 1.3L(Kg) |
| 835 | Head | — | 532.98 g | 18.3 g | 2.4 g | 3.2 g | 766 g | 1.3L(Kg) |
| 1900 | Head | 444.52 g | 552.42 g | 3.06 g | — | — | — | 1.0L(Kg) |
| 2600 | Head | 550ml | 450ml | — | — | — | — | 1.0L(Kg) |
| 3500 | Head | 550ml | 450ml | — | — | — | — | 1.0L(Kg) |
| 3700 | Head | 550ml | 450ml | — | — | — | — | 1.0L(Kg) |

### Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this Head-simulant fluid were measured by using the Agilent Model 85070E Dielectric Probe (rates frequency band 200 MHz to 20 GHz) in conjunction with Network Analyzer.
All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. The measured conductivity and permittivity are all within ± 5% of the target values.
The depth of the tissue simulant in the flat section of the phantom was ≥ 15 cm ± 5 mm (Frequency ≤3G) or ≥ 10 cm ± 5 mm (Frequency >3G) during all tests. (Fig. 2)

| Tissue Type | Measurement Date | Measured Frequency (MHz) | Target Dielectric Constant, εr | Target Conductivity, σ (S/m) | Measured Dielectric Constant, εr | Measured Conductivity, σ (S/m) | % dev εr | % dev σ |
|---|---|---|---|---|---|---|---|---|
| Head | Oct, 10. 2020 | 750.00 | 41.900 | 0.890 | 43.506 | 0.882 | 3.83% | -0.90% |
| | Oct, 10. 2020 | 835.00 | 41.500 | 0.900 | 42.018 | 0.907 | 1.25% | 0.78% |
| | Oct, 10. 2020 | 1900.00 | 40.000 | 1.400 | 40.545 | 1.419 | 1.36% | 1.36% |
| | Oct, 10. 2020 | 2600.00 | 39.000 | 1.960 | 39.345 | 1.985 | 0.88% | 1.28% |
| | Oct, 10. 2020 | 3500.00 | 37.929 | 2.913 | 36.994 | 2.942 | -2.46% | 1.01% |
| | Oct, 10. 2020 | 3700.00 | 37.700 | 3.118 | 36.835 | 3.068 | -2.29% | -1.59% |

## SAR System Verification

The microwave circuit arrangement for system verification is sketched in Fig. b. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within +/- 10% from the target SAR values. These tests were done at 750/835/1900/2600/3500/3700MHz. The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed in the table 1 (SAR values are normalized to 1W forward power delivered to the dipole). During the tests, the liquid depth above the ear reference points was ≥ 15 cm ± 5 mm (frequency ≤ 3 GHz) or ≥ 10 cm ± 5 mm (frequency > 3 G Hz) in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.

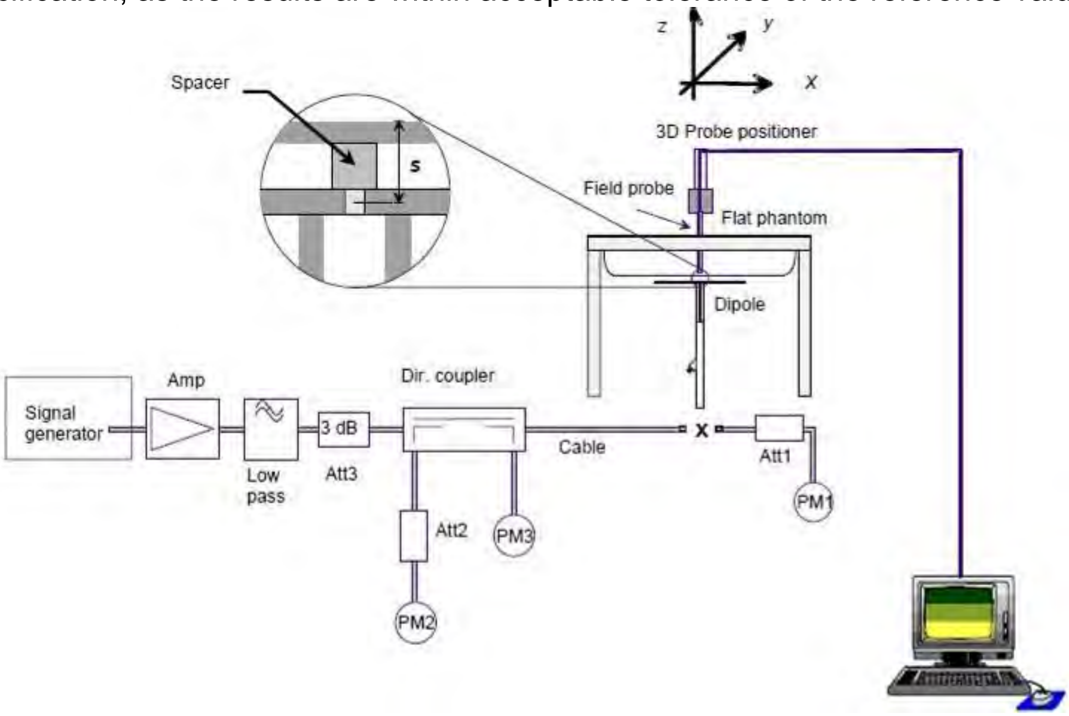



Fig. b The block diagram of system verification


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group

| Frequency | Input Power (mW) | Dipole S/N | Probe S/N | DAE S/N | Measured 1g SAR (W/kg) | Targeted 1g SAR (W/kg) | Normalized 1g SAR (W/kg) | Deviation (%) | Date |
|---|---|---|---|---|---|---|---|---|---|
| 750 | 250 | 1015 | EX3DV4 - SN7466 | DAE4 SN877 | 2.04 | 8.48 | 8.16 | -3.77% | Oct. 10, 2020 |
| 835 | 250 | 4d063 | EX3DV4 - SN7466 | DAE4 SN877 | 2.23 | 9.52 | 8.92 | -6.30% | Oct. 10, 2020 |
| 1900 | 250 | 5d173 | EX3DV4 - SN7466 | DAE4 SN877 | 9.67 | 39.4 | 38.68 | -1.83% | Oct. 10, 2020 |
| 2600 | 250 | 1005 | EX3DV4 - SN7466 | DAE4 SN877 | 14.55 | 57.3 | 58.2 | 1.57% | Oct. 10, 2020 |
| 3500 | 100 | 1009 | EX3DV4 - SN7466 | DAE4 SN877 | 6.83 | 67.6 | 68.3 | 1.04% | Oct. 10, 2020 |
| 3700 | 100 | 1057 | EX3DV4 - SN7466 | DAE4 SN877 | 6.73 | 68 | 67.3 | -1.03% | Oct. 10, 2020 |

## - End of report -


SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
Member of SGS Group