# LTE RF Measurements with the R&S®CMW500 according to 3GPP TS 36.521-1

## Application Note

**Products:**

- R&S®CMW500


The 3GPP TS 36.521-1 “Radio transmission and reception” LTE User Equipment (UE) conformance specification defines the measurement procedures for LTE terminals with regard to their transmitting characteristics, receiving characteristics and performance requirements as part of the 3G Long Term Evolution (3G LTE) standard.

This application note describes how to use the LTE Frequency Division Duplex (FDD) and Time Division Duplex (TDD) measurement functionality provided by the R&S®CMW500 wideband radio communication tester to perform LTE R8 transmitter and receiver measurements according to this test specification.


ROHDE&SCHWARZ

Application Note


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# 1 Introduction

The R&S ®CMW500 signaling and measurement solution can be used to perform all the transmitter and receiver tests specified in TS 36.521-1 for 3GPP Release-9. This document provides a step-by-step guide to performing Release-9 measurements according to **3GPP TS 36.521 V10.4.0**, Clauses 6 and 7, using the R&S®CMW500 LTE callbox. This description refers to the functionality provided with **Version 3.2.50 of the R&S®CMW500 firmware**. This document will be updated to specify relevant changes caused by new firmware releases.
Each test is explained in an example. Since each of the different measurements requires specific settings, this application note includes a set of sample save files. The explanation in Section 1.1 describes how to create and recall such files.

The tests described here are limited to the ones that don't need complicated external instruments, such as spectrum analyzers and filters. Spurious measurements, transmitter intermodulation, and out-of-band blocking tests, for example, are not covered. To see which other tests can be performed when using such additional equipment, please always refer to the latest R&S®CMW500 capability list, which can be found on the CMW customer web:

https://extranet.rohde-schwarz.com

## 1.1 How to Use Save Files in the R&S®CMW500

Save files provide a convenient way to save and restore settings to satisfy the requirements of certain tests that you might want to perform over and over again. These files contain the current settings for the R&S®CMW500 parameters. Save files can also be used to easily move settings from one R&S®CMW500 to another by storing the settings on the first device and then recalling them on the target R&S®CMW500. For your convenience, this application note comes with a set of save files for all the described tests.
To use them, begin by pressing the SAVE/RCL key on the top left of the R&S®CMW500's front panel.

***Fig. 1: The SAVE/RCL key.***

Then follow the dialog prompts to locate your save files and select the one you want to recall. Choose the desired file by pressing the *Recall* button on the top right of the screen. When recalling the save file, ensure that both the source and target devices are using the same firmware.

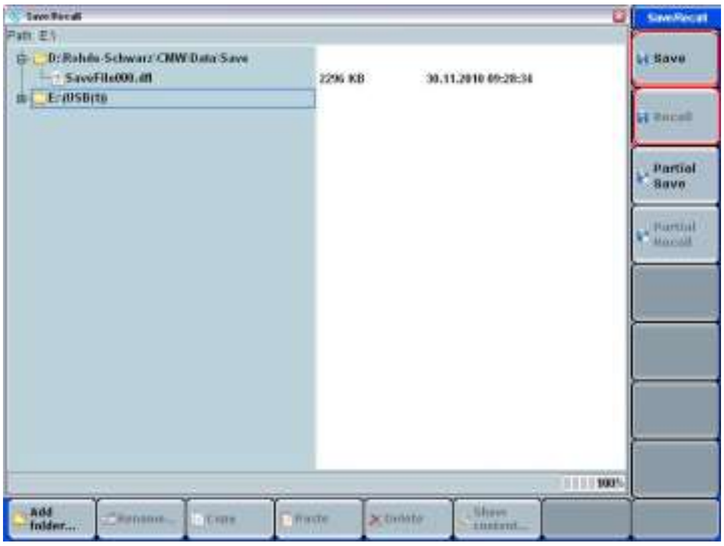



***Fig. 2: The Save/Recall dialog screen.***

## 1.2 Select the Duplex Mode

The duplex mode can only be selected at Signal OFF state.

For most test cases, the FDD and TDD test configurations and test steps are the same. Differences in the individual tests are specified in this document.

# 2 Transmitter Characteristics

## 2.1 Generic Call Setup for Transmitter Characteristics

The following parameters are set according to these specifications:

| | |
|---|---|
| Cell set up | 3GPP TS 36.508, Sub Clause 4.4.3 |
| Propagation conditions | 3GPP TS 36.521, Annex B.0 |
| Uplink reference measurement channels (RMCs) | 3GPP TS 36.521, Annex A.2 |
| Configuration of PDSCH and PDCCH before measurement | 3GPP TS 36.521, Annex C.2 |
| Initial downlink signal setup | 3GPP TS 36.521, Annexes C.0, C.1, and C.3.0 |
| Initial uplink signal setup | 3GPP TS 36.521, Annexes H.1 and H.3.0 |

***Table 1: Sources for parameter specifications.***

TS 36.521, Annex C.0 describes downlink signal levels. In the R&S®CMW500, the downlink signal level should be configured so that *RS EPRE* is set to *–85 dBm/15 kHz*.
TS 36.521, Annex C.1 describes the mapping of downlink physical channels and signals to physical resources.
TS 36.521, Annex C.3.0 mainly describes downlink physical channel levels.
TS 36.521, Annex H.1 describes the mapping of uplink physical channels and signals to physical resources.

The resulting settings for the R&S®CMW500 are as shown in Fig. 3.

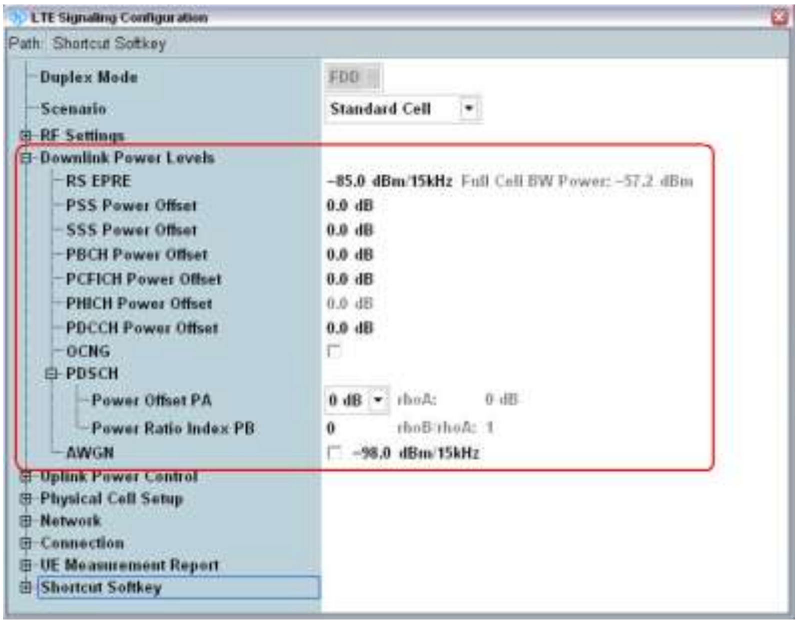



***Fig. 3: The LTE signaling configuration screen with settings based on TS 36.521.***

### 2.1.1 Rules for the Bandwidth and Frequency Settings

Frequencies and channel bandwidths are checked separately for each Evolved UMTS Terrestrial Radio Access (E-UTRA) operating band that the UE supports.
Applicable channel bandwidths should follow the rules from TS 36.521, Table 5.4.2.1-1, and the requirements from the test configuration table for each test case.

Most of the transmitter tests should be performed at the lowest and highest supported bandwidth as well as at the 5 MHz bandwidth. However, some tests also need to be performed at the 10 MHz bandwidth. Furthermore, some tests, such as the occupied bandwidth test, are to be performed at all bandwidths.

Test frequency settings should be taken from TS36.508, Table 4.3.1. There, the low-range, middle-range and high-range channel frequency information can be found for the operating band (OB) and channel bandwidth to be tested.

Most of the transmitter tests should be performed on one low-range, one middle-range and one high-range channel. However, some tests – such as the configured UE transmitted output power test or the occupied bandwidth test – should only be performed on a middle-range channel.

In the examples used in this application note, Operating Band 7 will be used with the 10 MHz and 20 MHz bandwidths. Therefore, the corresponding frequencies/channels provided in Table 2 will need to be set on the R&S®CMW500 when testing.

| OB | Bandwidth | Range | $N_{UL}$ | Frequency of Uplink [MHz] | $N_{DL}$ | Frequency of Downlink [MHz] |
|---|---|---|---|---|---|---|
| 7 | 10 MHz | Low | 20800 | 2505 | 2800 | 2625 |
| | | Middle | 21100 | 2535 | 3100 | 2655 |
| | | High | 21400 | 2565 | 3400 | 2685 |
| | 20 MHz | Low | 20850 | 2510 | 2850 | 2630 |
| | | Middle | 21100 | 2535 | 3100 | 2655 |
| | | High | 21350 | 2560 | 3350 | 2680 |

***Table 2: Test-frequency mapping.***

### 2.1.2 Measurement Issues Related to Expected Power

When using the R&S®CMW500 to perform callbox measurements, the R&S®CMW500 might occasionally display an *Input overdriven* or *Input underdriven* notice. When this happens, the measurement is not stable. This is related to the instrument’s dynamic range setting.

The figure below provides a simple illustration of the basic theory for this setting:

1. The reference level represents the R&S®CMW500’s maximum allowed input power. If the input signal level exceeds the reference level, the instrument will display an *Input overdriven* status. Remember here that the input signal level is determined using a PEAK detector.
2. When the input signal falls into the green area, the R&S®CMW500 will be able to perform the power measurement, as well as demodulate the signal.
3. When the input signal level drops into the yellow area, its SNR is not good enough for demodulation, but it is sufficient for taking power measurements.
4. In the R&S®CMW500 multi-evaluation interface, users should always keep the UE uplink signal inside the demodulation area (green).
5. When input signal levels are higher than the reference level or lower than the noise floor, they will not be measured correctly.

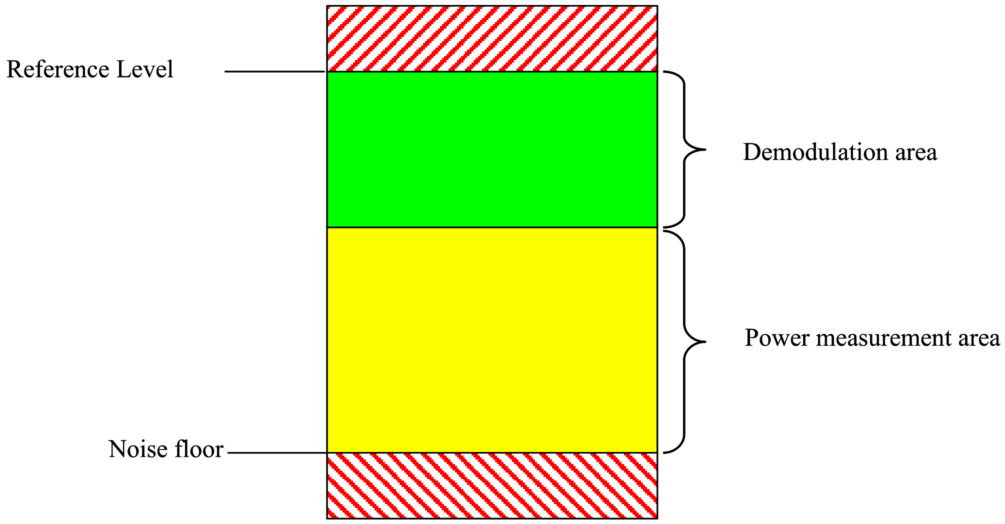



***Fig. 4: Measurement levels.***

Consequently, the R&S®CMW500's reference-level setting is important. There are two reference-level modes to select from. The section below states the difference between the two modes and explains how to use them. In the R&S®CMW500, the reference level is the sum of the *expected nominal power* and the *margin*. Only the sum of the expected nominal power and margin is significant for the R&S®CMW500. The individual values for these parameters are not relevant, except in that sum.

6. The R&S®CMW500 automatically sets the reference level according to the UL power control settings. When measuring PUSCH, using this setting is very simple.
7. Manual mode: Here, users set the reference level themselves. Using this mode is necessary for test cases that are related to time mask measurement for more accurate OFF power measurement.
8. On the basis of the information above, it is possible to state a general rule: The input signal's peak power should not exceed the reference level; furthermore, it should not fall out of the green field when using the multi-evaluation interface.

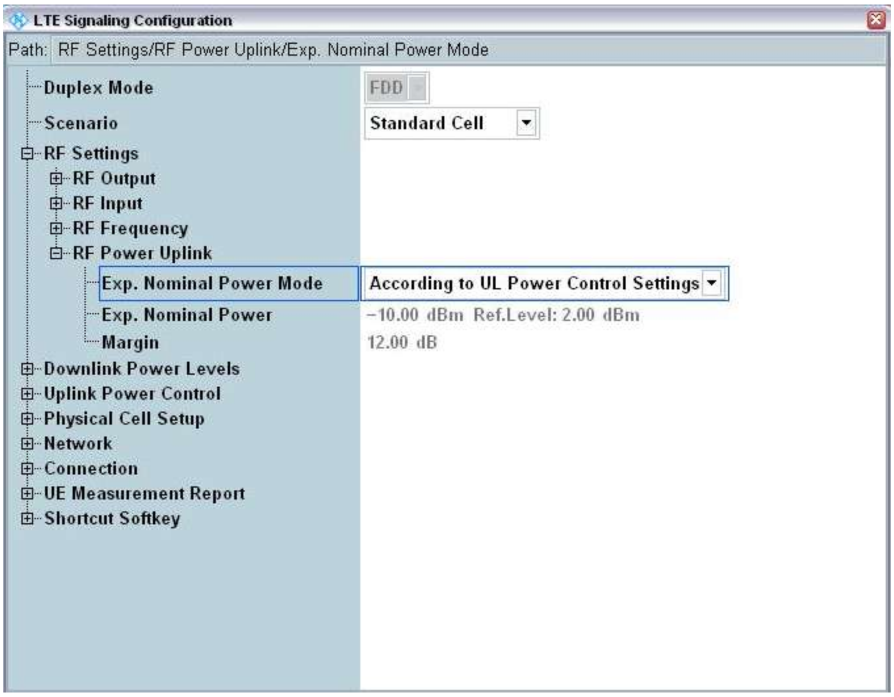



***Fig. 5: Configuring the expected nominal power mode.***

### 2.1.3 General Settings Related to Multi-Evaluation Measurements

The measurement setting should be linked to LTE signaling for frequency and power settings, as shown in Fig. 6.


***Fig. 6: Selecting LTE signaling for the measurement.***

The *Channel Type*, the *RB Allocation* (which determines the number of resources blocks) and the *Modulation* should be set to *Auto* at all times for all the tests described in this application note to avoid inconsistent configuration. Nevertheless it might be required to configure the Modulation scheme to the used TX signal Modulation scheme in case of lower TX signal power levels.

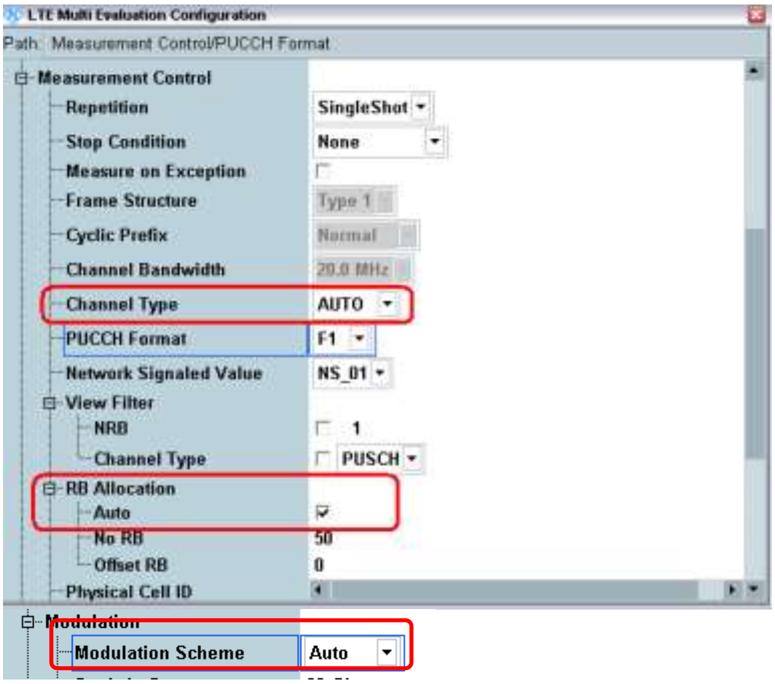



*Fig. 7: Three settings that should be set to "Auto" for all of the tests described in this application note.*

A different *Measure Subframe* is used for "FDD" and "TDD," as shown in Fig. 8. The default value for this parameter is "0". For FDD, the default value is OK for measurement. In TDD mode, the *Measure Subframe* can only be a selection from {2,3,7,8}, because the specification requires the uplink/downlink configuration to be "1."

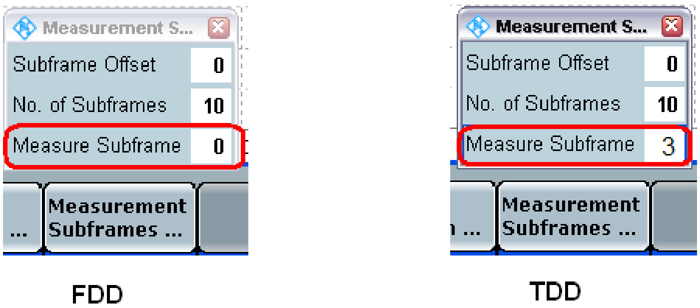



*Fig. 8: Measure Subframe settings for FDD and TDD.*

### 2.1.4 Explanation of Demos and Manual Operation

In between each test case description in this application note, a short demo has been added to illustrate how the R&S®CMW500 is used for each type of test. Therefore, these demos concentrate on one duplex mode, one operation band, one bandwidth and one channel only. For TDD mode, only the differences in the configuration or test steps between the FDD and TDD will be highlighted. If not specified, the test-specific configuration and test steps are the same for TDD and FDD.

In order to perform each test in strict adherence to the specification, the tests would need to be repeated for the different bandwidths and channels as explained in Section 2.1.1.

To perform the tests with your own device, please be sure to transfer the described example to the operation band that you are using in the device under test (DUT).

During manual testing in the R&D stage, you always need to change some parameters (such as the type of power control, the target power, or the RB settings) to perform your test. To make that possible, you can also change these parameters in the multi-evaluation interface so that you don't need to switch to the signaling interface. As shown in Fig. 9, if you press *Signaling Parameters* in the right column and then select the *Connection Setup* button, you will be able to change the *RB Allocation* and RB position (*RB Pos.)* as well as the *Modulation Scheme* for the *Uplink* and *Downlink*. From LTE V3.0.20, the DL power, Band, Channel settings can be changed by pressing *Cell Setup.*


***Fig. 9: Changing the signaling parameters.***

## 2.1.5 General Setup for TDD mode

According to the specification, the *Uplink Downlink Configuration* should be "1," and the *Special Subframe* should be "5." These values can be configured at *LTE Signaling > Config > Physical Cell Setup > TDD*, as shown in Fig. 10.

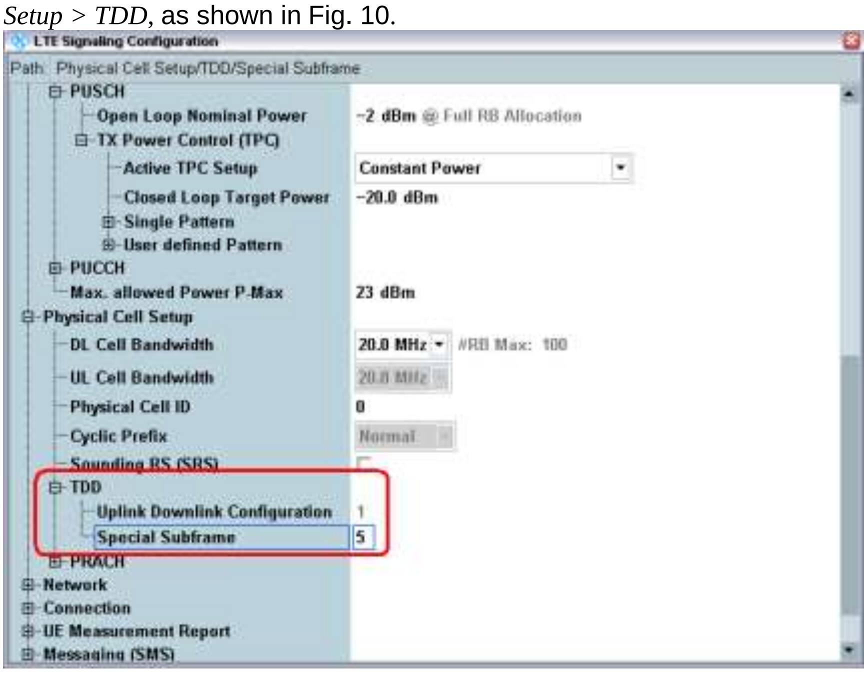



***Fig. 10: General configuration for TDD.***

### 2.1.6 Advanced PRACH/Open Loop Power

From CMW LTE V3.0.50 onward, the *Advanced PRACH /OL Power* setting can be enabled under the *Uplink Power Control* settings so that the user is able to change *Reference Signal Power, Preamble Initial Received Target Power* and other open loop related message components directly. KS510 – advance Signalling option is needed to enable these advanced settings.

Below diagram displays the default settings, which are according to TS 36.508 default values.

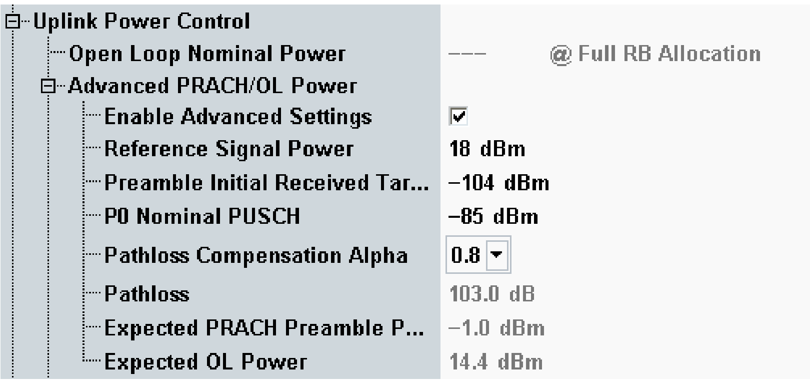



***Fig. 11 Advanced Power Default Settings***

To change the *Expected PRACH Preamble Power* at RRCIdle mode, it is recommended to do the necessary changes with a change of the DL *RS EPRE* first if needed, followed by *Preamble Initial Received Target Power*.

A change of the *Expected OL Power* can be achieved by changing *PO Nominal PUSCH* in either mode, RRCConnected (through RRCReconfiguration) or RRCIdle.

### 2.1.7 Non-Advanced Open Loop Power

If KS510 is not present in CMW, *Open Loop Nominal Power* is used for configuring PRACH/OL Power. It should be the target UL total BW open loop power. The target PRACH power is 8 dB lower than the *Open Loop Nominal Power*. For TDD, if PRACH *Configuration Index* is 48 or greater, the expected PRACH power is the same as *Open Loop Nominal Power,* because DELTA_PREAMBLE = 8dB, according to 3GPP TS 36.321 Table 7.6-1.

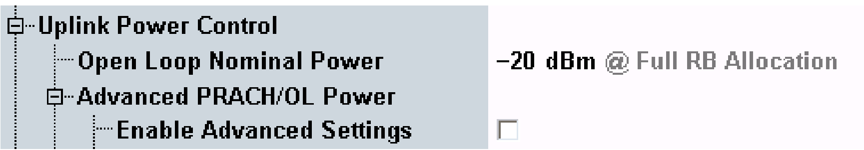



***Fig. 12: Open Loop Nominal Power Settings***

### 2.1.8 SIB Paging and RRCReconfiguration

Based on 3GPP test requirements, SIB related parameters should be changed at Cell ON state; therefore, a power cycle of the UE is required.

These SIB related parameters (*Network Signalling, p-Max, SRS, PO nominal PUSCH, Preamble Initial Received Target Power*) can be changed at RRC Idle or Connected mode as well through SIB paging or RRC Reconfiguration message initiated from the base station. However it needs to be carefully checked whether the UE is supporting the change via SIB paging or RRCReconfiguration with mobilityInfo.

By default, this application note will describe the tests in the way of changing the SIB related parameters at Cell ON state.

## 2.2 UE Maximum Output Power (TS 36.521, 6.2.2)

This test case is for verifying that the error for the UE maximum output power does not exceed the range prescribed by the specified nominal maximum output power and tolerance.
An excessively high maximum output power could interfere with other channels or systems. Insufficient maximum power would decrease the coverage area.

### 2.2.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.2.2.4.1-1. This test only uses QPSK modulation along with an *RB Allocation* of *1RB* or *Partial RB allocation* in the uplink.

According to TS 36.521, Table 5.4.2.1-1, there are four bandwidth configurations for Band 7: 5 MHz, 10 MHz, 15 MHz and 20 MHz. Furthermore, according to TS 36.521, Table 6.2.2.4.1-1, the maximum power only needs to be tested at the lowest bandwidth (5 MHz) and highest bandwidth. Therefore, the maximum power test only needs to be performed using the 5 MHz and 20 MHz bandwidth configurations for Band 7.

The test case described here will demonstrate this using Band 7 with a low-range channel and a 20 MHz bandwidth.

TS 36.521, Table 6.2.2.4.1-1 requires testing of a 20 MHz configuration with two different *RB Allocation* settings: *1RB* and *18RB*. Since a configuration with the settings *Band 7*, *20 MHz*, and *Low Range* does satisfy Note 2 of TS 36.521-1 Table 6.2.2.3-1, the lower limit is relaxed by 1.5 dB. Also, according to TS 36.521-1, Table 6.2.2.4.1-1, Note 2, the RB position (*RB Pos.*) for the low-range channel shall be low and high for 1 RB and low for 18 RB allocations.

### 2.2.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the network. Then press the *Connect* button to establish the connection as shown in Fig. 13.

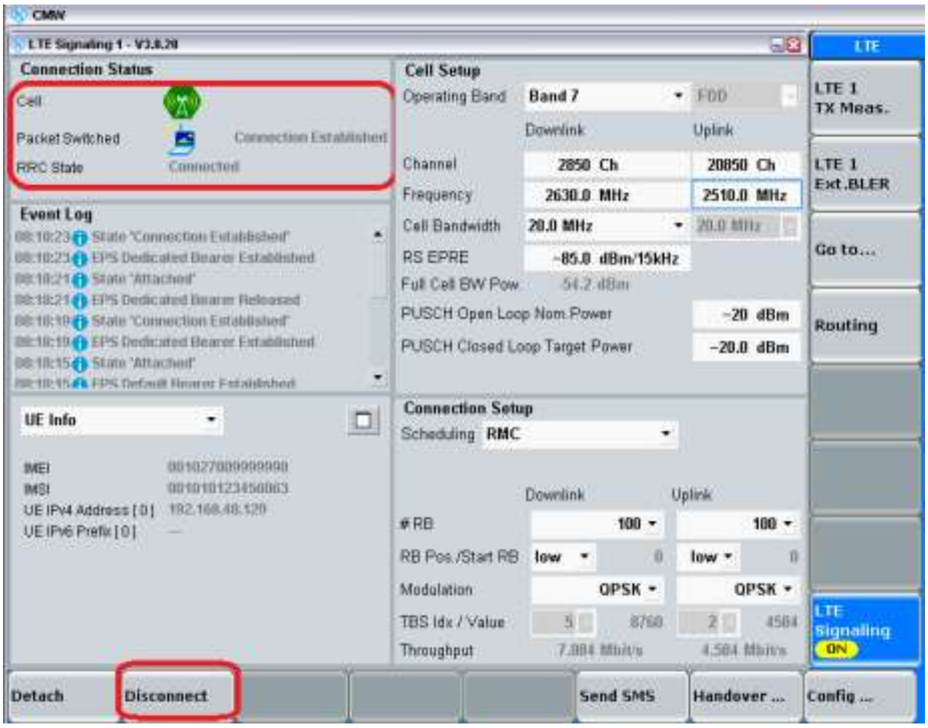



***Fig. 13: Established connection.***

1. Configure the uplink *RMC* by setting *# RB* to *1*, *RB Pos/Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC Setup* to *Max. Power* so that the UE output power reaches $P_{UMAX}$.
2. Measure the average UE output power (*22.45 dBm* in this example) in the error vector magnitude (EVM) measurement screen as shown in the screenshot below.

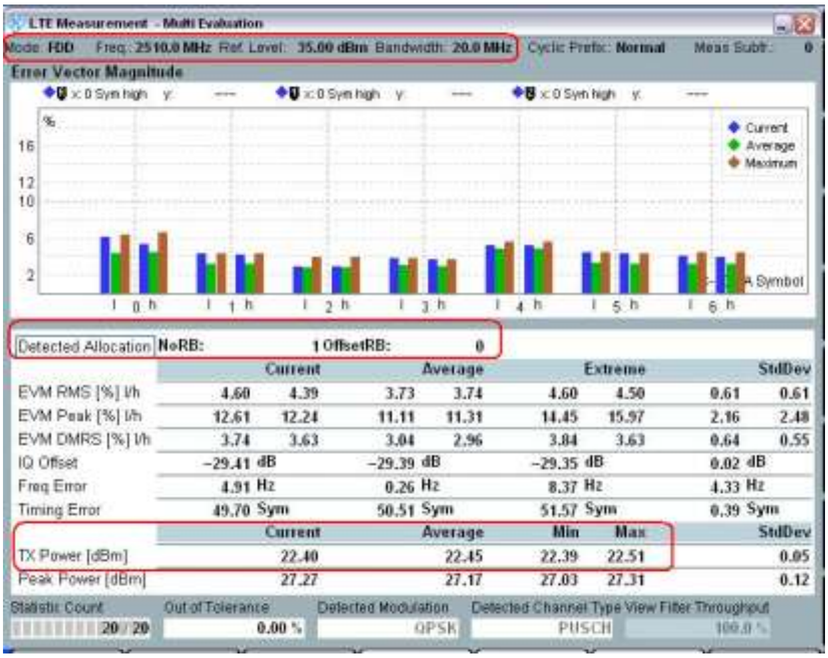



***Fig. 14: Measurement results for UE maximum output power for one resource block.***

3. Change *# RB* for the *RMC* uplink from *1* to *18*, and then press the *Restart/Stop* button to restart the measurement.
4. Read the average UE output power (*22.54 dBm* in this example) results in the EVM measurement screen as shown in Fig. 15: .


***Fig. 15: Measurement results for UE maximum output power for 18 resource blocks.***

### 2.2.3 Test Requirements

According to 3GPP 36.521-1, Table 6.2.2.5-1, the maximum output power must be within the range of 23±2.7 dBm.

For the bands beyond 3GHz, the limits are slightly different. For Band 22, the limit is +3/-4.5 dB; for Band 42 & 43, the limit is +3/-4 dB.

Note: For transmission configurations (Figure 5.4.2-1) confined within FUL_low and FUL_low + 4 MHz or FUL_high – 4 MHz and FUL_high, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB.

## 2.3 Maximum Power Reduction (TS 36.521, 6.2.3)

The number of RBs defined in TS 36.521, Table 6.2.2.3-1, is based on meeting the requirements for the adjacent channel leakage ratio and the maximum power reduction (MPR) due to the cubic metric (CM).

### 2.3.1 Test Description

For UE Power Class 3, the MPR allowed for the maximum output power due to higher-order modulation and to the transmit bandwidth configuration (resource blocks) is specified in TS 36.521-1, Table 6.2.3.3-1.

The core concept for this test is that using the higher-order modulation scheme (16QAM) and/or a large number of allocated RBs (e.g. full RB allocation) will cause a high crest factor and thus present a challenge in the design of power amplifiers. Therefore, the specification allows a reduction of the maximum output power's lower limit in such cases.
When QPSK modulation is used with a higher number of RBs, the lower limit is relaxed by 1 dB. Also, when 16QAM is used as the UL modulation scheme, the lower limit is relaxed by 1 dB.

When both conditions apply (16QAM and a higher number of RBs), the lower limit is relaxed by 2 dB.

For the example, a Band 7 DUT will be used. According to TS 36.521, Tables 5.4.2.1-1, and 6.2.3.4.1-1, the maximum power reduction needs to be tested using the 5 MHz, 10 MHz and 20 MHz bandwidth configurations. This example will concentrate on the 20 MHz bandwidth using a mid-range channel.

### 2.3.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE and wait for it to attach to the network. Then press *Connect* to establish the connection.

The six test sets shown in Table 3 should be performed for a 20 MHz mid-range channel according to Note 3 in TS 36.521, Table 6.2.3.4.1-1. The example shown here will use Test Set 6.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | **18** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 2 | **18** | **High** | **QPSK** | $P_{UMAX}$ |
| Test Set 3 | **18** | **Low** | **16QAM** | $P_{UMAX}$ |
| Test Set 4 | **18** | **High** | **16QAM** | $P_{UMAX}$ |
| Test Set 5 | **100** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 6 | 100 | Low | 16QAM | $P_{UMAX}$ |

***Table 3: Test setup for MPR (mid range).***

When measuring 16QAM modulation signals, please make sure that the *Modulation Scheme* in the measurement configuration is set to *16QAM* or *Auto*.
Hint: It is best to use the *Auto* modulation scheme setting so that you do not need to confirm this parameter yourself. That makes it easier to perform the test.

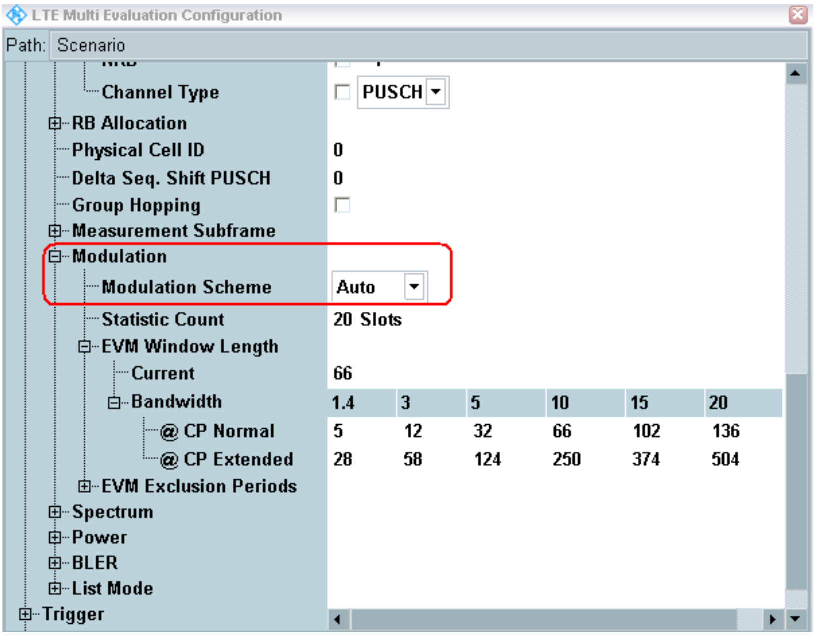



***Fig. 16: Setting the modulation scheme.***

Test Set 6:

1. Set the RMC uplink *# RB* to *100*, *RB Pos/Start RB* to *Low*, and *Modulation* to *16QAM*; set *Active TPC setup* to *Max Power* until the UE output power reaches $P_{UMAX}$.
2. Measure the average UE output power (*21.48 dBm* in this example). Configure the settings that are marked red in Fig. 17.

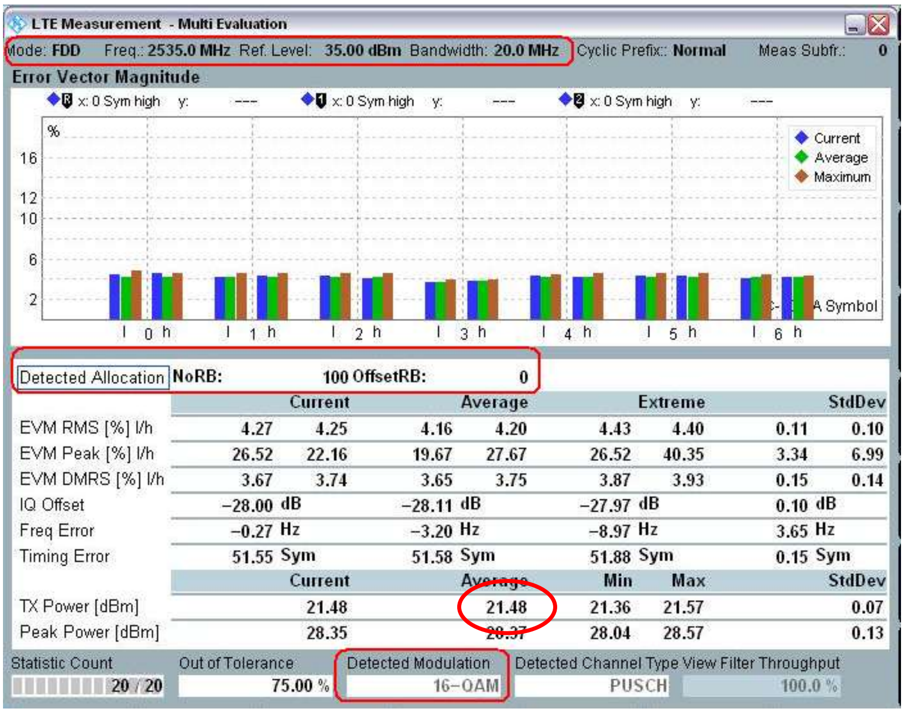


***Fig. 17: Settings for Test Set 6.***

### 2.3.3 Test Requirements

The maximum output power shall be within the range prescribed by the nominal maximum output power and tolerance in TS 36.521-1, Table 6.2.3.5-1. For Band 7 and the example above, this is 23 dBm +2.7 dB/–4.7 dB

| E-UTRA Band | Class 3 (dBm) | QPSK, full RB allocation tol. (dB) | 16QAM, partial RB allocation tol. (dB) | 16QAM, full RB allocation tol. (dB) |
|---|---|---|---|---|
| 7 | 23 | +2.7 / –3.7 | +2.7 / –3.7 | +2.7 / –4.7 |

***Table 4: Test requirements for the UE power class (source: TS 36.521-1, Table 6.2.3.5-1).***

## 2.4 Additional Maximum Power Reduction (TS 36.521-1, 6.2.4)

Additional ACLR and spectrum emission requirements can be signaled by the network to indicate that the UE must also meet additional requirements in a specific deployment scenario. To meet these additional requirements, additional maximum power reduction (A-MPR) is allowed for the output power as specified in TS 36.521-1, Table 6.2.2.3-1. Unless stated otherwise, an A-MPR of *0 dB* shall be used.

### 2.4.1 Test Description

The network signal (NS) value, which the cell broadcasts from SIB2, is a key parameter for this test item. If, for example, a Band-1 UE detects that the additional spectrum emission information element equals NS_05 from SIB2, it knows that it should meet the additional requirement of spurious emissions and maximum power reduction according to TS 36.521-1, Table 6.2.4.3-1.

The network signal value parameter can be set in the R&S®CMW500 in the *LTE Signaling* configuration menu. By default, this parameter is set to NS_01 as shown in Fig. 18. The *NS_01* setting means that no additional spectrum or additional max power reduction is used. The default value *NS_01* is also the setting that is required for the maximum power test and for the MPR test described above.

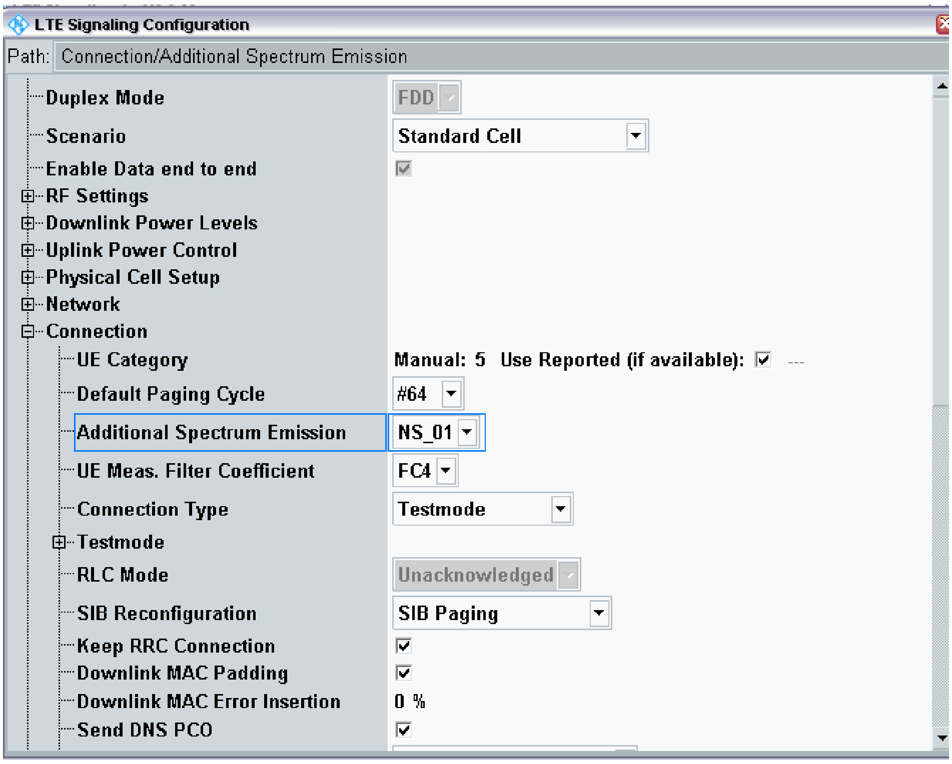



***Fig. 18: Additional spectrum emission.***

NS has a fixed relationship with the operating band, the channel bandwidth, and the RB allocation. Detailed information on this is provided in TS 36.521, Table 6.2.4.3-1, while Tables 6.2.4.3-2, 6.2.4.3-3 and 6.2.4.3-4 mainly describe detailed requirements for NS_07, NS_10, and NS_04.

### 2.4.2 Test Procedure

The example for A-MPR will use a Band-1 UE, because no A-MPR requirements apply for Band 7. According to TS 36.521, Table 6.2.4.3-1, only NS_05 applies for Band 1, so this setting is used for the example.

Different tables describe different RMC, RB position, frequency and bandwidth settings. Table 5 shows the relationship between NS and the test configuration table.

| | Additional spectrum emission | Test configuration table in TS 36.521-1 | E-UTRA Band |
|---|---|---|---|
| 1 | **NS_03** | 6.6.2.2.3.1 | 2,4,10,23,25,35,36 |
| 2 | **NS_04** | 6.6.2.2.3.2 | 41 |
| 3 | **NS_05** | 6.6.3.3.3.1 | 1 |
| 4 | **NS_06** | 6.6.2.2.3.3 | 12, 13, 14, 17 |
| 5 | **NS_07** | 6.6.2.2.3.3<br>6.6.3.3.3.2 | 13 |
| 6 | **NS_08** | 6.6.3.3.3.3 | 19 |
| 7 | **NS_09** | 6.6.3.3.3.4 | 21 |
| 8 | NS_10 | FFS | 20 |
| 9 | NS_11 | 6.6.2.2.1 | 23 |

***Table 5: The relationship between the network signal (NS) value and the test configuration table in TS 36.521-1.***

Change the *Additional Spectrum Emission* setting on the R&S®CMW500 from *NS_01* to *NS_05* as shown in Fig. 19 at Cell ON state.

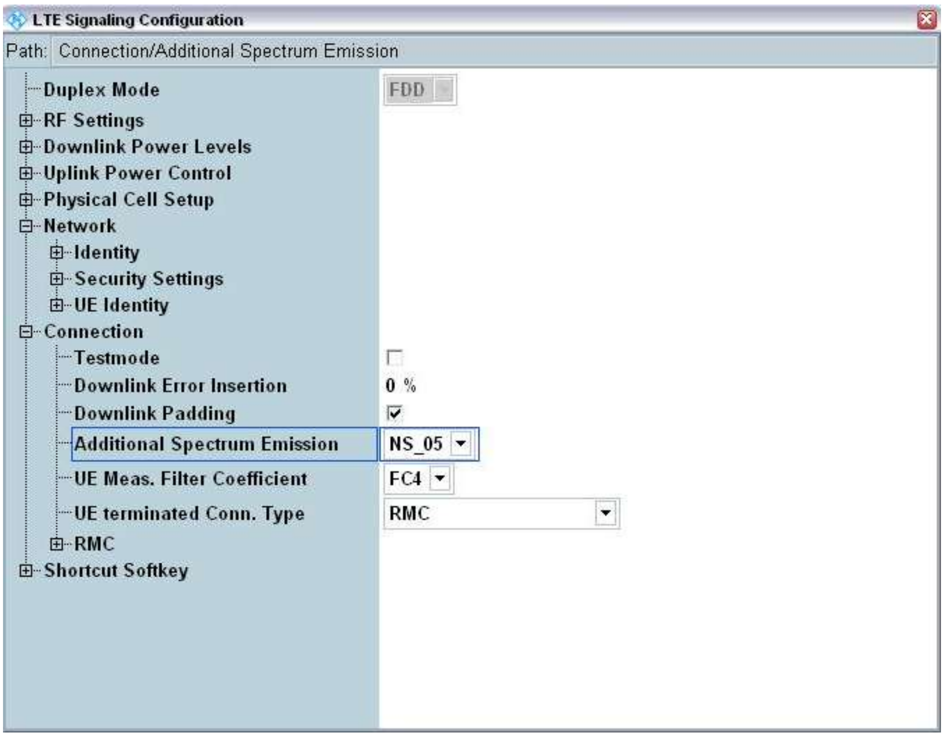



***Fig. 19: Additional spectrum emission setting for NS_05.***

TS 36.521-1, Table 6.2.4.4.1-3 defines the test bandwidth settings, frequency settings and RMC settings for NS_05.

For NS_05, this test should apply to 5 MHz, 10 MHz, 15 MHz and 20 MHz. The frequency should be low range, and a middle-range channel should be used. This demo uses a middle-range channel and a 10 MHz bandwidth.

The RMC, RB position (according to Table TS 36.521-1, 6.2.4.4.1-3) and the output power conditions are listed in Table 6 for the 10 MHz channel bandwidth. In the example, configuration IDs 3 and 6 are used. Configuration IDs are used to combine the test settings and test requirements. As a result, you only need to check the corresponding configuration ID that you have configured.

| Configuration ID | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| **3** | 1 | Low & High | QPSK | $P_{UMAX}$ |
| **4** | 12 | Low & High | QPSK | $P_{UMAX}$ |
| **5** | 48 | Low & High | QPSK | $P_{UMAX}$ |
| **6** | 50 | Low | QPSK | $P_{UMAX}$ |
| **7** | 50 | Low | 16QAM | $P_{UMAX}$ |

***Table 6: Settings for the 10 MHz bandwidth.***

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3.

Enable the LTE cell. Set the downlink frequency to a frequency such as 2140 MHz to make sure that the test is being performed on a middle-range channel. Then power on the LTE UE so that it attaches to the network, and press *Connect* to establish the connection.

**Configuration ID 3:**

1. Set the Uplink RMC setting *# RB* to *1*, *RB Pos./Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC Setup* to *Max. Power* so that the UE output power reaches $P_{UMAX}$.
2. Measure the average UE output power (*21.78 dBm* in this example) in the tabular result screen as shown in Fig. 20.

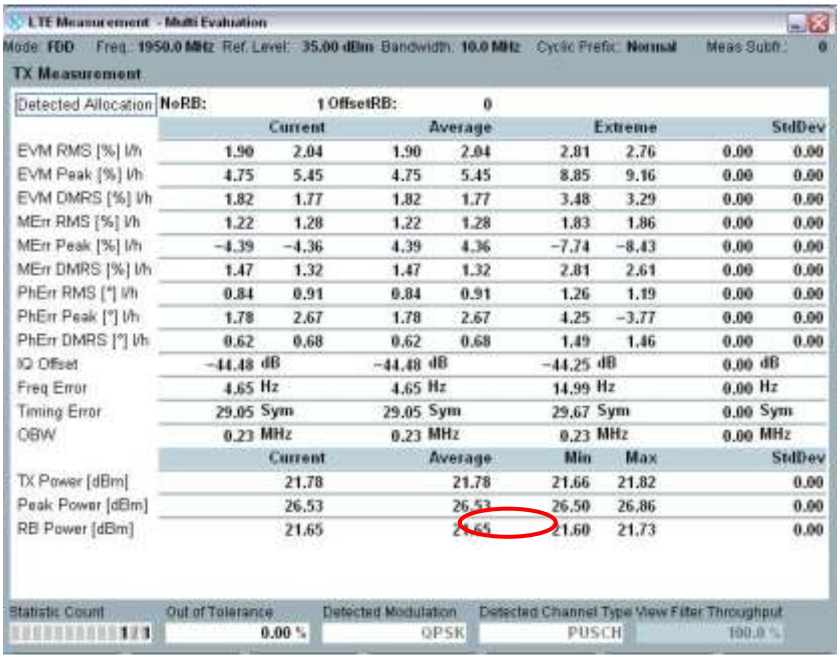



***Fig. 20: Measurement of the average TX power for Configuration ID 3.***

**Configuration ID 6:**

3. Set *# RB* to *50*, *RB Pos./Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC Setup* to *Max. Power* until the UE output power reaches $P_{UMAX}$.
4. Measure the average UE output power (*19.03 dBm* in this example) as shown in Fig. 21.

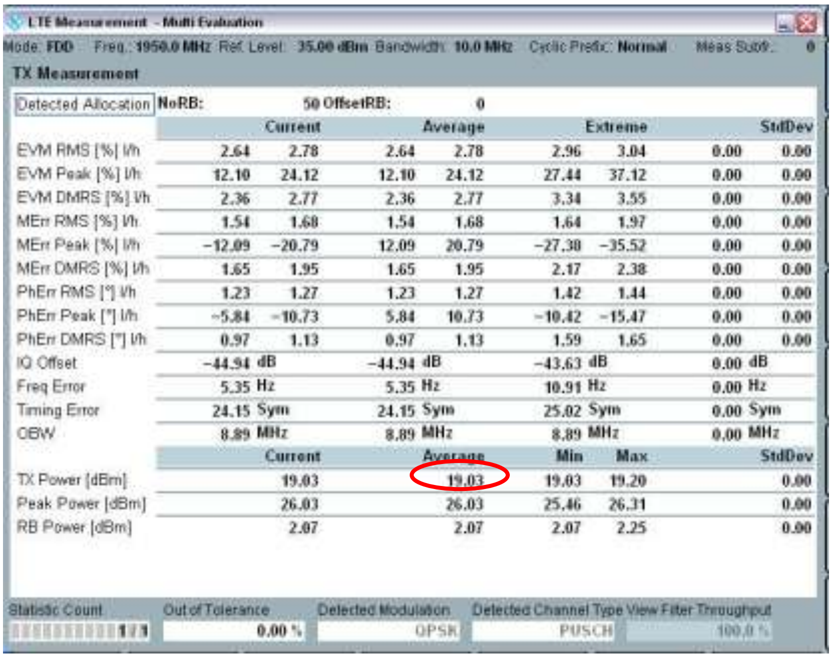



*Fig. 21: Measurement results for the average TX power for Configuration ID 6.*

### 2.4.3 Test Requirements

The maximum output power should not exceed the requirements from TS 36.521-1, Tables 6.2.4.5-1 through 6.2.4.5-8. Since this example uses NS_05, TS 36.521-1, Table 6.2.4.5-4 applies.
As there are many requirements for different NS values, but not all combinations are necessarily required for a specific UE, "configuration IDs" are introduced to map the applicable test configuration to the corresponding test requirements.

For NS_05 and the 10 MHz channel bandwidth as used in the example, the test configuration and tolerance are listed Table 7. To test different bands, and therefore different NS values, the configuration ID must be used to match the applicable configuration table with the corresponding test requirement table.

| Configuration table for NS_05 (TS 36.521-1, Table 6.2.4.4.1-3) | | | | Configura-tion ID | Test requirement table for NS_05 (TS 36.521-1, Table 6.2.4.5-4) | |
|---|---|---|---|---|---|---|
| Bandwidth | #RB | RB Position | Modulation | | Class 3 (dBm) | Tol.(dB) |
| 10MHz | 1 | Low & high | QPSK | **3** | 23 | +2.7 /–2.7 |
| 10MHz | 12 | Low & high | QPSK | **4** | 23 | +2.7 /–2.7 |
| 10MHz | 48 | Low & high | QPSK | **5** | 23 | +2.7 /–3.7 |
| 10MHz | 50 | Low & high | QPSK | **6** | 23 | +2.7 /–4.7 |
| 10MHz | 50 | Low & high | 16QAM | **7** | 23 | +2.7 /–6.2 |

*Table 7: Test configuration and tolerances for NS_05 and the 10 MHz channel bandwidth.*

# 2.5 Configured UE Transmitted Output Power (TS 36.521, 6.2.5)

The purpose of this test is to verify that the UE does not exceed the minimum between the $P_{EMAX}$ , the allowed maximum UL TX power signaled by the E-UTRAN, and the $P_{UMAX}$ , the maximum UE power for the UE power class.

$P_{EMAX}$ , is the value given to IE *P-Max*,  the maximum allowed UE output power signaled by higher layers, $P_{EMAX}$.

## 2.5.1 Test Description

The purpose of this test is to verify the UE's ability to interpret the P-max parameter in SIB1 and react accordingly. For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, and details on the RB allocations, are defined in TS 36.521, Table 6.2.5.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1 and 6.2.5.4.1-1 into account. Each bandwidth configuration should only apply to the middle-range channel with QPSK modulation and partial RB allocation.

## 2.5.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3.

Set the channel to the middle range, and the P-max parameter in the R&S®CMW500's signaling configuration as shown in Fig. 22.

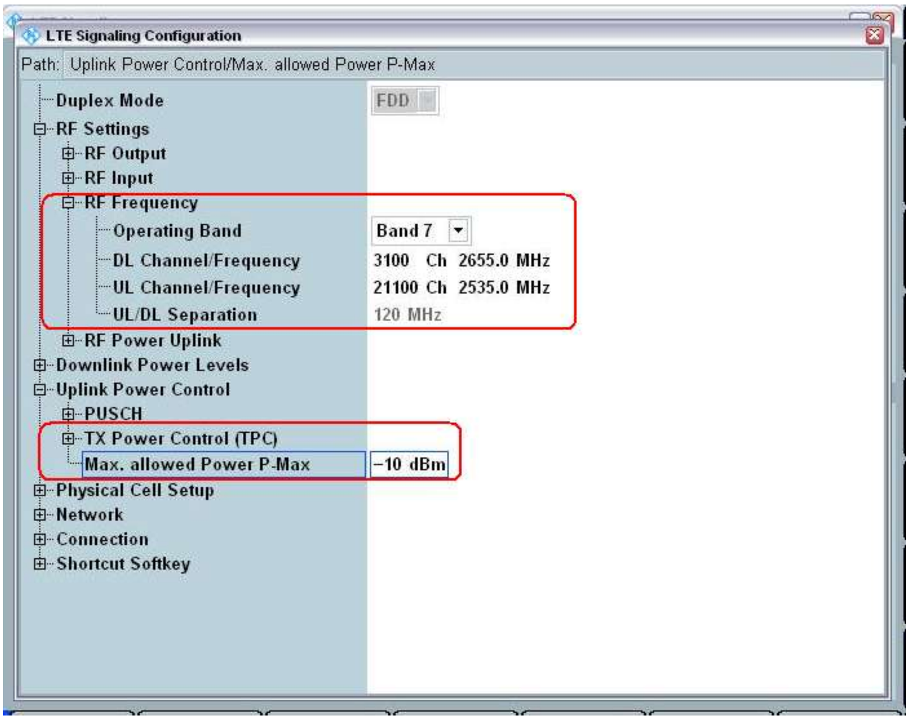



***Fig. 22: Test setup for the configured UE transmitted output power.***

First, enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to setup the connection.

This test defines three test points with different P-max values signaled on SIB1. These values are –10 dBm, 10 dBm and 15 dBm

In this example, the focus is on Band 7, the 20 MHz bandwidth and the middle-range channel. The resulting test setups are as shown in Table 8. The example explains Test Point 1.

| | #RB | RB Pos/Start RB | Modulation | p-Max |
|---|---|---|---|---|
| Test Point 1 | 18 | Low | QPSK | –10 |
| Test Point 2 | 18 | Low | QPSK | 10 |
| Test Point 3 | 18 | Low | QPSK | 15 |

***Table 8: Setup for testing the configured UE output power.***

Test Point 1:

1. Set *# RB* to 18, *RB Pos./Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC Setup* to *Maximum Power* until the UE output power reaches maximum.
2. Measure the average UE output power (*–10.56 dBm* in this example).

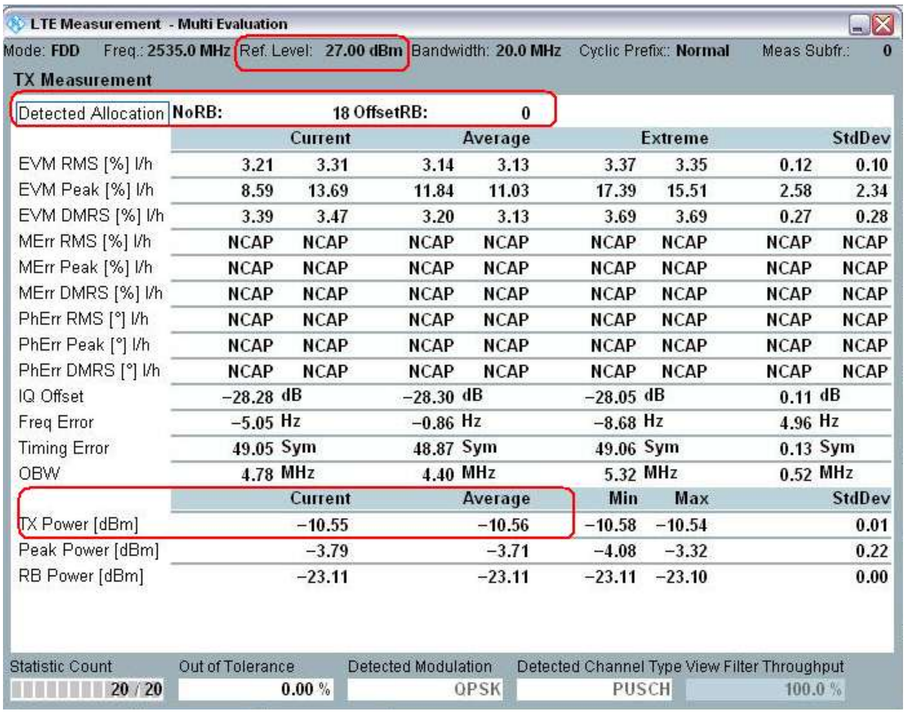



***Fig. 23: Measurement results for the average UE output power.***

Note:
The output power for Test Point 1 is around –10 dBm. Therefore, if the reference level is set to a power level that is too high (such as 35 dBm), the measurement will show a warning indicating that the signal is low. In such cases, please configure the *RF Reference level* manually. The setting for this can be found in the signaling configuration menu.

### 2.5.3 Test Requirements

The maximum output power measured at test points 1, 2 and 3 should not exceed the values specified in TS 36.521-1, Table 6.2.5.5-1 (details in Table 9 of this document).

| | Channel bandwidth / maximum output power | | | | | |
|---|---|---|---|---|---|---|
| | 1.4 MHz | 3.0 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Measured UE output power test point 1 | For carrier frequency f ≤ 3.0GHz: -10 dBm ± 7.7<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: -10 dBm ± 8.0 | | | | | |
| Measured UE output power test point 2 | For carrier frequency f ≤ 3.0GHz: 10 dBm ± 6.7<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: 10 dBm ± 7.0 | | | | | |
| Measured UE output power test point 3 | For carrier frequency f ≤ 3.0GHz: 15 dBm ± 5.7<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: 15 dBm ± 6.0 | | | | | |
| Note: In addition note 2 in Table 6.2.2.3-1 shall apply to the tolerances. | | | | | | |

***Table 9: $P_{CMAX}$ configured UE output power (Source: TS 36.521-1, Table 6.2.5.5-1).***

# 2.6 Minimum Output Power (TS 36.521, 6.3.2)

The purpose of this test is to verify the UE's ability to transmit at a broadband output power below the value specified in the test requirement when the power is set to a minimum value.

## 2.6.1 Test Description

For general test conditions and settings, please refer to paragraph 2.1 in this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.3.2.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.3.2.4.1-1, into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The test verifies the UE's minimum output power using QPSK modulation and full RB allocation.

## 2.6.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

1. Set *# RB* to *100*, *RB Pos./Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC Setup* to *Min. Power* until the UE output power reaches the minimum level.
2. Measure the average UE output power (*–45.70 dBm* in this example).

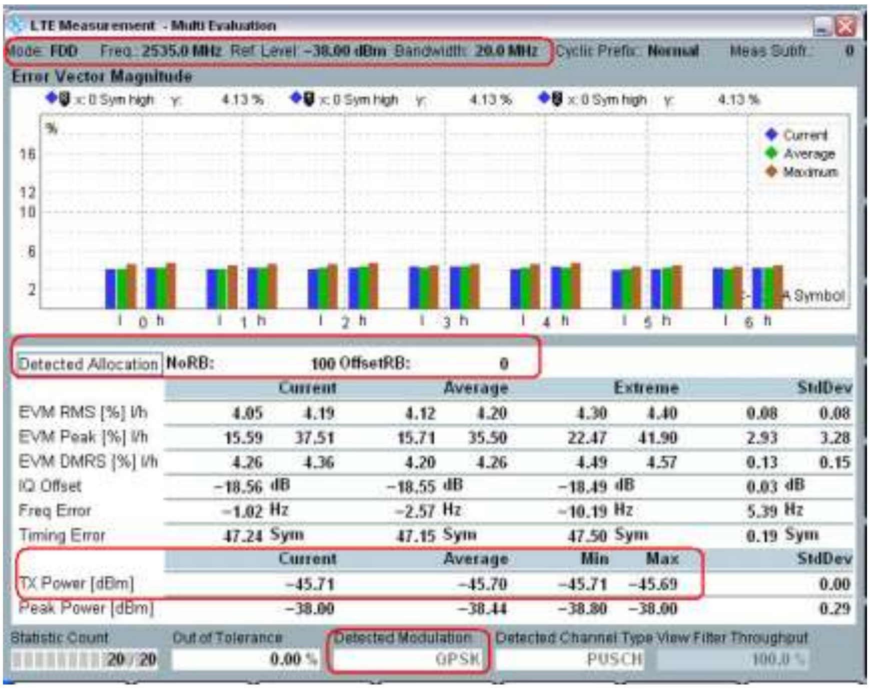



*Fig. 24: Measuring the minimum output power.*

## 2.6.3 Test Requirements

The minimum output power measured shall not exceed the values specified in TS 36.521-1, Table 6.3.2.5-1 (shown here in Table 10).

| | **Channel bandwidth / minimum output power / measurement bandwidth** | | | | | |
|---|---|---|---|---|---|---|
| | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** |
| Minimum output power | For carrier frequency f ≤ 3.0GHz: ≤ -39 dBm<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: ≤ -38.7 dBm | | | | | |
| Measurement bandwidth (Note 1) | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |
| Note 1: Different implementations such as FFT or spectrum analyzer approach are allowed. For spectrum analyzer approach the measurement bandwidth is defined as an equivalent noise bandwidth. | | | | | | |

*Table 10: Minimum output power (source: TS 36.521-1, Table 6.3.2.5-1)*

# 2.7 Transmit OFF Power (TS 36.521, 6.3.3)

The purpose of this test is to verify that the UE's "transmit OFF power" is lower than the value specified in the test requirement. An excessively high transmit OFF power can potentially increase the rise over thermal (RoT) values, thus reducing the cell coverage area for other UEs.

## 2.7.1 Test Description

The main purpose of this test is to evaluate the UE in a "silent state" (meaning that neither PUSCH nor PUCCH are transmitted).
This test procedure is included in Test Case 6.3.4.1 and Test Case 6.3.4.2.

## 2.7.2 Test Requirements

The requirement for the "transmit OFF power" shall not exceed the values specified in TS 36.521-1, Table 6.3.3.5-1 (shown here in Table 11).

| | **Channel bandwidth / Transmit OFF power / measurement bandwidth** | | | | | |
|---|---|---|---|---|---|---|
| | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** |
| Transmit OFF power | For carrier frequency f ≤ 3.0GHz: ≤ -48.5 dBm<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: ≤ -48.2 dBm | | | | | |
| Measurement bandwidth | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |

***Table 11: Requirements for "transmit OFF power" (Source: TS 36.521-1, Table 6.3.3.5-1)***

# 2.8 General ON/OFF Time Mask (TS 36.521-1, 6.3.4.1)

The purpose of this test is to verify that the general ON/OFF time mask meets the requirements given in TS 36.521-1, Clause 6.3.4.1.5. The time mask for transmit ON/OFF defines the ramping time allowed for the UE between the "transmit OFF power" and "transmit ON power."

## 2.8.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.3.4.1.4.1-1.

For Band 7, the test is defined for the 5 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1 and 6.3.4.1.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of the test is to verify the UE's ability to perform fast switches on the transmitter and maintain a certain power level and its ability to quickly switch the transmitter off to keep silence as shown in Figure 6.3.4.1.3-1 (reproduced here in Fig. 25).

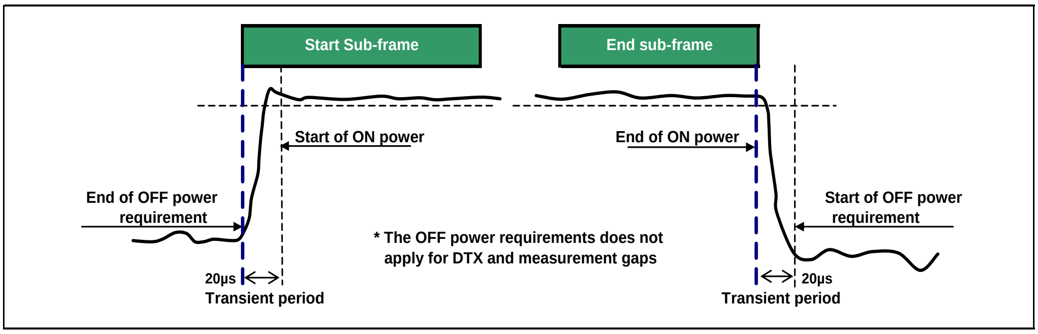



***Fig. 25: General ON/OFF time mask (source: TS 36.521-1, Figure 6.3.4.1.3-1).***

## 2.8.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. This test needs an open-loop power control test setup. The open loop power should be set according to TS 36.521-1, Table 6.3.4.1.5-1.

The most important thing is to create a situation in which the Nth uplink subframe is fully occupied by PUSCH, while the (N–1)th and (N+1)th sub-frames are “OFF,” meaning that the UE should not transmit anything (neither PUCCH nor PUSCH) at the (N–1)th and (N+1)th subframes. According to the HARQ process, if subframe x is used for PDSCH transmission, the UE will transmit ACK/NACK at subframe (x + 4), using either PUSCH or PUCCH if no PUSCH is scheduled. For 3GPP 36.521 V9.3 onward, the ON subframe is “2.” Therefore, Rohde & Schwarz recommends the scheduling configurations described below.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

Prepare the test:

a. Reset *LTE Signaling*.
b. Set the *Scheduling Type* to *User Defined*, *TTI-Based*, and press *Edit All* to configure the settings as shown in Fig. 26 for FDD. After changing the values accordingly, set the *Scheduling Type* back to *RMC mode* for call connection.
c. If Non-Advanced PRACH/OL power settings: Set *PUSCH Open-Loop Nominal Power* to *–3 dBm* (for 20 MHz; for other bandwidths, this value refers to below table based on CMW signalling implementation).

| Bandwidth | *PUSCH Open Loop Nom. Power* (dBm)<br>(LTE Version >=3.0.50) |
|---|---|
| 1.4M | -15 |
| 3 M | -11 |
| 5 M | -9 |
| 10 M | -6 |
| 15 M | -4 |
| 20 M | -3 |

Enable Advanced Settings, based on the default settings, set *PO Nominal PUSCH* to *-105 dBm*.

d. Set *PUSCH Active TPC Setup* to *Constant Power.*

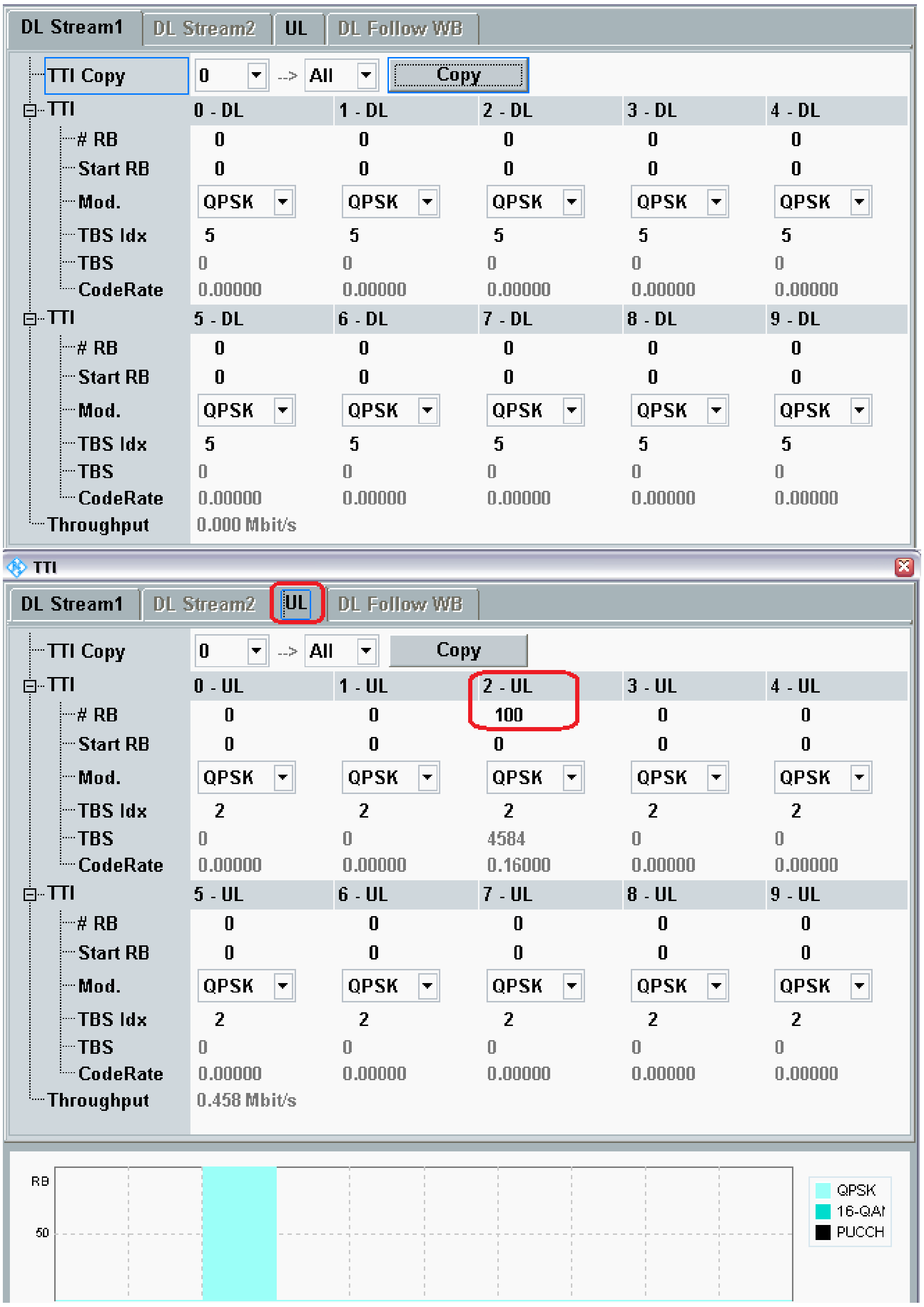



*Fig. 26: DL and UL RB scheduling settings for the general "ON/OFF Time Mask" test – FDD.*

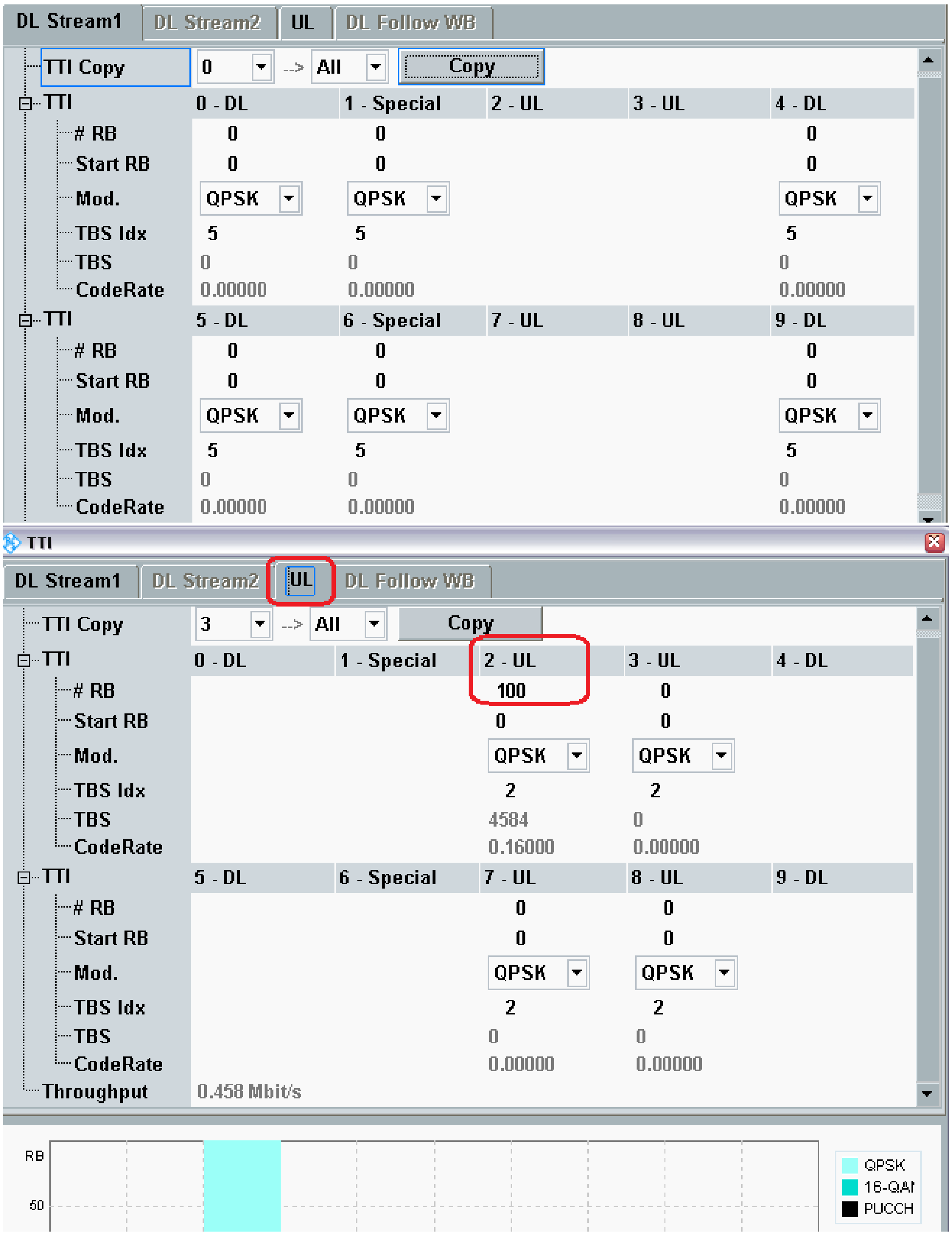



*Fig. 27: DL and UL RB scheduling settings for the general "ON/OFF Time Mask" test – TDD.*

Start the test:

1. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

2. Set *Exp. Nominal Power Mode* to *Manual*, and *Exp. Nominal Power* to *–3 dBm* (i.e. expected open-loop power); the *Margin remains 12 dB*. This setting is recommended for obtaining a more accurate OFF power measurement. The difference between the ON power and OFF power is around 40 dB ~ 50 dB. Both power points need to fall within the R&S®CMW500's dynamic range, which is explained in Section 2.1.2. Therefore, Rohde & Schwarz recommends setting the expected nominal power to be the "UE transmitted ON power."

3. Press *Multi Evaluation* and the *Measurement Subframes*, and set *Measure Subframe* to *2*, as shown in Fig. 28.

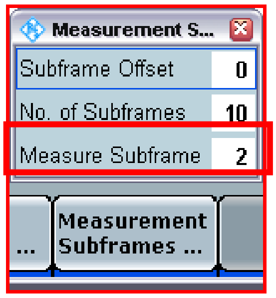



***Fig. 28: Setting the measurement subframe value.***

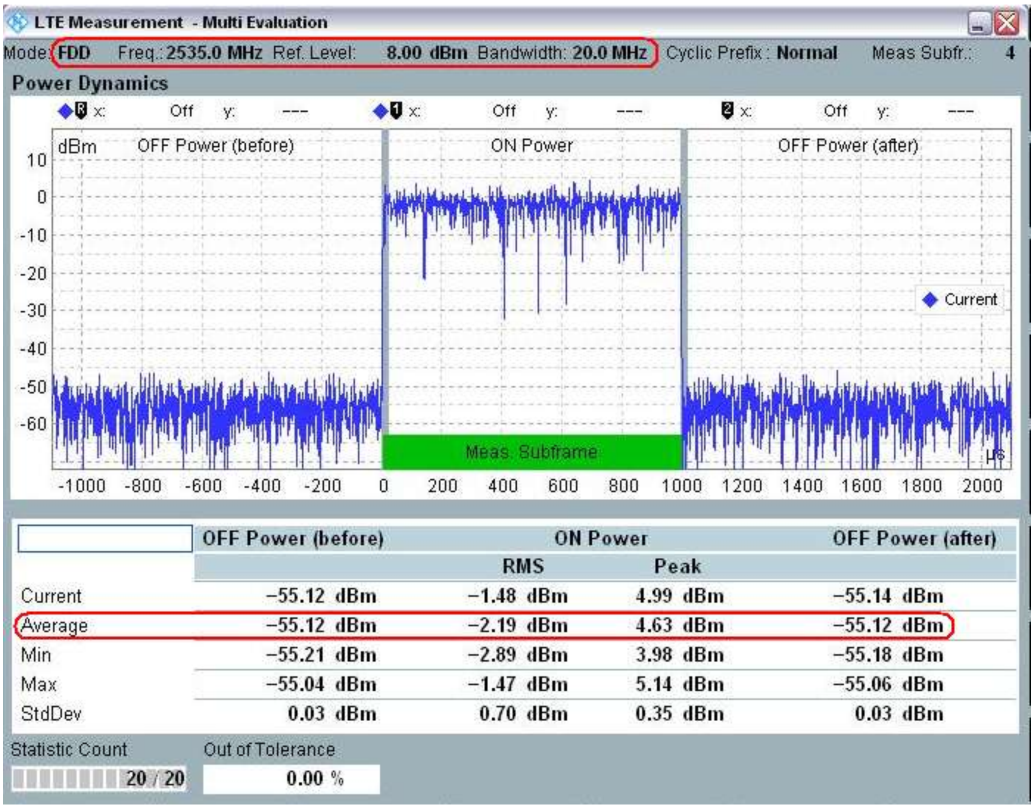



***Fig. 29: Measurement results for the general ON/OFF time mask.***

4. Activate the *Power Dynamics* measurement. This delivers the "OFF Power" result required by TS 36.521-1, Section 6.3.3. The *OFF Power (before)* value in this example is *–55.12 dBm*; *OFF Power (after)* is *–55.12 dBm*. The *ON Power* is *–2.19 dBm*, which is within the limit set forth in the specification (–10.1 dBm ~ 4.9 dBm).

### 2.8.3 Test Requirements

The requirement for the power measured in steps (2), (3) and (4) of the test procedure shall not exceed the values specified in TS 36.521-1, Table 6.3.4.1.5-1.

| | **Channel bandwidth / minimum output power / measurement bandwidth** | | | | | |
|---|---|---|---|---|---|---|
| | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** |
| Transmit OFF power | For carrier frequency f ≤ 3.0GHz: ≤ -48.5 dBm<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: ≤ -48.2 dBm | | | | | |
| Transmission OFF Measurement bandwidth | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |
| Expected Transmission ON Measured power | -14.8 dBm | -10.8 dBm | -8.6 dBm | -5.6 dBm | -3.9 dBm | -2.6 dBm |
| ON power tolerance<br>f ≤ 3.0GHz<br>3.0GHz < f ≤ 4.2GHz | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB |

***Table 12: General ON/OFF time mask (source: TS 36.521-1, Table 6.3.4.1.5-1).***

## 2.9 PRACH and SRS Time Mask (TS 36.521-1, 6.3.4.2)

### 2.9.1 PRACH Time Mask

For general test conditions and settings, please refer to Section 2.1 of this application note.

#### 2.9.1.1 Test Description

The purpose of this test is to verify the UE's ability to transmit the preamble at the output power required by the specification and with the correct ramping time for the UE between "transmit OFF power" and "transmit ON power" when transmitting the preamble.

This test should be performed with all the PRACH Format 0 ~ 3 for frequency division duplex (FDD) and Format 4 for time division duplex (TDD).

The PRACH *Configuration Index* should be *3* for *FDD* and *51* for *TDD*.
The *Power Ramping Step* should be *0 dB*.

If non-Advanced OL Power is set, for FDD, the PUSCH Open Loop Nomial Power should be 8 dB higher than the expected PRACH power, 7 dBm. For TDD, with PRACH *Configuration Index* higher than 48, it should be the same as expected PRACH power, -1 dBm. The difference between FDD and TDD is because when PRACH *Configuration Index 51* is set for *TDD*, according to specification, the expected PRACH power will be 8 dB higher (DELTA_PREAMBLE = 8dB, according to 3GPP TS 36.321 Table 7.6-1) when all the other parameters are the same with PRACH *Configuration Index 3.* Therefore, the *PUSCH Open Loop Nom. Power* should be 8dB lower to achieve the same expected PRACH power.

If *Advanced OL Power* is selected, configure *Preamble Initial Received Target Power* to achieve the target PRACH power, shown as below.

| | *FDD* | *TDD* |
|---|---|---|
| Preamble Initial Received Target Power | -104 | -112 |
| PRACH configIndex | 3 | 51 |

### 2.9.1.2 Test Procedure

The settings for configuring the PRACH signal are found at *LTE Signaling* > *Config* > *Physical Cell Setup* >*PRACH*.

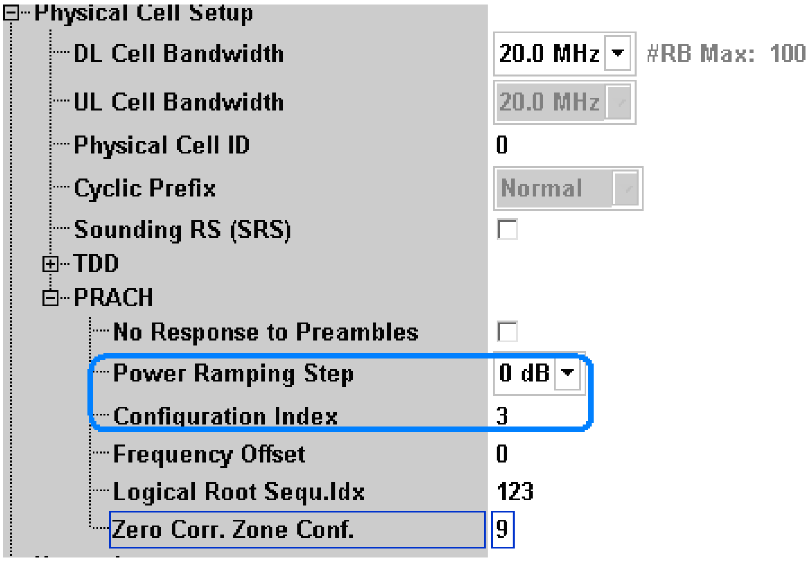



***Fig. 30: PRACH time mask test settings.***

1. Reset *LTE Signaling*.
2. Set the *Power Ramping Step* to *0 dB* and the *Configuration Index* to *3* for FDD or *51* for TDD. Selecting *No Response to Preambles* is optional. If it is selected, the R&S®CMW500 will not respond to the UE's preamble, and the UE should repeat transmission of the preamble without a power change. If it is not selected, only one preamble will be captured for analysis and the statistics should only be set to *1*.
3. Set the open loop power according to the section above.
4. Set the *RS EPRE* to *–85 dBm/15 KHz*.
5. Add the *LTE PRACH Measurement Task* (to include this in the task list, press the "Measure" hardkey) and select the scenario: *Combined Signal Path*, controlled by *LTE Sig1*. The default trigger is *LTE Sig1: PRACH Trigger*.
6. Press the *ON/OFF* button to activate the PRACH measurement.
7. Connect the UE and wait for the *Power Dynamics* measurement to be performed.
8. If *No Response to Preambles* has been selected, the measurement is repeatable. Adjust the reference level to get an accurate *OFF power* measurement as specified according to the *General ON/OFF Time Mask*.

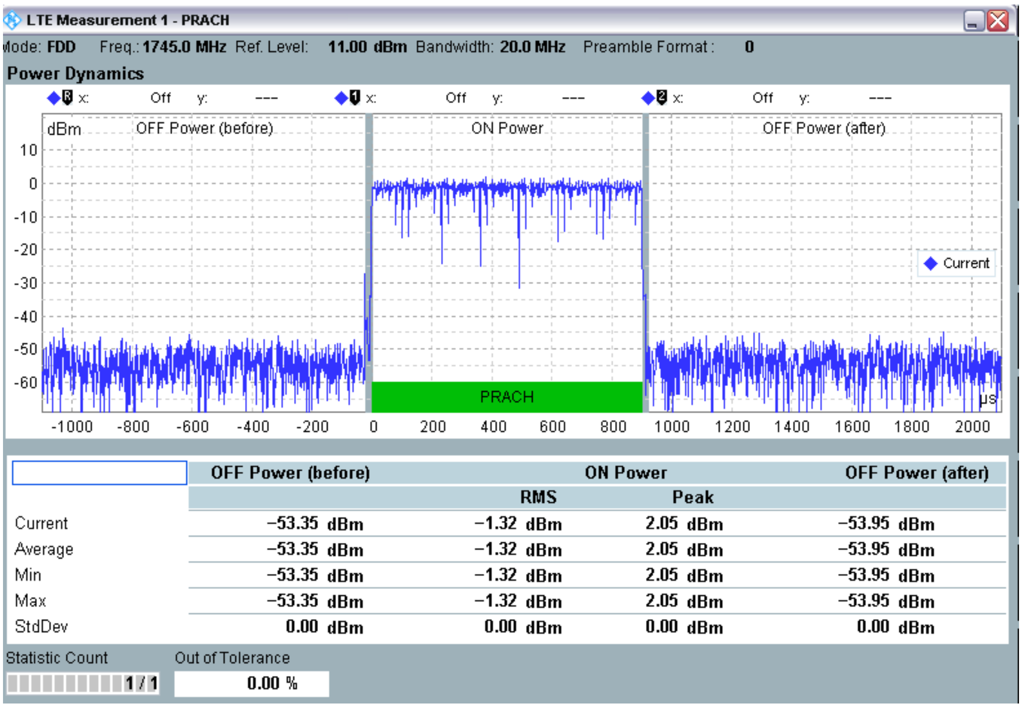



***Fig. 31: PRACH measurement results.***

Remarks:

**1.** The trigger timeout warning can be ignored, because it doesn't impact the measurement results.

**2.** With advanced power settings it might not be possible to establish the call if the open loop PUSCH power is much higher than the PRACH power and the reference power is set close to PRACH power in order to get an accurate OFF power. If the user desires to establish the call during the measurement, it is recommended to adjust the *PO Nominal PUSCH* to bring the open loop PUSCH power close to PRACH power.

### 2.9.1.3 Test Requirements

The test requirement is shown as below table. The default limits setting in CMW500 is according to the specification. If the user wants to test a different PRACH power, the limit setting should be changed at *LTE PRACH Configuration > Config > Limits > Power > Dynamics > ON Power*

| | **Channel bandwidth / Output Power [dBm] / Measurement bandwidth** | | | | | |
|---|---|---|---|---|---|---|
| | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** |
| Transmit OFF power | ≤ –48.5 dBm | | | | | |
| Transmission OFF measurement bandwidth | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |
| Expected PRACH transmission ON measured power | -1 ± 7.5 | -1 ± 7.5 | -1 ± 7.5 | -1 ± 7.5 | -1 ± 7.5 | -1 ± 7.5 |

***Table 13: PRACH time mask (source: TS 36.521-1, Table 6.3.4.2.1.5-1).***

## 2.9.2 SRS Time Mask

For general test conditions and settings, please refer to Section 2.1 of this application note.

### 2.9.2.1 Test Description

The purpose of this test is to verify the UE's ability to transmit the sounding reference symbol (SRS) signaling using the output power according to the specification and with the correct ramping time for the UE between the transmit OFF power and the transmit ON power when transmitting the preamble.

### 2.9.2.2 Test Procedure

SRS can be activated at *LTE Signaling* > *Config* > *Physical Cell Setup*.

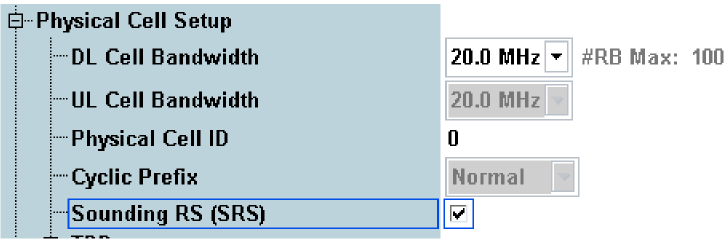



***Fig. 32: Activating SRS signaling.***

1. Reset *LTE Signaling*.
2. Set the proper band, frequency channel and bandwidth and activate *Sounding RS (SRS)* in the *LTE Signaling* settings as shown in Fig. 32.
3. Set *Active TPC Setup* to *Constant Power*.
4. If Non-Advance PRACH/OL Power Settings, *Open loop Nominal Power* should be set according to below table.

| Bandwidth | *Open loop Nominal Power* (dBm)<br>(LTE version >= V3.0.50) |
|---|---|
| 1.4M | 8.5 |
| 3 M | 9 |
| 5 M | 11 |
| 10 M | 14 |
| 15 M | 16 |
| 20 M | 17 |

With Advanced Power Settings, set all the open loop related parameters to default values.

5. Set the *RS EPRE* to *–85 dBm/15 KHz*.
6. Add the LTE SRS measurement task (to include this in the task list, press the "Measure" hardkey) and select the *Combined Signal Path* scenario controlled by *LTE Sig1*. The default trigger is *IF Power*.
7. Turn on the cell and connect the UE to the R&S®CMW500, waiting for it to connect in the default RMC mode.

**8.** Deactivate *Downlink MAC Padding* at *LTE Signaling > Connection*, as shown in Fig. 33. Then set both *DL* and *UL RMC* to *0*.

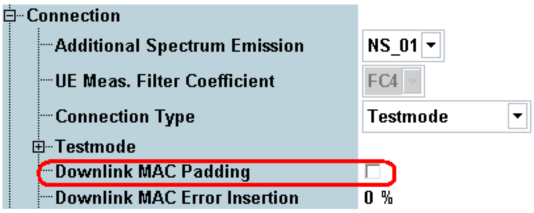
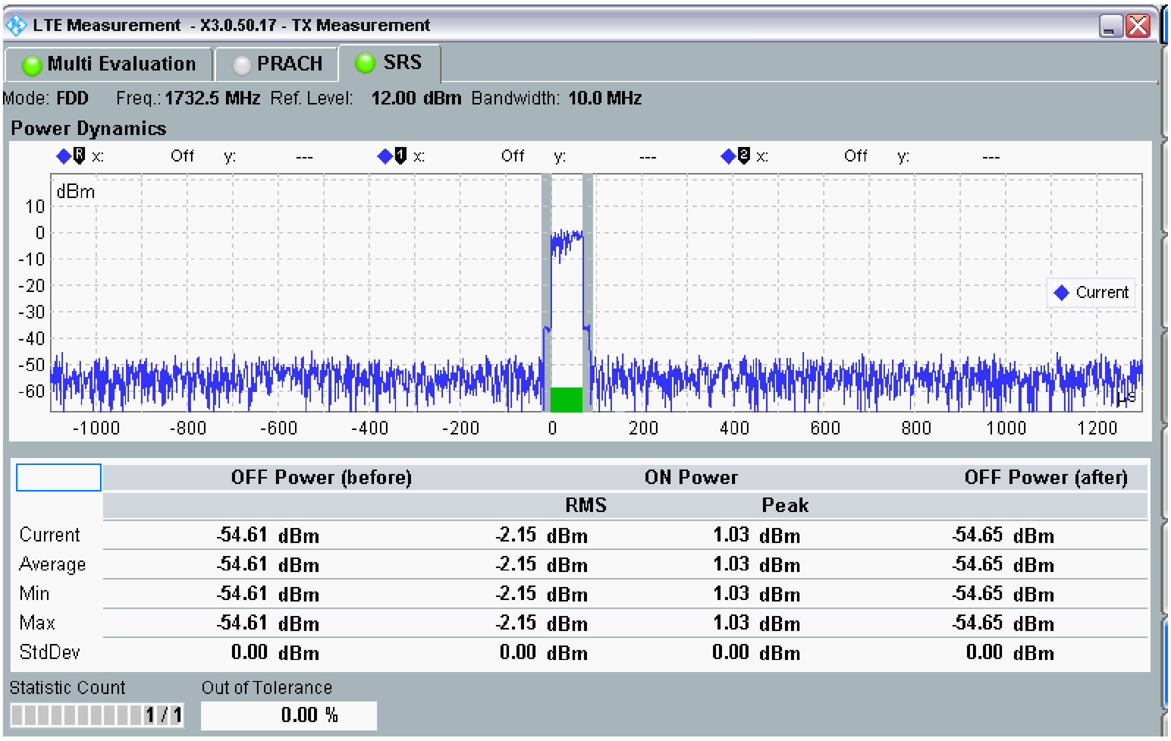



***Fig. 33: Deactivating the downlink MAC padding.***

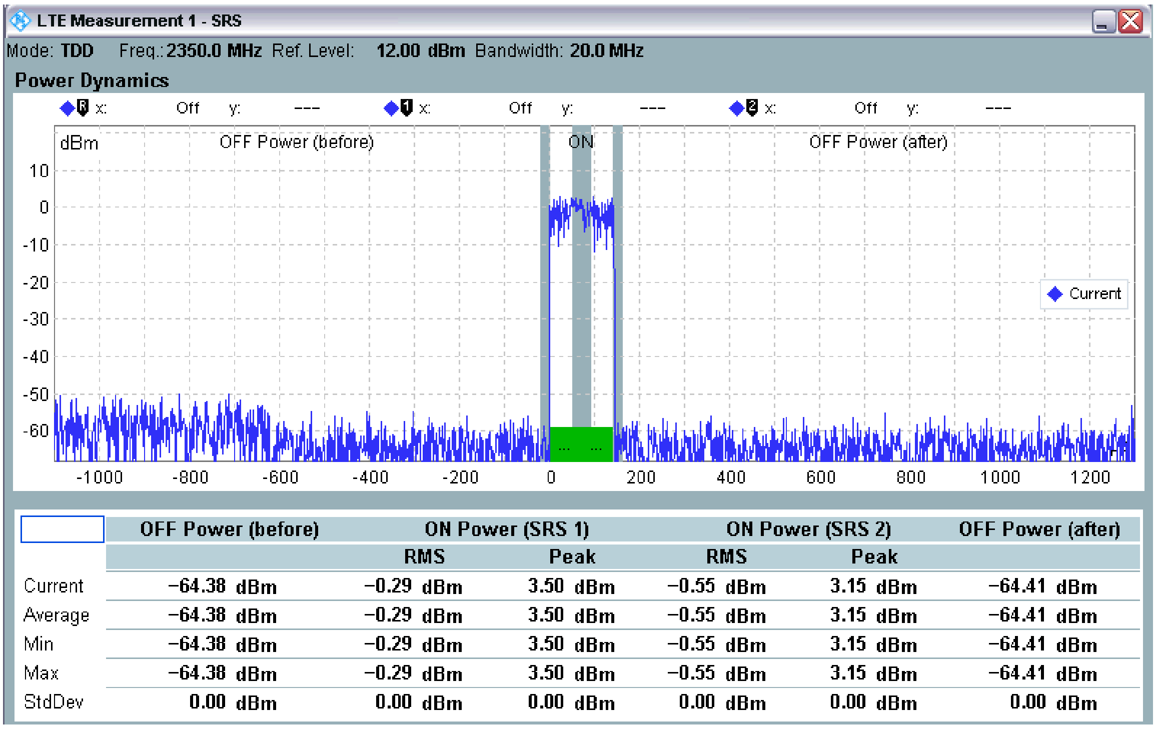
**9.** Press the *ON/OFF* button to activate the SRS measurement.

**10.** Set the *RF Reference Power* to *Manual*. Adjust the *Expected Nominal Power* to get a valid SRS measurement. For the same reason as explained for the general ON/OFF time mask it is recommended to set the *Ref. Level* to *Peak Power + 3 dB*, to guarantee that the “OFF power” measurement is correct.




| | OFF Power (before) | ON Power RMS | ON Power Peak | OFF Power (after) |
|---|---|---|---|---|
| Current | -54.61 dBm | -2.15 dBm | 1.03 dBm | -54.65 dBm |
| Average | -54.61 dBm | -2.15 dBm | 1.03 dBm | -54.65 dBm |
| Min | -54.61 dBm | -2.15 dBm | 1.03 dBm | -54.65 dBm |
| Max | -54.61 dBm | -2.15 dBm | 1.03 dBm | -54.65 dBm |
| StdDev | 0.00 dBm | 0.00 dBm | 0.00 dBm | 0.00 dBm |

*a) SRS Measurement result for FDD*




| | OFF Power (before) | ON Power (SRS 1) RMS | ON Power (SRS 1) Peak | ON Power (SRS 2) RMS | ON Power (SRS 2) Peak | OFF Power (after) |
|---|---|---|---|---|---|---|
| Current | −64.38 dBm | −0.29 dBm | 3.50 dBm | −0.55 dBm | 3.15 dBm | −64.41 dBm |
| Average | −64.38 dBm | −0.29 dBm | 3.50 dBm | −0.55 dBm | 3.15 dBm | −64.41 dBm |
| Min | −64.38 dBm | −0.29 dBm | 3.50 dBm | −0.55 dBm | 3.15 dBm | −64.41 dBm |
| Max | −64.38 dBm | −0.29 dBm | 3.50 dBm | −0.55 dBm | 3.15 dBm | −64.41 dBm |
| StdDev | 0.00 dBm | 0.00 dBm | 0.00 dBm | 0.00 dBm | 0.00 dBm | 0.00 dBm |

*b) SRS Measurement result for TDD*

***Fig. 34: Measurement results for the SRS time mask.***

#### 2.9.2.3 Test Requirements

The SRS power should be in line with the specification.

The test requirements are defined in Table 14.

| | Channel bandwidth / Output Power [dBm] / measurement bandwidth | | | | | |
|---|---|---|---|---|---|---|
| | 1.4 MHz | 3.0 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Transmit OFF power | For carrier frequency f ≤ 3.0GHz: ≤ -48.5 dBm<br>For carrier frequency 3.0GHz < f ≤ 4.2GHz: ≤ -48.2 dBm | | | | | |
| Transmission OFF Measurement bandwidth | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |
| Expected SRS Transmission ON Measured power | -2.6 dBm | -2.6 dBm | -2.6 dBm | -2.6 dBm | -2.6 dBm | -2.6 dBm |
| ON power tolerance<br>f ≤ 3.0GHz<br>3.0GHz < f ≤ 4.2GHz | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB | ± 7.5dB<br>± 7.8dB |

***Table 14: Requirements for the SRS time mask test.***

## 2.10 Power Control – Absolute Power Tolerance (TS 36.521, 6.3.5.1)

The purpose of this test is to verify the UE transmitter's ability to set its initial output power to a specific value at the start of a contiguous transmission or non-contiguous transmission with a long transmission gap.

### 2.10.1 Test Description

For general test conditions and settings, please refer to paragraph 2.1 in this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.3.5.1.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1 and 6.3.5.1.4.1-1 into account. Each bandwidth configuration should only apply to middle-range channels. The purpose of this test is to verify the UE's power control performance using only QPSK modulation and full RB allocation.

In the specification, a set of system information parameters are configured according to TS36.508. The ultimate purpose is to get the initial output power to a specific value.

With Non-Advanced PRACH/OL power setting, this initial output power is configured through the *Open loop Nominal Power*.

| Bandwidth | *Open loop Nominal Power* (dBm) (Test Point 1) | *Open loop Nominal Power* (dBm) (Test Point 2) |
|---|---|---|
| 1.4M | -15 | -3 |
| 3 M | -11 | 1 |
| 5 M | --9 | 3 |
| 10 M | -6 | 6 |
| 15 M | -4 | 8 |
| 20 M | -3 | 9 |

With Advanced PRACH/OLpower settings, *PO Nominal PUSCH* should be changed from the default value.

| Parameters | Test Point 1 | Test Point 2 |
|---|---|---|
| *PO Nominal PUSCH* | -105 dBm | -93 dBm |

## 2.10.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3.

1. Reset *LTE Signaling*.
2. Enable the *LTE* cell. Before powering on the UE, set *Active TPC Setup* to *Constant Power* and *open loop power settings* according to above description for test point 1.

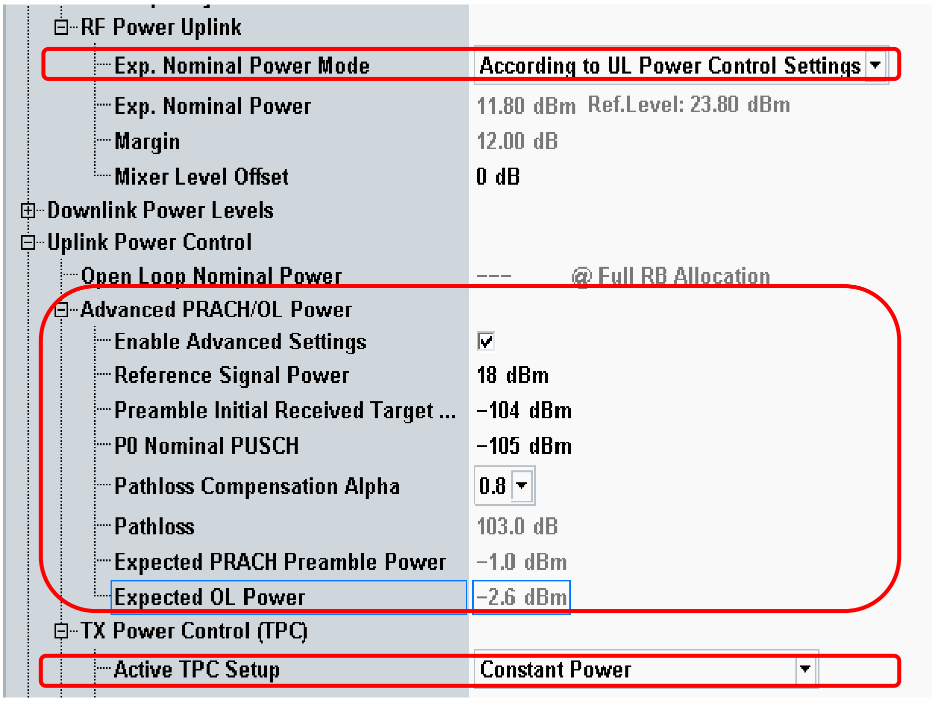



***Fig. 35: Settings for the "Power Control – Absolute Power Tolerance" test.***

3. Deselect *Keep RRC Connection* to enable RRC Idle mode.
4. Power on the UE and wait for the UE to attach to the network. Once the UE has attached to the R&S®CMW500, press *Connect* to establish the connection.
5. Go to the multi-evaluation interface to obtain the measurement result for Test Point 1 (*–5.23 dBm* in the example shown in Fig. 36).

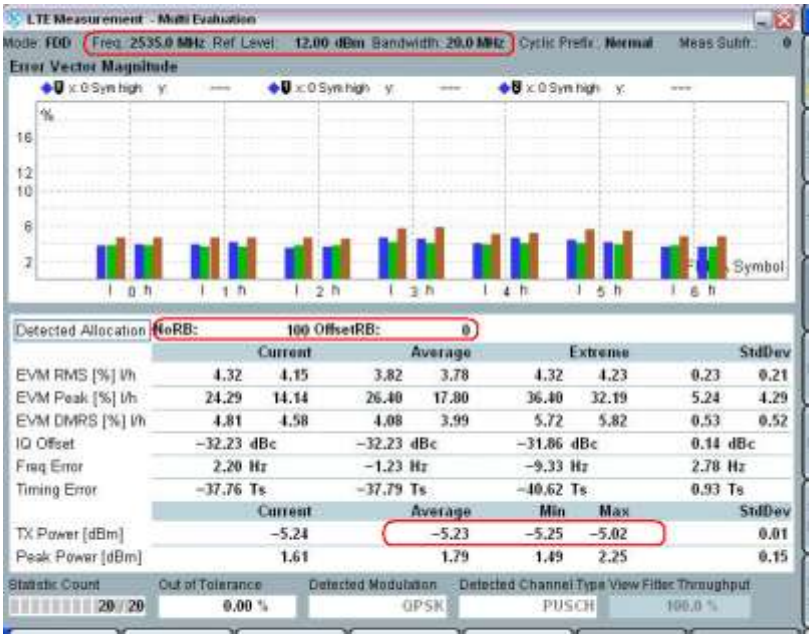



*Fig. 36: Example results for the Test Point 1 measurement.*

6. Press 'Disconnect' from the LTE 1 Signaling. Then change the *open loop power setting* according to test point 2. The other settings remain the same.
7. Press *Connect* to establish the connection again.
8. Go to the multi-evaluation interface and get the Test Point 2 measurement result (*6.07 dBm* in the example shown in Fig. 37).

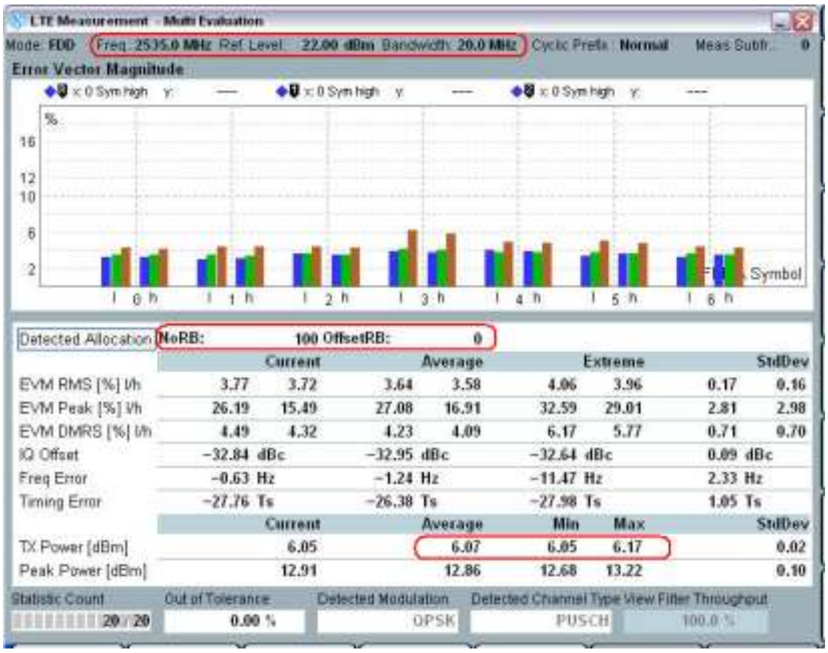



*Fig. 37: Example results for the Test Point 2 measurement.*

## 2.10.3 Test Requirements

The requirement for the power measured in step (2) of the test procedure is that the results must not exceed the values specified in TS 36.521-1, Tables 6.3.5.1.5-1 and 6.3.5.1.5-2.

| | Channel bandwidth / expected output power (dBm) | | | | | |
|---|---|---|---|---|---|---|
| | 1.4 MHz | 3.0 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Expected Measured power Normal conditions | -14.8 dBm | -10.8 dBm | -8.6 dBm | -5.6 dBm | -3.9 dBm | -2.6 dBm |
| Power tolerance f ≤ 3.0GHz 3.0GHz < f ≤ 4.2GHz | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB |
| Expected Measured power Extreme conditions | -14.8 dBm | -10.8 dBm | -8.6 dBm | -5.6 dBm | -3.9 dBm | -2.6 dBm |
| Power tolerance f ≤ 3.0GHz 3.0GHz < f ≤ 4.2GHz | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB |
| Note 1: The lower power limit shall not exceed the minimum output power requirements defined in sub-clause 6.3.2.3 | | | | | | |
| | Channel bandwidth / expected output power (dBm) | | | | | |
| | 1.4 MHz | 3.0 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Expected Measured power Normal conditions | -2.8 dBm | 1.2 dBm | 3.4 dBm | 6.4 dBm | 8.2 dBm | 9.4 dBm |
| Power tolerance f ≤ 3.0GHz 3.0GHz < f ≤ 4.2GHz | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB | ± 10.0dB ± 10.4dB |
| Expected Measured power Extreme conditions | -2.8 dBm | 1.2 dBm | 3.4 dBm | 6.4 dBm | 8.2 dBm | 9.4 dBm |
| Power tolerance f ≤ 3.0GHz 3.0GHz < f ≤ 4.2GHz | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB | ± 13.0dB ± 13.4dB |
| Note 1: The lower power limit shall not exceed the minimum output power requirements defined in sub-clause 6.3.2.3 | | | | | | |

***Table 15: Absolute power tolerance under normal conditions (source: TS 36.521-1, Tables 6.3.5.1.5-1 and 6.3.5.1.5-2).***

## 2.11 Power Control – Relative Power Tolerance (TS 36.521, 6.3.5.2)

The purpose of this test is to verify the UE transmitter's ability to set its output power relative to the power in a target sub-frame, relative to the power of the most recently transmitted reference sub-frame, if the transmission gap between these sub-frames is ≤ 20 ms.

### 2.11.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note.

The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.3.5.2.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.3.2.4.1-1 into account. Each bandwidth configuration should only apply to the middle-range channel. The purpose of this test is to verify the UE's power control performance using only QPSK modulation.

The power changes can be caused by TPC commands and/or RB changes. For this reason, this test case defines three scenarios for verifying the LTE UE's power control performance:

- Ramping up test power patterns (TS 36.521-1, Figure 6.3.5.2.4.2-1)
- Ramping down test power patterns (TS 36.521-1, Figure 6.3.5.2.4.2-2)
- Alternating test power patterns (TS 36.521-1, Figure 6.3.5.2.4.2-5).

Due to the different points in time specified for the RB change, there are three separate test power patterns each for both ramping up and ramping down (Pattern A, Pattern B, Pattern C).

## 2.11.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection. This example will use Band 7, a 20 MHz bandwidth, and a middle-range channel.

Common Configurations for both ramping up and ramping down:

The power control measurement is a one-shot measurement. For this reason, it should not be tested in continuous mode. Therefore, set the *Repetition* to *Single Shot* and *Statistic Count (Power)* to *1 Subframe*. Furthermore, set the *No. of Subframes* to *80(FDD)/100(TDD)* in order to catch all the power steps that are needed.

For TDD, it is recommended to set the *Subframe Offset* to *0*, the *No. of Subframes* to *100*, and the *Measure Subframe* to *2*.

Here, Rohde & Schwarz recommends disabling all other measurement windows and leaving only the power monitor window enabled.

TPC trigger must be used throughout the measurement. Set the trigger to *LTE Sig1:TPC trigger*

Since CMW LTE firmware 3.2.50, one button solution is supported for ramping up and ramping down.

After the phone is connected at RMC mode, at LTEMeasurement page, select Signaling Parameters > TPC, shown as in below Figure.

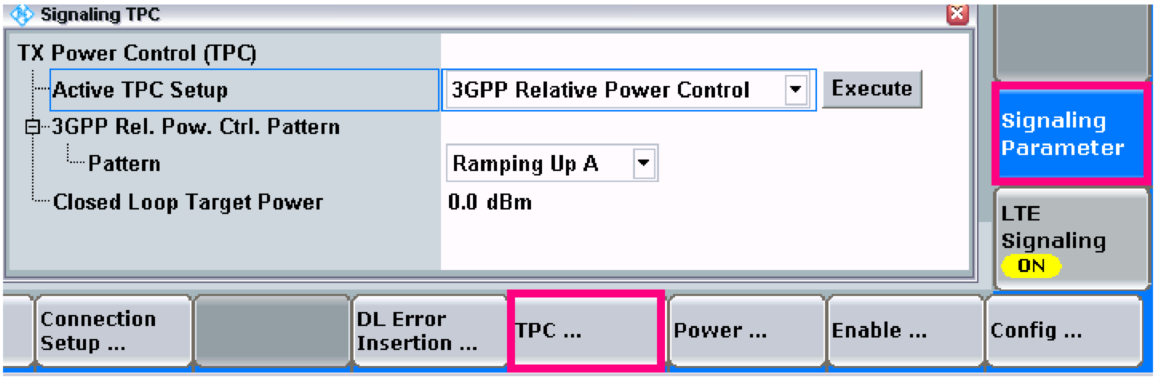



***Fig. 38 Choose 3GPP relatevie power control test pattern***

***Test Procedures for ramping up and ramping down:***

1. Reset *LTE Signaling*. Enable LTE Cell. Set the measurement statistics, repetition, views, trigger, measurement subfames according to the common configuration.
2. Power on the mobile and wait for it to be connected.
3. Select *Active TPC Setup* to be '*3GPP Relative Power Control*' and *Pattern* to be tested.
4. Press the *ON/OFF* button to initialize the measurement. It will wait for the TPC trigger. Then press *Execute* to get the measurement trace shown in Fig. 39.

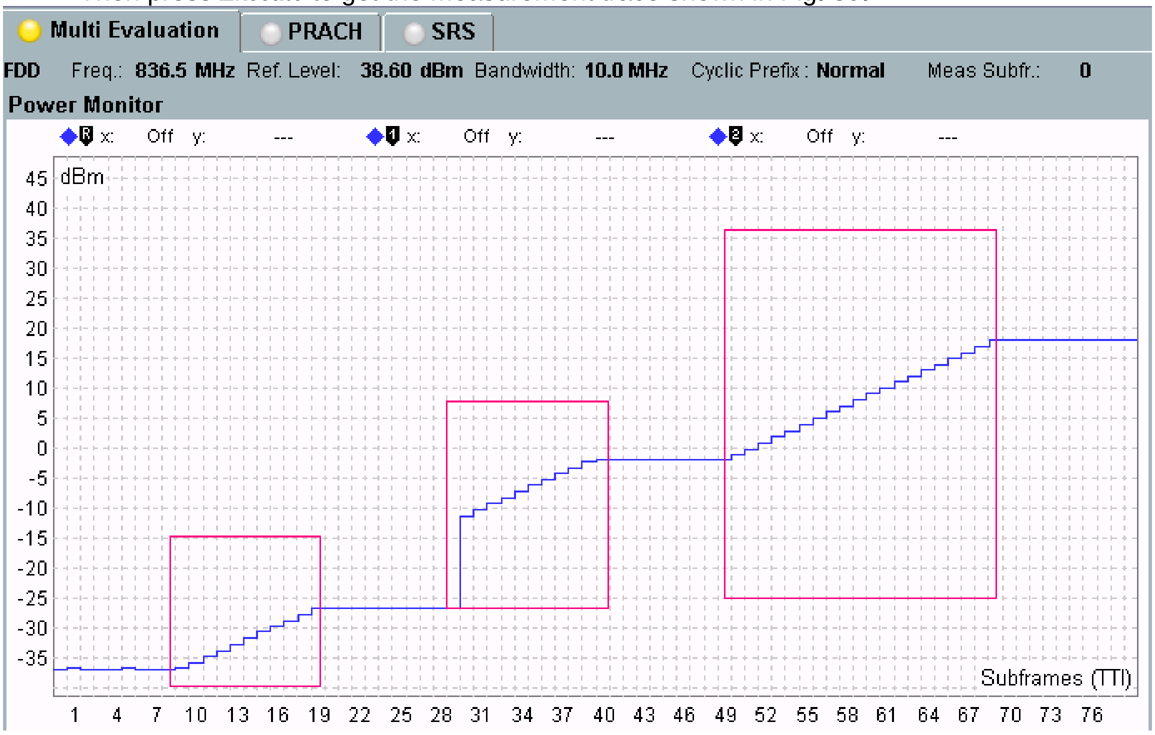



***Fig. 39. FDD Relative Power Control Test Measurement Result: Ramping Up Pattern A.***

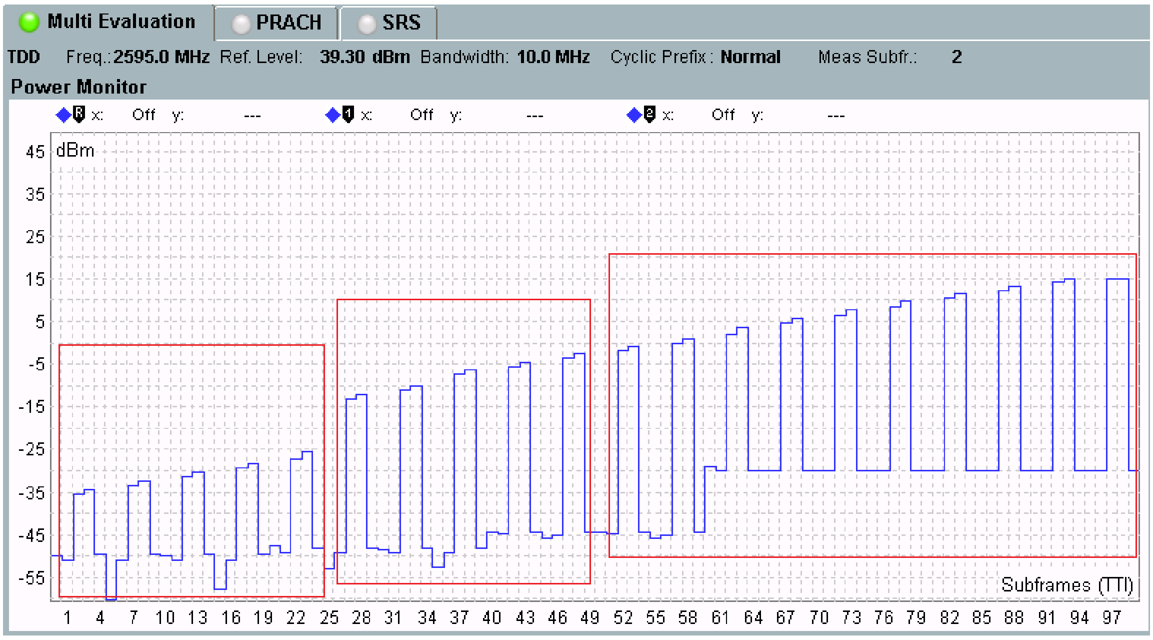



***Fig. 40 TDD Relative Power Control Test Measurement Result: Ramping Up Pattern A.***

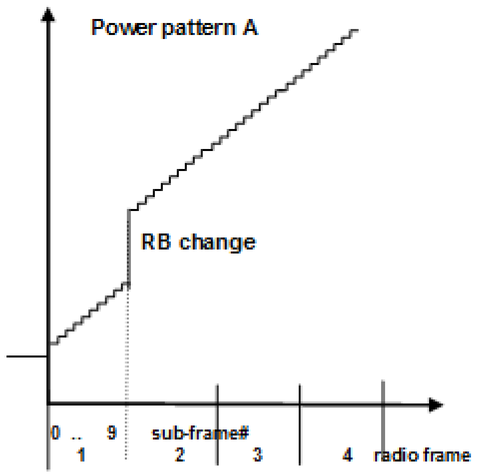



*Fig. 41 Relative Power Control Test according to 3GPP: Ramping Up Pattern A*

The 3GPP specification allows to interrupt the power ramping. The interruptions must be whole numbers of radio frames without power change (0 dB commands). The R&S CMW inserts such interruptions in order to reconfigure the input path according to the changing expected nominal power, therefore, Fig. 39 would be observed.

The detail explanation of Fig. 39 is
● Frame 1: constant initial target power
● Frame 2: ramping up
● Frame 3: constant power for input path configuration
● End of frame 3: change of RB allocation
● Frame 4: ramping up
● Frame 5: constant power for input path configuration
● Frame 6 and 7: ramping up
● Frame 8: constant power

The detail explanation of Fig. 40 is
● Frame 1and 2: ramping up
● Frame 3: ramping up change of RB allocation
● Frame 4 - 10: ramping up

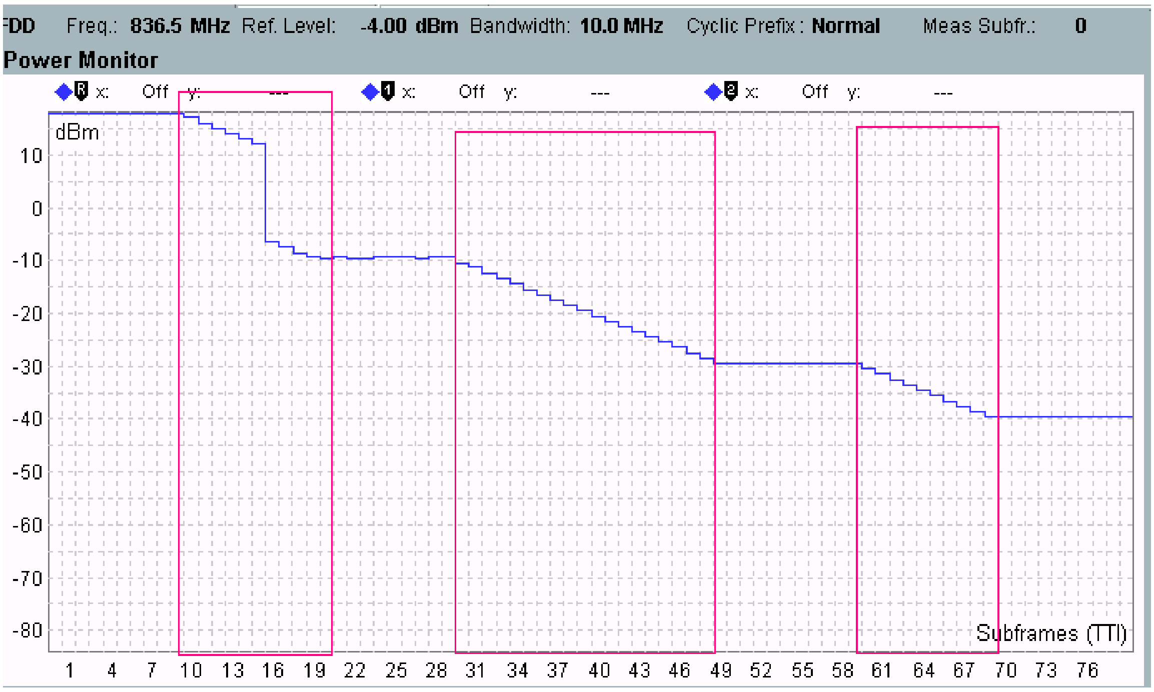



*Fig. 42. FDD Relative Power Control Test Measurement Result: Ramping Down Pattern A.*

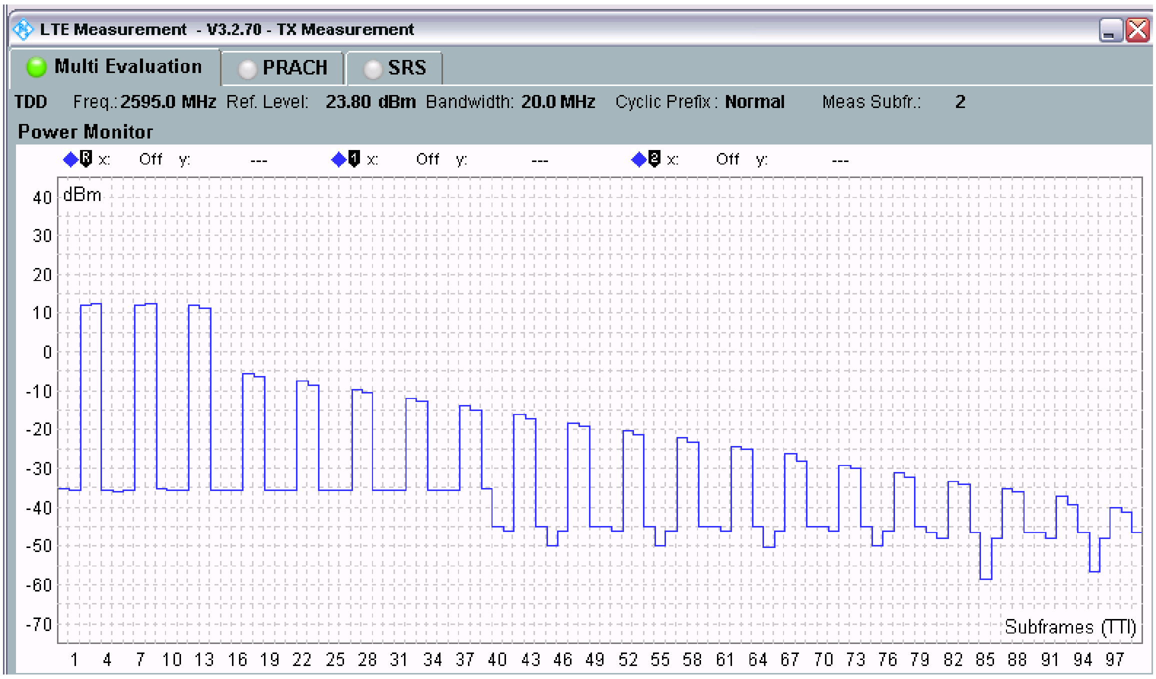



*Fig. 43 TDD Relative Power Control Test Measurement Result: Ramping Down Pattern A.*

The detail explanation of Fig. 42 is

- Frame 1: constant initial target power
- Frame 2: ramping down including change of RB allocation @ subframe 6
- Frame 3: constant power for input path configuration
- Frame 4 and 5: ramping down
- Frame 6: constant power for input path configuration
- Frame 7: ramping down
- Frame 8: constant power

***Test procedure for the alternating pattern:***

1. Set the TPC trigger to *LTE Sig1:Frame trigger*, and set the uplink *RMC* as follows: *#RB* = *1*, *Modulation* = *QPSK,* the *Active TPC Setup* = *Closed Loop,* and *Closed-Loop Target Power* = *–10 dBm* so that the measurement powers are in the range from –10 dBm +/– 3.2 dB.
2. Set the *Active TPC Pattern* to *Constant Power.*
3. From the connection menu, change the *Scheduling Type* from *RMC* to *User Defined*, *TTI Based*. Then press *Edit All* to configure the *UL > TTI* settings as shown in Fig. 44.

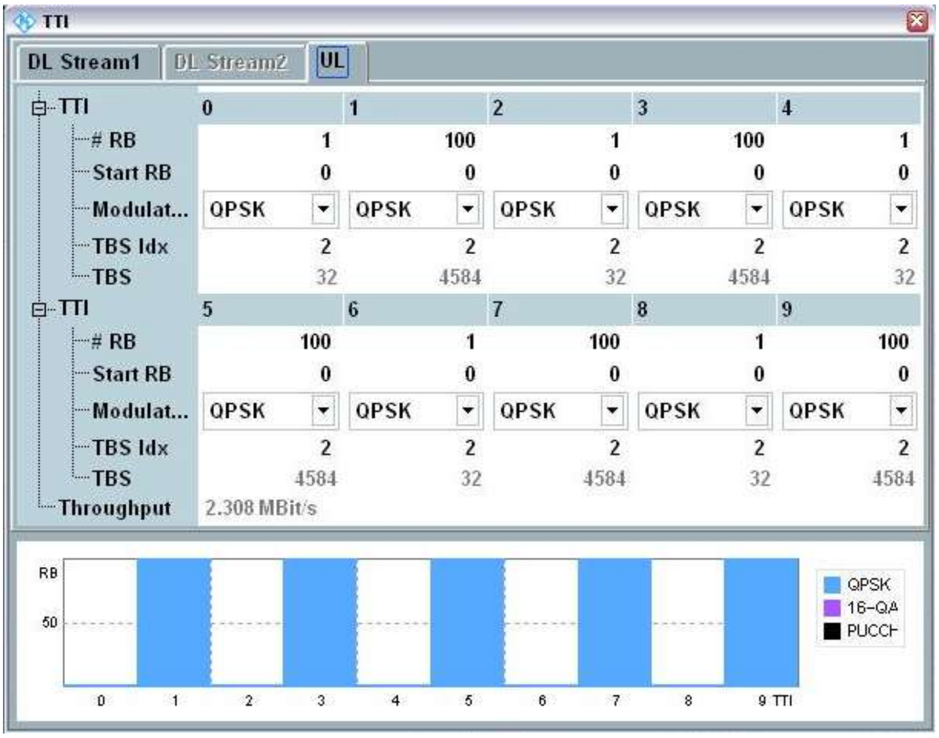



***Fig. 44: Configuring the UL TTI settings for the alternating test pattern.***

4. Set the *No. of Subframes* to *> 10* in order to catch all 10 power steps in one shot. It would be possible to use markers to get all 1 RB and 100 RB power levels, or to just use a simple SCPI command to get all the results. The example in Fig. 45 shows a measurement with 40 subframes.

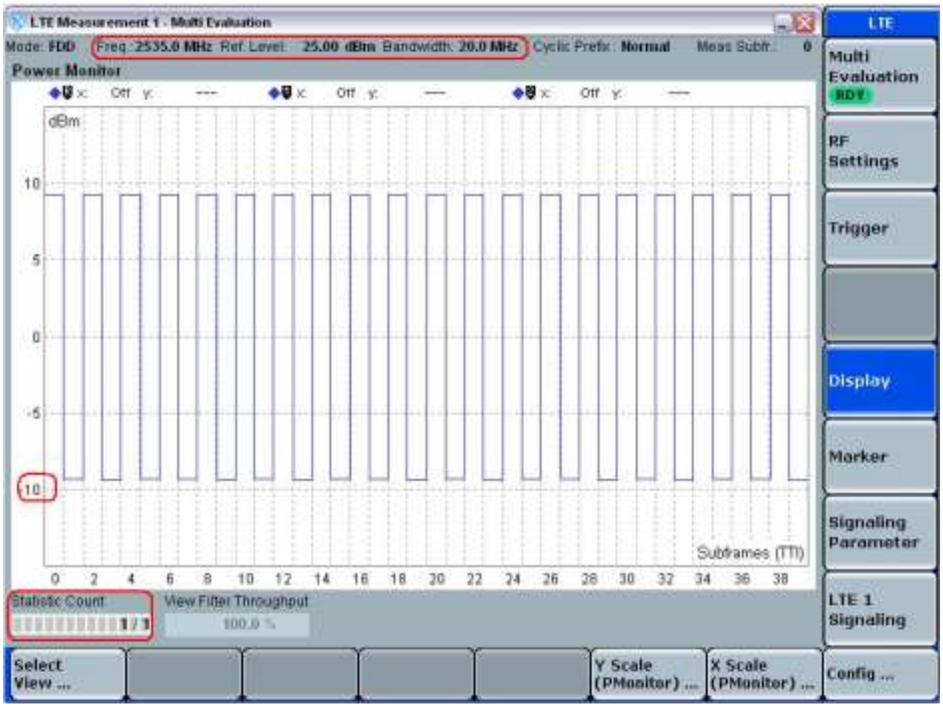



*Fig. 45: Measurement with 40 subframes.*

### 2.11.3 Test Requirements

The test requirements are defined in TS 36.521-1, Tables 6.3.5.2.5-1 through 6.3.5.2.5-13. This includes different bandwidth configuration requirements and different scenario requirements.

For example, when testing an LTE UE that supports Band 7, TS 36.521-1, Tables 6.3.5.2.5-5, 6.3.5.2.5-6 and 6.3.5.2.5-13 define the requirements for a 5 MHz bandwidth configuration, and TS 36.521-1, Tables 6.3.5.2.5-11, 6.3.5.2.5-12 and 6.3.5.2.5-13 define the requirements for a 20 MHz bandwidth configuration.

According to 3GPP 36.521, 2 exceptions are allowed for each of the ramping up and ramping down test patterns. For these exceptions, the power tolerance limit is a maximum of ±6.7 dB. If an exception arises in the power step due to the RB change for any of the test patterns (A, B, C), the UE has failed.

# 2.12 Aggregate Power Control Tolerance (TS 36.521-1, 6.3.5.3)

The purpose of this test is to verify the UE's ability to maintain its power level during a non-contiguous transmission within 21 ms in response to 0 dB TPC commands with respect to the first UE transmission, when the power control parameters specified in TS 36.213 are constant.

## 2.12.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note.

The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Tables 6.3.5.3.4.1-1 and 6.3.5.3.4.1-2.

TS 36.521-1, Table 6.3.5.3.4.1-1 mainly defines the downlink RMC settings and PUCCH format setting for different bandwidth configurations, and Table 6.3.5.3.4.1-2 mainly defines uplink RMC settings for different bandwidths.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1, 6.3.5.3.4.1-1 and 6.3.5.3.4.1-2 into account. Each bandwidth configuration should only apply to middle-range channels. The purpose of this test is to verify the ability of PUSCH and PUCCH to keep the output power constant when TPC=0 is executed.

The procedure is separated into two subtests to verify the PUCCH and PUSCH aggregate power control tolerances respectively. The uplink transmission patterns are described in TS 36.521, Fig. 6.3.5.3.4.2-1. This section will concentrate exclusively on FDD test patterns.

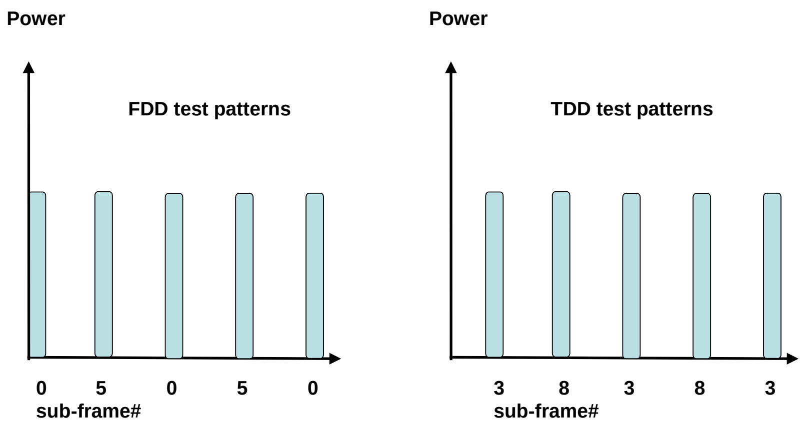



*Fig. 46: Number of subframes for FDD and TDD test patterns.*

## 2.12.2 Test Procedure

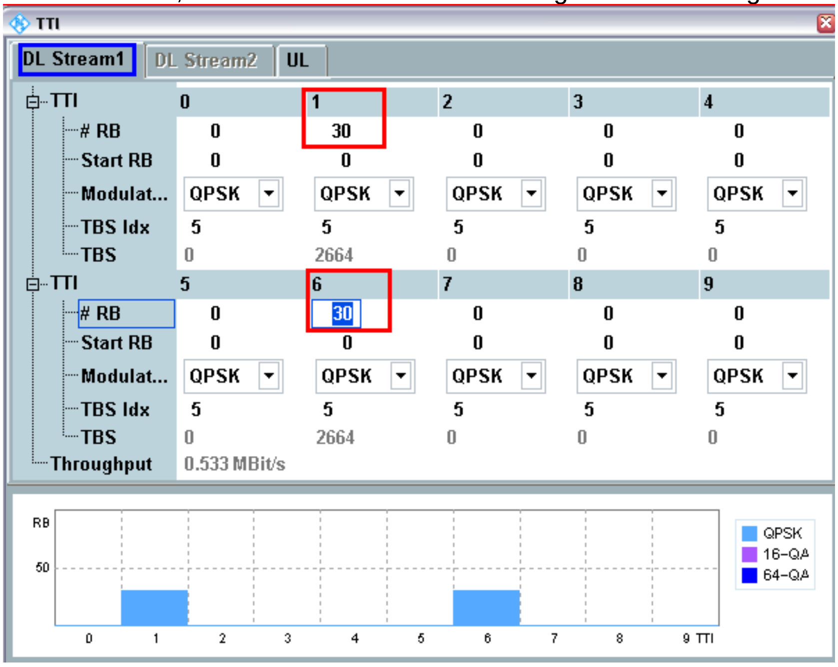
Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure, A3.

Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

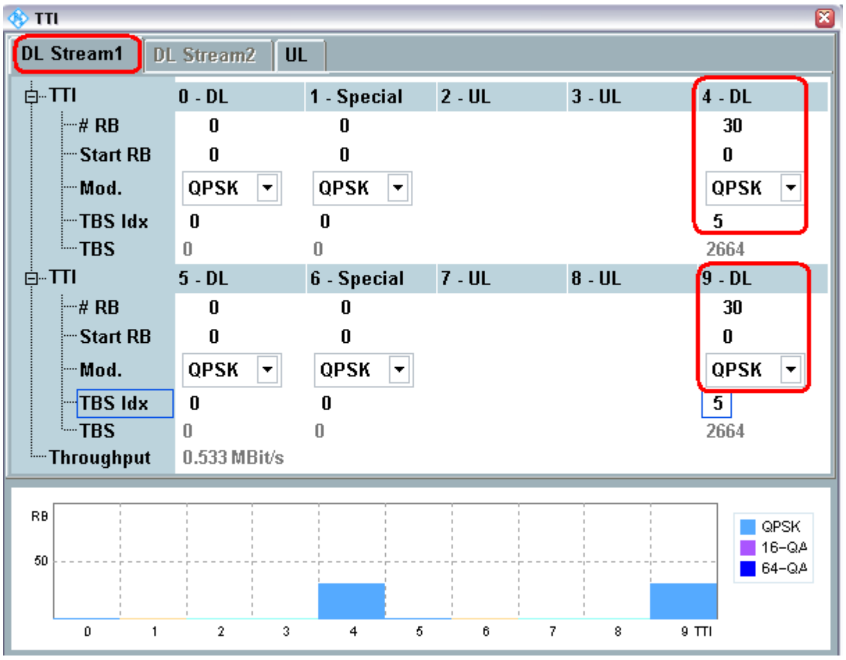
We will use Band 7, a middle-range channel, and 20 MHz as the example for this demonstration.

PUCCH subtest:

1. Set the RF Reference power to be around 15 dBm.
2. Set the Downlink *#RB* to *30*; the *PUCCH Format* will be *Format 1a*.
3. Set the *Active TPC Setup* to *Closed Loop*, and the *Closed-Loop Target Power* to *0 dBm* so that the measurement powers are in the range of 0 dBm +/– 3.2 dB.
4. Set the *Scheduling Type* to *User Defined, TTI Based*. Set the number of uplink *RBs* to *0* for all subframes, and set the downlink scheduling as shown in Fig. 47.




*a) Downlink scheduling setting for FDD*




*b) Downlink scheduling setting for TDD*

***Fig. 47: Downlink scheduling settings for the PUCCH subtest***

5. Go to the Power Monitor view, and set the *Multi Evaluation > Measurement Subframes > No. of Subframes* to *> 21*. For TDD, the *Measure Subframe* value should be *3* and the *No. of Subframes* should be greater than 25. You will be able to observe the pattern shown in the specification (see Fig. 46). In this measurement example, a total of 25 subframes are displayed; in between five of the subframes, there is a 4 ms gap. As a result, there is a total of five non-contiguous PUCCH transmissions. The gap only shows the OFF power; no PUSCH is transmitted.

PUSCH subtest:

6. Set the uplink RMC's *# RB* to *18*, and the *Modulation* to *QPSK*.
7. Set the *Active TPC Setup* to *Closed Loop*, and the *Closed-Loop Target Power* to *0 dBm* so that the measurement powers are in the range of 0 dBm +/– 3.2 dB. Then set the *Active TPC Setup* to *Constant*.

8. Set the *Scheduling Type* to *User Defined, TTI Based*. Set the number of downlink *RBs* to *0* for all subframes, and set the *Uplink Scheduling* as shown in Fig. 48: Settings for the PUSCH subtest.Fig. 48


a) Uplink scheduling setting for FDD


b) *Uplink scheduling setting for TDD*

***Fig. 48: Settings for the PUSCH subtest.***

9. Go to the Power Monitor view, and repeat Step 4. You will be able to observe 5 PUSCH transmissions with gaps of 4 ms in between them.

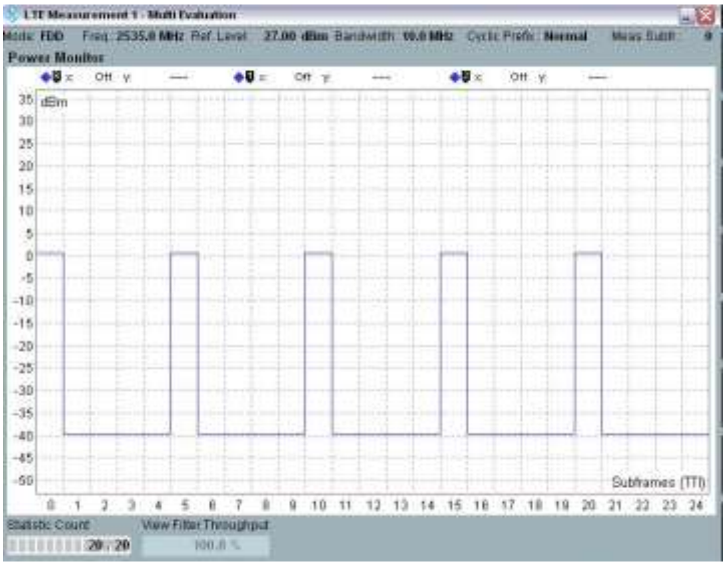



***Fig. 49: Power monitor view.***

10. Use the *Marker* function to obtain the results for the five active PUSCH transmissions. These five measurement results are the data points required for the test.

### 2.12.3 Test Requirements

The requirements for the power measurements performed in steps 1.3 and 2.3 of the test procedure shall not exceed the values specified in TS 36.521-1, Table 6.3.5.3.5-1. The power measurement period shall be 1 subframe, excluding transient periods.

| TPC command | UL channel | Test requirement for measured power |
|---|---|---|
| 0 dB | PUCCH | Given 5 power measurements in the pattern, The 2nd, 3rd, 4th, and 5th measurements shall be within ± 3.2 dB of the 1st measurement. |
| 0 dB | PUSCH | Given 5 power measurements in the pattern, The 2nd, 3rd, 4th, and 5th measurements shall be within ± 4.2 dB of the 1st measurement. |
| Note 1: The UE transmission gap is 4 ms. TPC command is transmitted via PDCCH 4 subframes preceding each PUCCH/PUSCH transmission. | | |

***Table 16: Power control tolerance (source: TS 36.521-1, Table 6.3.5.3.5-1)***

## 2.13 Frequency Error (TS 36.521, 6.5.1)

The purpose of this test is to verify the ability of both the receiver and the transmitter to process frequencies correctly.

The receiver is to extract the correct frequency from the stimulus signal, which the system simulator supplies under ideal propagation conditions and at a low level.
The transmitter is to derive the correct modulated carrier frequency from the results gained by the receiver.

### 2.13.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are in TS 36.521, Table 6.5.1.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.5.1.4.1-1 into account.
Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of this test is to verify the quality of the transmit signal using QPSK modulation and full RB allocation.

### 2.13.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the network. Then press *Connect* to setup the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

1. Set *# RB* to *100*, *RB Pos./Start RB* to *Low*, and *Modulation* to *QPSK*; set *Active TPC setup* to *Max Power* until the UE output power reaches PUMAX.
2. Measure the frequency error (*–2.20 Hz* in this example).

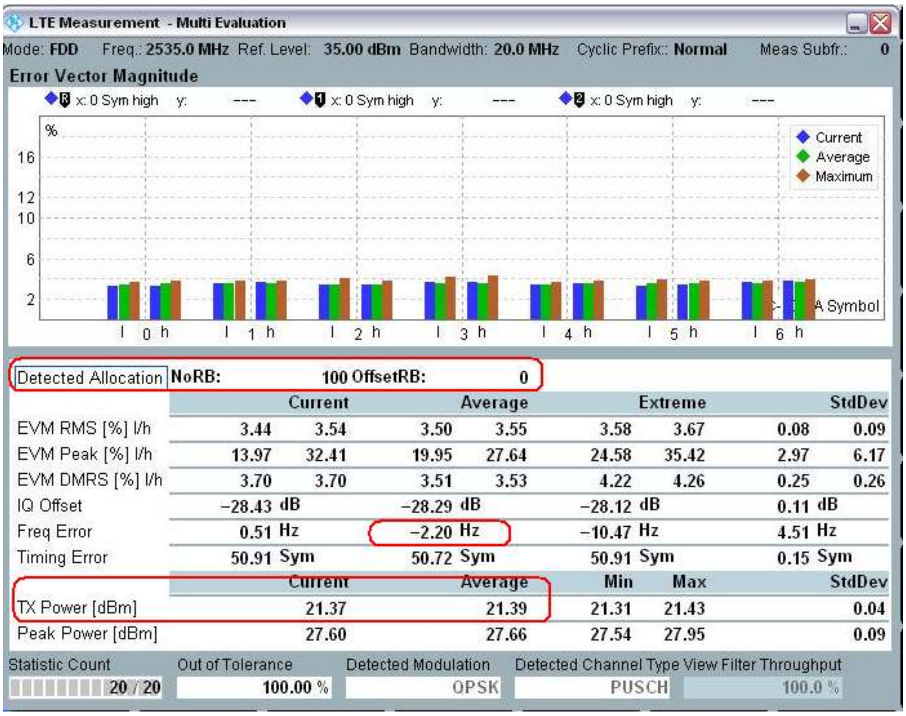



***Fig. 50: Measurement results for the frequency error.***

### 2.13.3 Test Requirements

The 20 frequency error Δf results must fulfill this test requirement:
$|\Delta f| \leq (0.1\ \text{PPM} + 15\ \text{Hz})$
Consequently, for Band 7 in the low range, |Δf| should not exceed the level of 265 Hz, averaged over 20 measurement results.

## 2.14 Error Vector Magnitude (TS 36.521-1, 6.5.2.1)

The error vector magnitude (EVM) is a measure of the difference between the reference waveform and the measured waveform. This difference is called the error vector. Before calculating the EVM, the measured waveform is corrected by the sample timing offset and the RF frequency offset. Then the IQ origin offset is removed from the measured waveform before calculating the EVM.

### 2.14.1 Test Description

This test case contains the measurement requirements for PUSCH, PUCCH and PRACH EVM measurements.

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521 in the tables listed in Table 17 of this document.

| Test configuration table type | Detailed configuration table in TS 36.521 |
|---|---|
| PUSCH | Table 6.5.2.1.4.1-1 |
| PUCCH | Table 6.5.2.1.4.1-2 |
| PRACH | Table 6.5.2.1.4.1-3 |

***Table 17: Where to find details for EVM configurations.***

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.5.1.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels.

The purpose of the test is to verify the quality of the PUSCH signal for both QPSK and 16QAM as well as for partial and full RB allocation. This test will also verify the quality of the PUCCH signal and the PRACH signal.

### 2.14.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.
At the *Measurement Control* in the *LTE Multi-Evaluation Configuration* page, set the *Channel Type* to *Auto*, as shown in Fig. 7.

#### 2.14.2.1 PUSCH EVM:

For TDD-LTE PUSCH EVM testing, slot 3 should be used with the EVM Exclusion Periods Lagging set to be 5µs. This setting can be found at *LTE Multi Evaluation Configuration* > *Modulation*, which is shown as in Fig. 56: Setting the exclusion periods.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.
The # RB, the RB position and output power should be set according to TS 36.521-1, Table 6.5.2.1.4.1-1. Table 18 lists these configurations for a 20 MHz channel bandwidth. This example uses Test Set 2 and Test Set 16.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | **18** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 2 | **18** | **High** | **QPSK** | $P_{UMAX}$ |
| Test Set 3 | **18** | **Low** | **QPSK** | –36.8±3.2dBm |
| Test Set 4 | **18** | **High** | **QPSK** | –36.8±3.2dBm |
| Test Set 5 | **18** | **Low** | **16QAM** | $P_{UMAX}$ |
| Test Set 6 | **18** | **High** | **16QAM** | $P_{UMAX}$ |
| Test Set 7 | **18** | **Low** | **16QAM** | –36.8±3.2dBm |
| Test Set 8 | **18** | **High** | **16QAM** | –36.8±3.2dBm |
| Test Set 9 | **100** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 10 | **100** | **Low** | **QPSK** | –36.8±3.2dBm |
| Test Set 11 | **100** | **Low** | **16QAM** | $P_{UMAX}$ |
| Test Set 12 | **100** | **Low** | **16QAM** | –36.8±3.2dBm |

***Table 18: Test setup for PUSCH EVM measurement (low, middle, and high range).***

Test Set 2:

1. Set the trigger to *LTE Sig1:Frame trigger*, and set the uplink *RMC* as follows: *# RB = 18*, *RB Pos/Start RB = High*, *Modulation = QPSK*, *Active TPC Setup = Max. Power* until the UE output power reaches PUMAX.

2. In the EVM measurement result screen, read the results for:

   EVM l/h = 3.05 % / 3.16 % , $\overline{EVM}_{DMRS}$ l/h = 3.04 % / 3.17 %

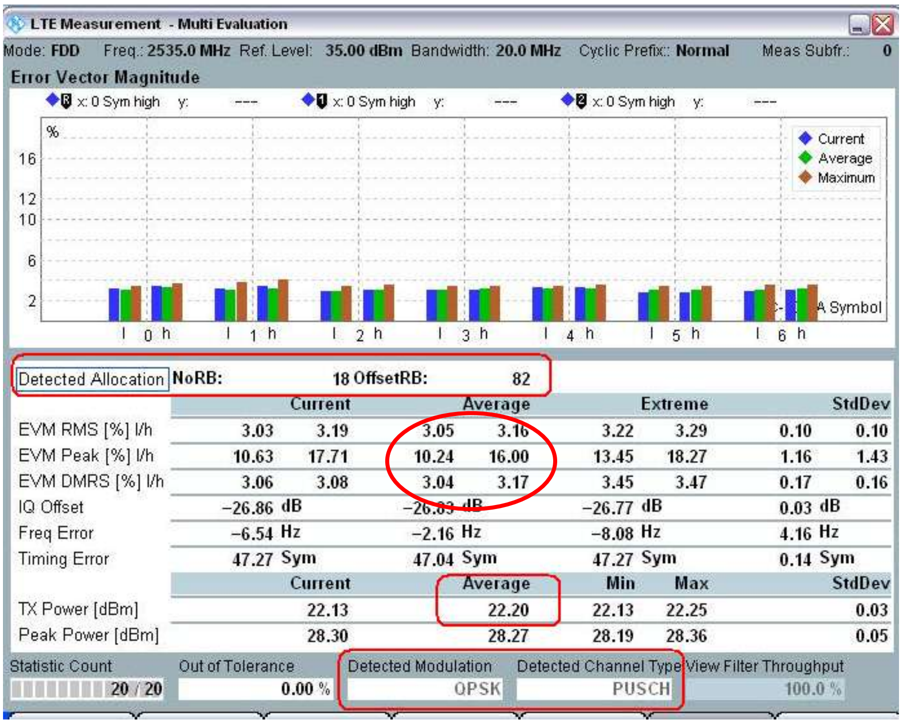



***Fig. 51: EVM measurement screen with results for Test Set 2.***

Test Set 16:

3. Set the uplink RMC as follows: *# RB* = *100*, *RB Pos/Start RB* = *Low*, *Modulation* = *16QAM*, *Uplink TPC Pattern* = *Closed Loop*; set *Closed-Loop Target Power* to *–37 dBm* to ensure an uplink power in the range of –40 dBm to –33.6 dBm.

4. In the EVM measurement result screen, read the results for:

   EVM l/h = 2.73 % / 2.79 %, $\overline{EVM}_{DMRS}$ l/h = 2.88 % / 2.95 %.

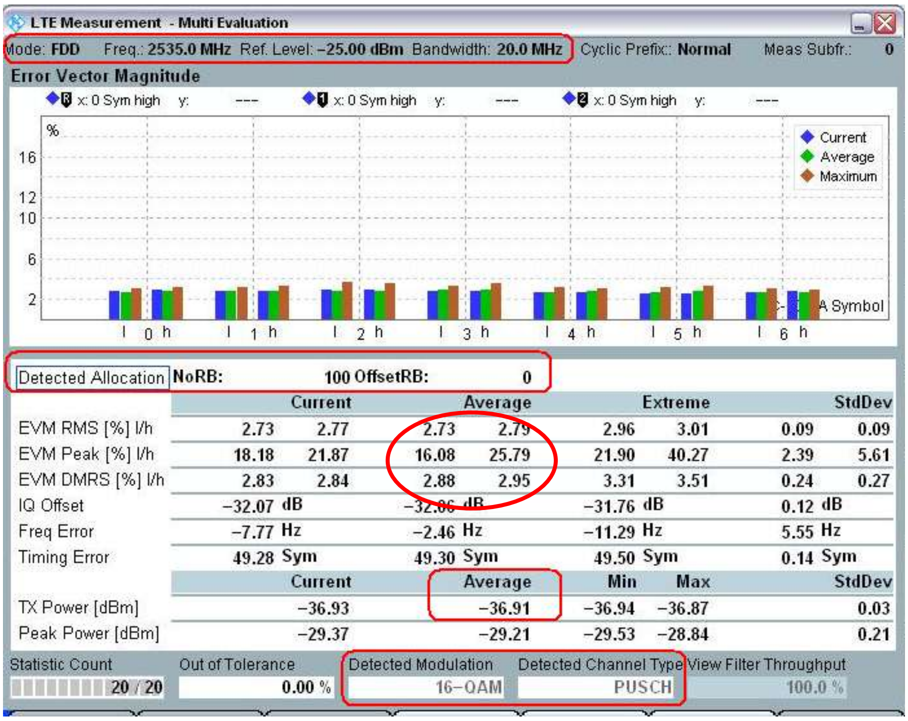



***Fig. 52: EVM measurement screen with results for Test Set 16.***

### 2.14.2.2 PUCCH EVM:

In the LTE system, the UE will transmit data on either PUCCH or PUSCH. Consequently, the PUCCH can only be activated when no PUSCH is scheduled. For the EVM measurement, it is possible to set the *UL* > *RMC* > *RB* to *0* to let the UE transmit PUCCH with the downlink RB allocation that is recommended in the specification.

The PUCCH power control setting is the same as PUSCH from LTE firmware 3.0.50.

| | Downlink RB Allocation | | | | | | UE Output Power |
|---|---|---|---|---|---|---|---|
| | **1.4M** | **3M** | **5M** | **10M** | **15M** | **20M** | |
| 1 | **3** | **4** | **8** | **16** | **25** | **30** | **PMAX** |
| 2 | | | | | | | –36.8 ±3.2 dBm |

***Table 19: Details for PUCCH EVM.***

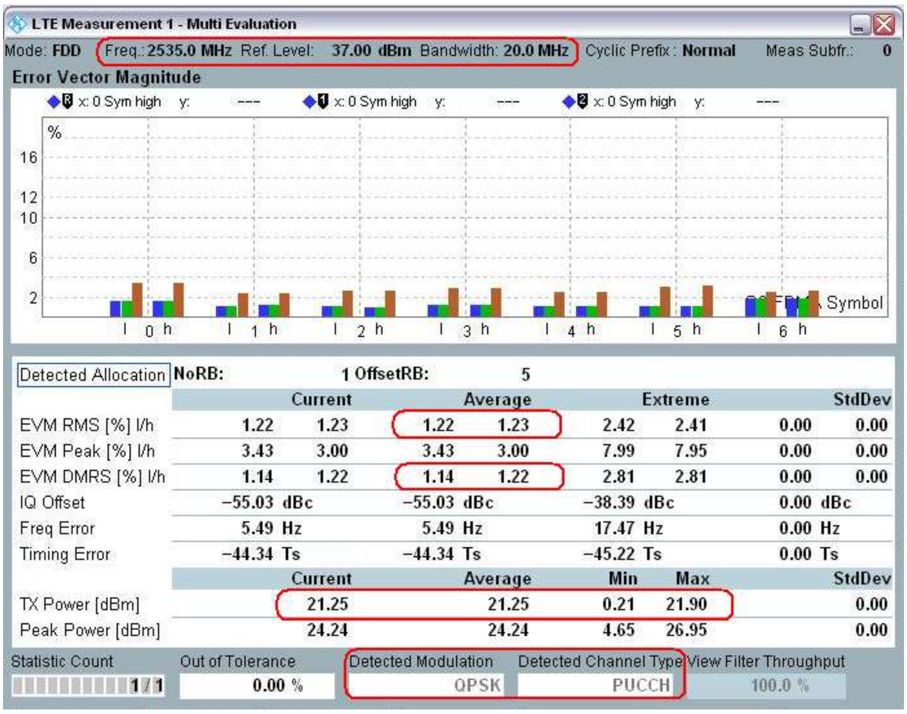



***Fig. 53: Measurement results for PUCCH EVM.***

## 2.14.2.3 PRACH EVM:

| | RS EPRE Settings (FDD/TDD) | PRACH Configuration Index (FDD/TDD) | PreambleInitialReceived TargetPower | Expected PRACH Power |
|---|---|---|---|---|
| Test Point 1 | **–71 / -63** | **4 / 53** | **–120** | –31 dBm |
| Test Point 2 | –86 / -78 | 4 / 53 | –90 | 14 dBm |

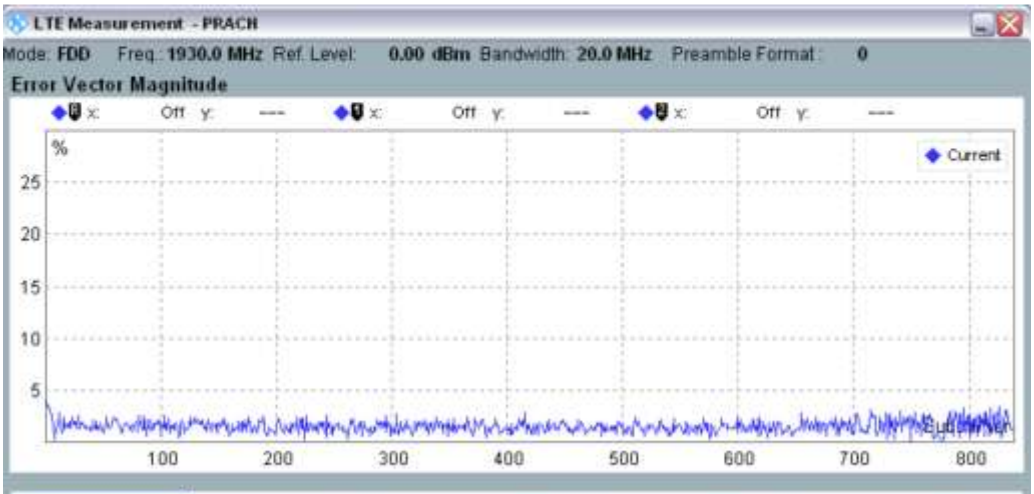
***Table 20: Details for PRACH EVM.***

*PreambleInitialReceivedTargetPower* can be configured with LTE V3.0.50 advanced power settings. Please refer to section 2.1.6. For the other related PRACH parameters please refer to Fig. 30: PRACH time mask test settings.

According to the specification, two preambles are needed for this measurement. Thus, *No Response to Preambles* needs to be selected until the measurement is ready.

Remarks:
With non-Advanced OL Power, for FDD, the PUSCH Open Loop Nomial Power should be 8 dB higher than the expected PRACH power. For TDD, with PRACH *Configuration Index* higher than 48, it should be the same as expected PRACH power.

For the test procedure please refer to the PRACH ON/OFF time mask measurement in section 2.9.1.2.




| | Current | | Average | | Extreme | | StdDev | |
|---|---|---|---|---|---|---|---|---|
| EVM RMS [%] l/h | 1.63 | 1.63 | 1.63 | 1.63 | 1.68 | 1.68 | 0.02 | 0.02 |
| EVM Peak [%] l/h | 4.10 | 4.10 | 3.78 | 3.78 | 4.11 | 4.11 | 0.18 | 0.18 |
| Freq Error | −3.24 Hz | | −0.72 Hz | | 3.78 Hz | | 1.75 Hz | |
| Timing Error | 0.56 Ts | | 0.66 Ts | | 1.41 Ts | | 0.52 Ts | |

| | Current | Average | Min | Max | StdDev |
|---|---|---|---|---|---|
| TX Power [dBm] | −7.99 | −7.99 | −8.01 | −7.99 | 0.00 |
| Peak Power [dBm] | −3.45 | −3.46 | −3.48 | −3.45 | 0.01 |

*Fig. 54: PRACH EVM measurement results.*

### 2.14.3 Test Requirements

The PUSCH EVM and $\overline{EVM}_{DMRS}$ shall not exceed 17.5 % for QPSK and BPSK, and 12.5 % for 16QAM.
The PUCCH EVM shall not exceed 17.5 %.
The PRACH shall not exceed 17.5 %.

## 2.15 PUSCH EVM with Exclusion Period (TS 36.521-1, 6.5.2.1A)

### 2.15.1 Test Description

The purpose of this test is to verify the UE transmitter's ability to keep the EVM minimum requirements, even when transients are present.

### 2.15.2 Test Procedure

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.5.2.1A.4.1-1. Only the low-frequency channel and the 10 MHz bandwidth must be tested.

| Test parameters for channel bandwidths | | | | |
|---|---|---|---|---|
| | Downlink configuration | Uplink configuration | | |
| Ch BW | N/A | Modulation | RB allocation | |
| | | | FDD | TDD |
| 10 MHz | | QPSK | Alternating 12 and 1 | Alternating 12 and 1 |
| 10 MHz | | 16 QAM | Alternating 12 and 1 | Alternating 12 and 1 |

***Table 21: Test configuration (source: TS 36.521-1, Table 6.5.2.1A.4.1-1)***

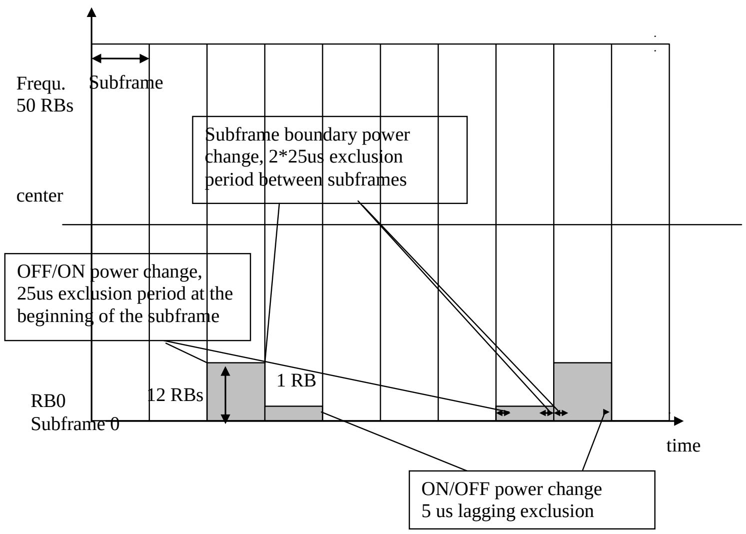



***Fig. 55: Test pattern.***

The EVM Exclusion Periods can be set at *LTE Multi Evaluation Configuration > Modulation*, as shown in Fig. 56.

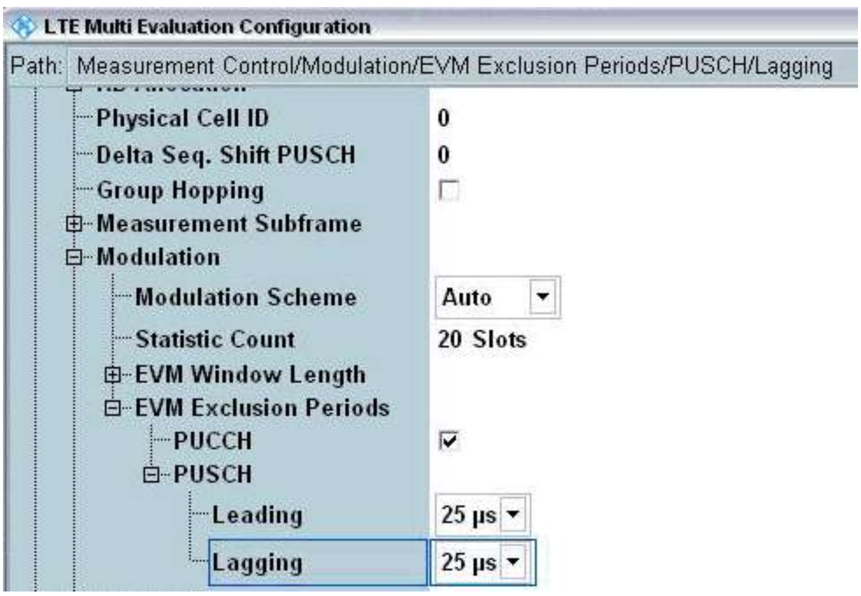



***Fig. 56: Setting the exclusion periods.***

The *Leading* setting refers to the beginning of the subframe. *Lagging* refers to the end of the subframe.

1. Set the *UL* > *RMC* to *12*. Deselect the *Downlink Mac Padding* at *LTE Signaling* > *Connection*, so that the R&S®CMW500 won't send any dummy data.
2. Set the *PUSCH Closed-Loop Power* to *0 dBm*.
3. Set the *Active TPC Setup* to *Constant Power*.
4. Set the *Reference Power* to *Manual*, the *Expected Nom. Power* to *0 dBm* and the *Margin* to *12 dB*.
5. To satisfy the above scheduling, *User Defined*, *TTI Mode* must be used. The *UL Scheduling* is shown in Fig. 57. For TDD, the UL scheduling is the same as TDD.

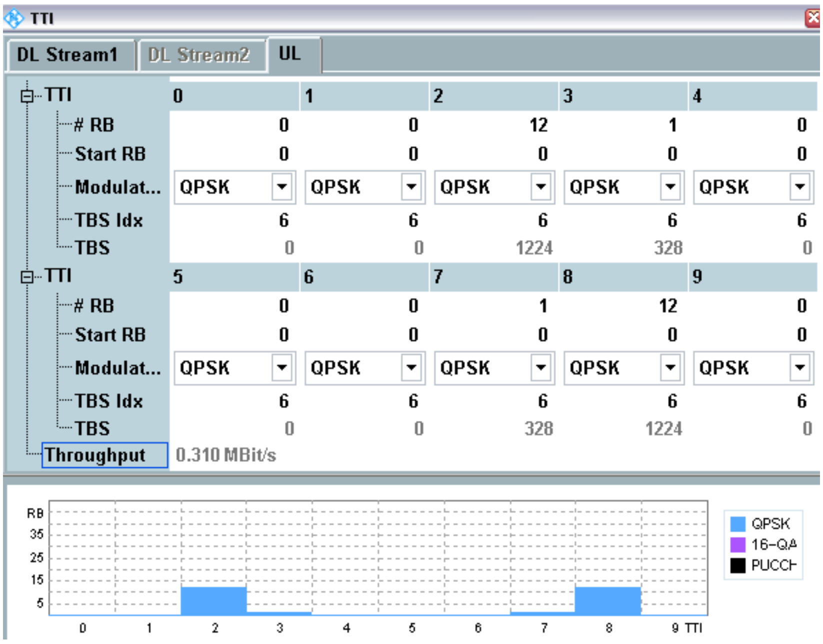



***Fig. 57: UL scheduling for the "PUSCH EVM with exclusion period" test.***

6. To get the measurement results, set the exclusion period according to the measured subframe:
   a. *Subframe = 2*, *Leading = 25µs*, *Lagging = 25µs*
   b. *Subframe = 3*, *Leading = 25µs*, *Lagging = 5µs*
   c. *Subframe = 7*, *Leading = 25µs*, *Lagging = 25µs*
   d. *Subframe = 8*, *Leading = 25µs*, *Lagging = 5µs*

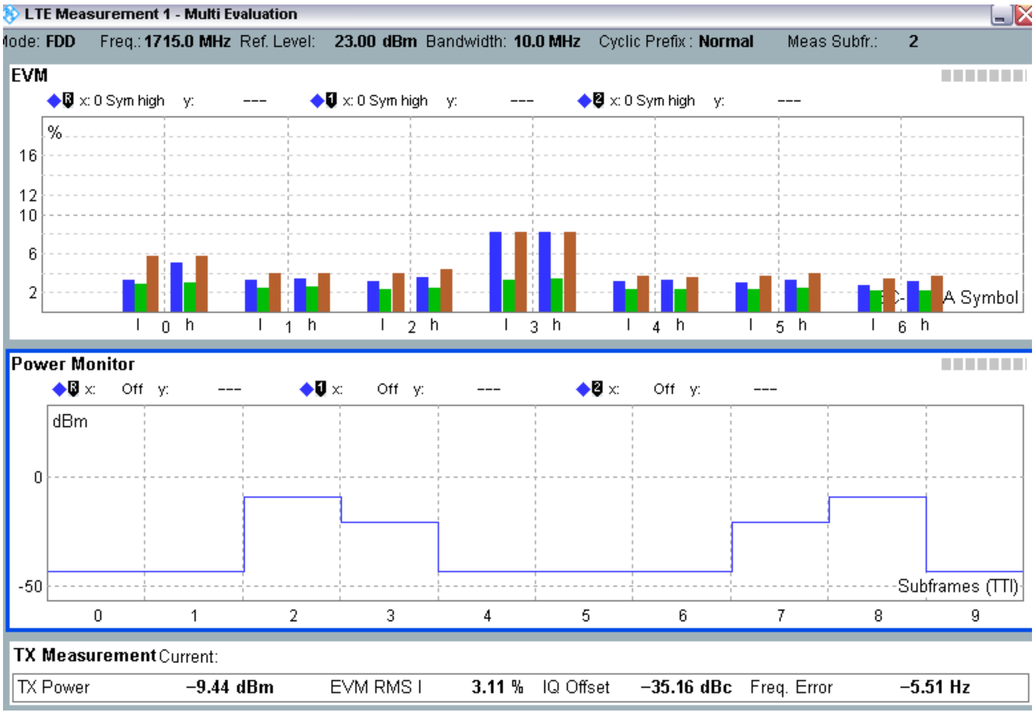



***Fig. 58: Measurement results for a "PUSCH EVM with exclusion period" test.***

Note: In order to obtain the statistics that the specification requires, each subframe needs to be measured separately with each statistics count equal to *4*.

### 2.15.3 Test Requirements

The test requirements are the same as the EVM requirement in TS 36.521-1 section 6.5.2.1.

## 2.16 Carrier Leakage (TS 36.521-1, 6.5.2.2)

Carrier leakage (the I/Q origin offset) is a form of interference caused by crosstalk or DC offset. It expresses itself as an unmodulated sine wave with the carrier frequency. The amplitude of this interference remains approximately constant and is independent of the wanted signal's amplitude. I/Q origin offset interferes with the center sub carriers of the UE under test (if allocated), especially when those subcarriers have a low amplitude. The measurement interval is defined over one slot in the time domain.
The purpose of this test is to evaluate the UE transmitter to verify its modulation quality in terms of carrier leakage.

### 2.16.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.5.2.2.4.1-1.

For Band 7, the test is defined for the 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.5.1.4.1-1into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of this test is to verify the quality of the transmit signal for QPSK modulation and partial RB allocation at the low and high RB positions.

### 2.16.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.
The RMC and RB position are selected according to TS 36.521-1, Table 6.5.2.2.4.1-1, and the output power conditions are listed in Table 22 for a 20 MHz channel bandwidth. In this example, Test Set 1 is used.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | **18** | **Low** | **QPSK** | 3.2±3.2 dBm |
| Test Set 2 | **18** | **High** | **QPSK** | 3.2±3.2 dBm |
| Test Set 3 | **18** | **Low** | **QPSK** | –26.8±3.2 dBm |
| Test Set 4 | **18** | **High** | **QPSK** | –26.8±3.2 dBm |
| Test Set 5 | **18** | **Low** | **QPSK** | –36.8±3.2 dBm |
| Test Set 6 | **18** | **High** | **QPSK** | –36.8±3.2 dBm |

***Table 22: Test setup for carrier leakage measurement.***

Test Set 1:

1. Set *# RB* to *18*, *RB Pos/Start RB* to *Low*, and *Modulation* to *QPSK*.
2. Set *Active TPC Setup* to *Closed Loop*, and set *Closed-Loop Target Power* to *3 dBm* to ensure that the output power is in the range of 0 dBm ~ 6.4 dBm.
3. Read the *IQ offset* (*–28.05 dB* in this example) on the EVM measurement result screen.

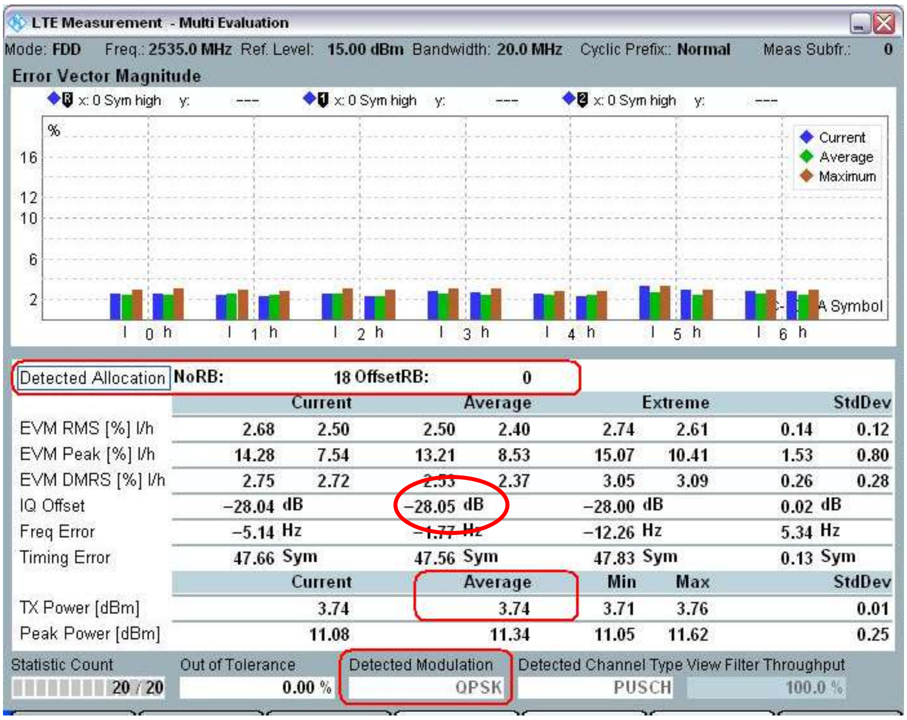



*Fig. 59: The EVM measurement result screen.*

### 2.16.3 Test Requirements

None of the 20 IQ offset results may exceed the values in TS 36.521-1, Table 6.5.2.2.5-1 for the different output power ranges.

| LO leakage | Parameters | Relative limit (dBc) |
|---|---|---|
| | 3.2 dBm ±3.2 dB | –24.2 |
| | –26.8 dBm ±3.2 dB | –19.2 |
| | –36.8 dBm ±3.2 dB | –9.2 |

*Table 23: Test requirements for relative carrier leakage power (source: TS 36.521-1, Table 6.5.2.2.5-1).*

## 2.17 In-Band Emissions for Non-Allocated RBs (TS 36.521-1, 6.5.2.3)

The in-band emissions are a measure of the interference that arises in the non-allocated resource blocks.

The in-band emissions value is defined as the average across 12 subcarriers and as a function of the RB offset from the edge of the allocated UL transmission bandwidth. The in-band emissions are measured as the ratio of the UE output power in a non-allocated RB to the UE output power in an allocated RB. The basic in-band emissions measurement interval is defined over one slot in the time domain. When the PUSCH or PUCCH transmission slot is shortened due to multiplexing with SRS, the in-band emissions measurement interval is reduced accordingly by one SC-FDMA symbol.

### 2.17.1 Test Description

This test case contains two subtests. The PUSCH in-band emissions test as well as the PUCCH in-band emissions test.

For general test conditions and settings, please refer to Section 2.1 in this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.5.2.3.4.1-1.

Fig. 60 shows three different parts of the requirement results: the general part, the DC part and the IQ image part. None of these three parts should exceed the limit established in the specification.

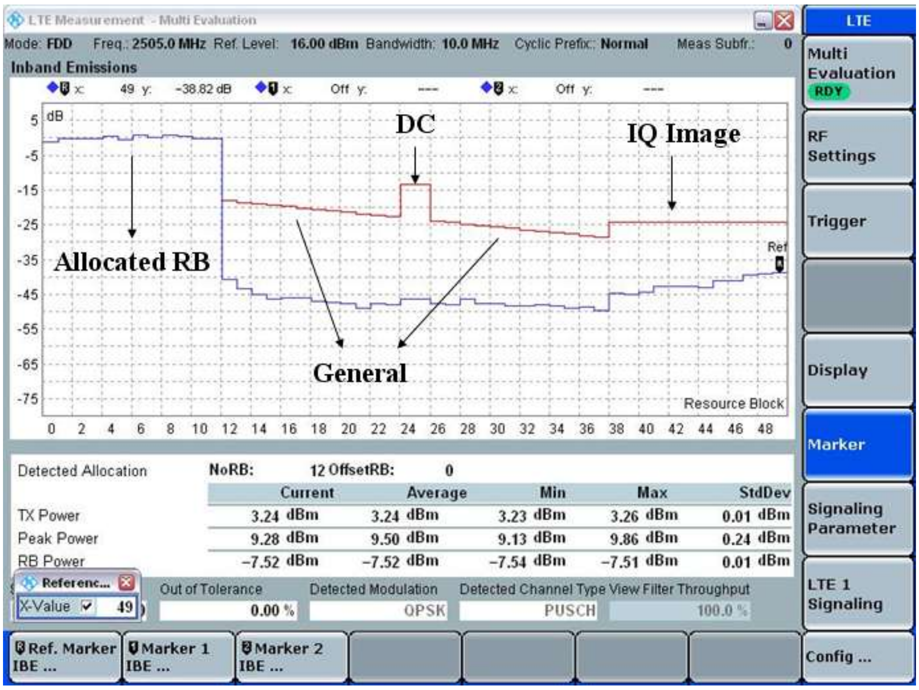



***Fig. 60: Three parts of the results for in-band emissions for non-allocated RBs.***

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1 and 6.5.1.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of this test is to verify the in-band emissions using QPSK and partial RB allocation under three different output power levels.

### 2.17.2 Test Procedure

#### 2.17.2.1 PUSCH In-Band Emissions Measurements

This example will use Band 7, a 20 MHz bandwidth and a low-range channel. Table 24 lists the RMC and RB position according to TS 36.521-1, Table 6.5.2.3.4.1-1 as well as the output power conditions for a 20 MHz channel bandwidth. This example uses Test Set 1 and Test Set 2.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | 18 | Low | QPSK | 3.2 ± 3.2 dBm |
| Test Set 2 | 18 | High | QPSK | 3.2 ± 3.2 dBm |
| Test Set 3 | 18 | Low | QPSK | –26.8 ± 3.2 dBm |
| Test Set 4 | 18 | High | QPSK | –26.8 ± 3.2 dBm |
| Test Set 5 | 18 | Low | QPSK | –36.8 ± 3.2 dBm |
| Test Set 6 | 18 | High | QPSK | –36.8 ± 3.2 dBm |

***Table 24: Test setup for PUSCH in-band emissions measurement.***

Test Set 1:

1. Set *# RB* to *18*, *RB Pos/Start RB* to *Low*, and *Modulation* to *QPSK*.
2. Set *Active TPC Setup* to *Closed Loop*, and *Closed-Loop Target Power* to *3 dBm* to ensure that the output power is in the range of 0 dBm to 6.4 dBm.
3. Read the measurement results in the in-band emissions measurement screen as shown in Fig. 61.

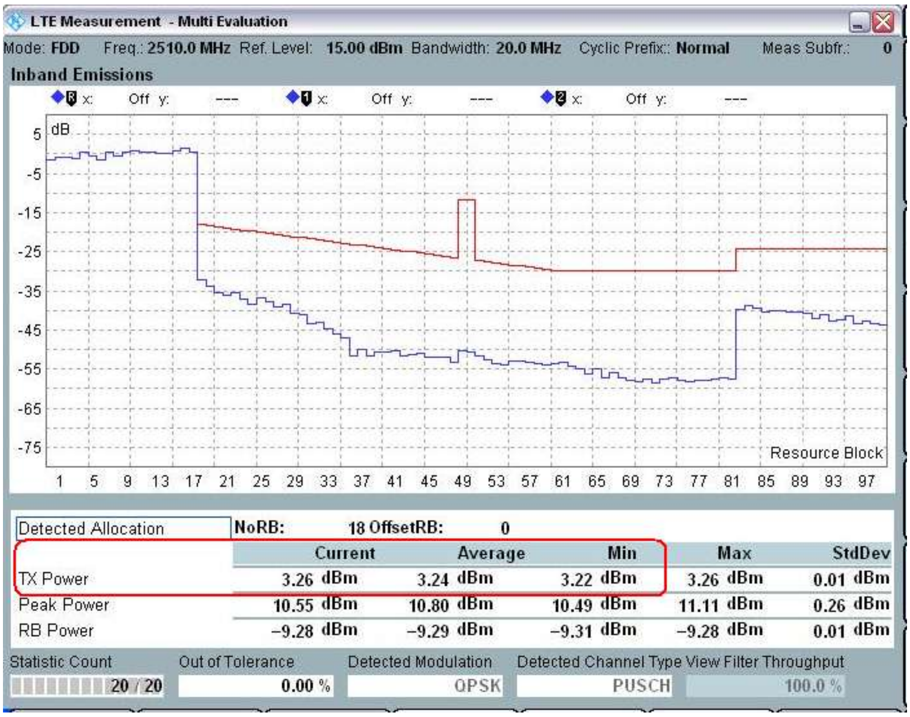



***Fig. 61: Measurement results for Test Set 1 in the in-band emissions measurement screen.***

Test Set 2:

1. Set the *# RB* to *18*, *RB Pos/Start RB* to *High*, and *Modulation* to *QPSK*.
2. Set *Active TPC Setup* to *Closed Loop*, and *Closed-Loop Target Power* to *3 dBm* to ensure that the output power is in the range of 0 dBm ~ 6.4 dBm.
3. Read the measurement results from the in-band emissions measurement screen as shown in Fig. 62.

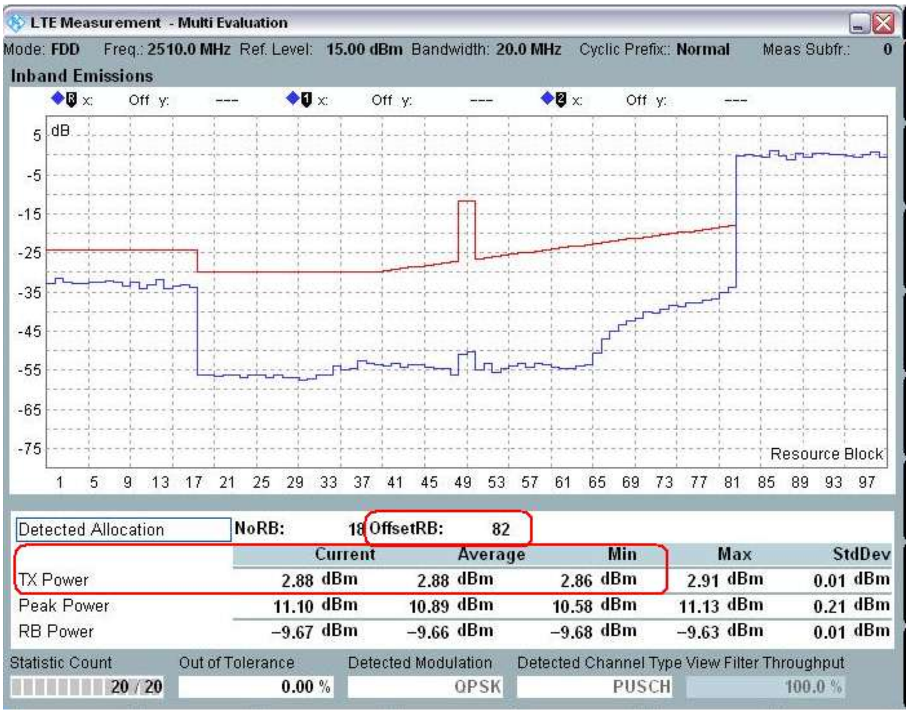



***Fig. 62: Measurement results for Test Set 2 in the in-band emissions measurement screen.***

For all six test sets, the output power (blue) in non-allocated areas shall not exceed the limit line (red).
In addition, the smallest margin between the measurement trace and the limit line can be read from the R&S®CMW500 using the corresponding SCPI command.

### 2.17.2.2 PUCCH In-band Emissions Measurement

The setup for this measurement is the same as 6.5.2.1 PUCCH EVM. The three UL power points are the same as for the PUSCH in-band emission measurement.

An example of the measurement is shown Fig. 63, with *20 MHz* and *Closed Loop* set to *3.2 dBm*.

Remarks: the RF reference level for PUCCH should be set manually according to the PUCCH closed-loop power.

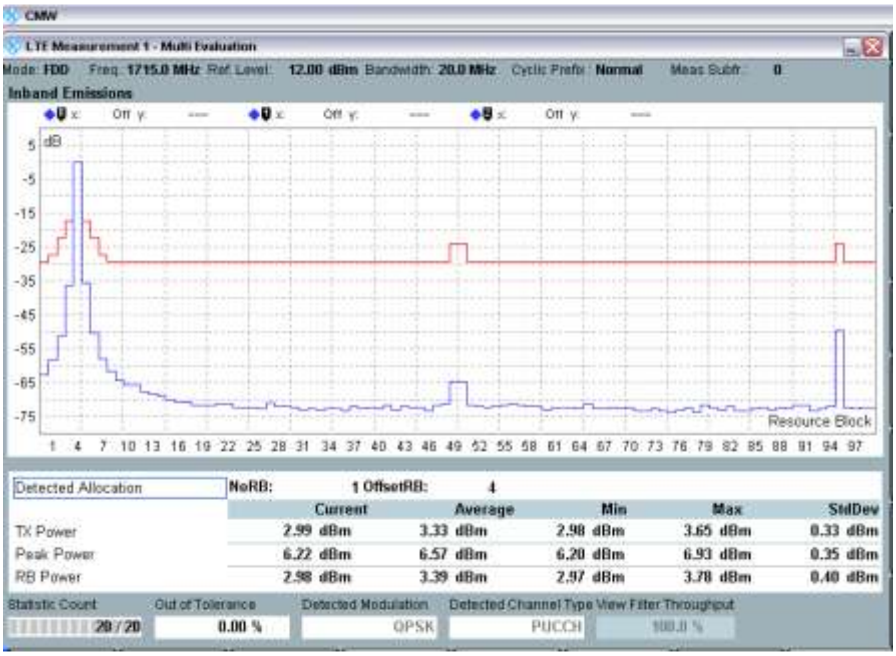



***Fig. 63: Results from a PUCCH in-band emissions measurement.***

### 2.17.3 Test Requirements

None of the 20 in-band emission results may exceed the corresponding values in TS 36.521-1, Table 6.5.2.3.5-1.

## 2.18 EVM Equalizer Spectrum Flatness (TS 36.521, 6.5.2.4)

The EVM equalizer spectrum flatness is defined as the variation in dB of the equalizer coefficients generated by the EVM measurement process.

### 2.18.1 Test Description

After Rel-9 of TS 36.521, two new test requirements were added. Therefore, the corresponding measurements have also been added to the R&S®CMW500.

Before this test case can be performed, it is necessary to first find out which part of the frequency range is to be measured and to define the measurement domain. There are two kinds of measurement-range definitions: normal conditions and extreme conditions. The differences between these two types of conditions are defined in the specification. Generally, normal conditions will be used.

Under normal conditions, the tests are divided into two ranges (Range 1 and Range 2). These ranges are defined in TS 36.521-1, Table 6.5.2.4.5-1, and an illustration is provided in TS 36.521-1, Figure 6.5.2.4.5-1.

In this test, a total of two or four (depending the location of the transmission bandwidth) sets of results is used to qualify the LTE UE’s performance:

1. Max(Range1) – Min(Range1) / Ripple 1
2. Max(Range2) – Min(Range2) / Ripple 2
3. Max(Range1) – Min(Range2)
4. Max(Range2) – Min(Range1)

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.5.2.4.4.1-1.

For Band 7, the test is defined for the 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.5.1.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of this test is to verify the spectrum flatness using QPSK and full RB allocation at the maximum output power level.

### 2.18.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth, low range and middle range. This will show that the test delivers slightly different results depending on the measurement range.

1. Set the *Downlink Channel* to *2505 MHz*, *# RB* to *100*, *RB Pos* to *Low*, and *Modulation* to *QPSK*.
2. Set *Active TPC setup* to *Max. Power* to ensure that the UE power reaches its maximum.
3. Read the EVM equalizer spectrum flatness from the corresponding measurement screen as shown in Fig. 64.

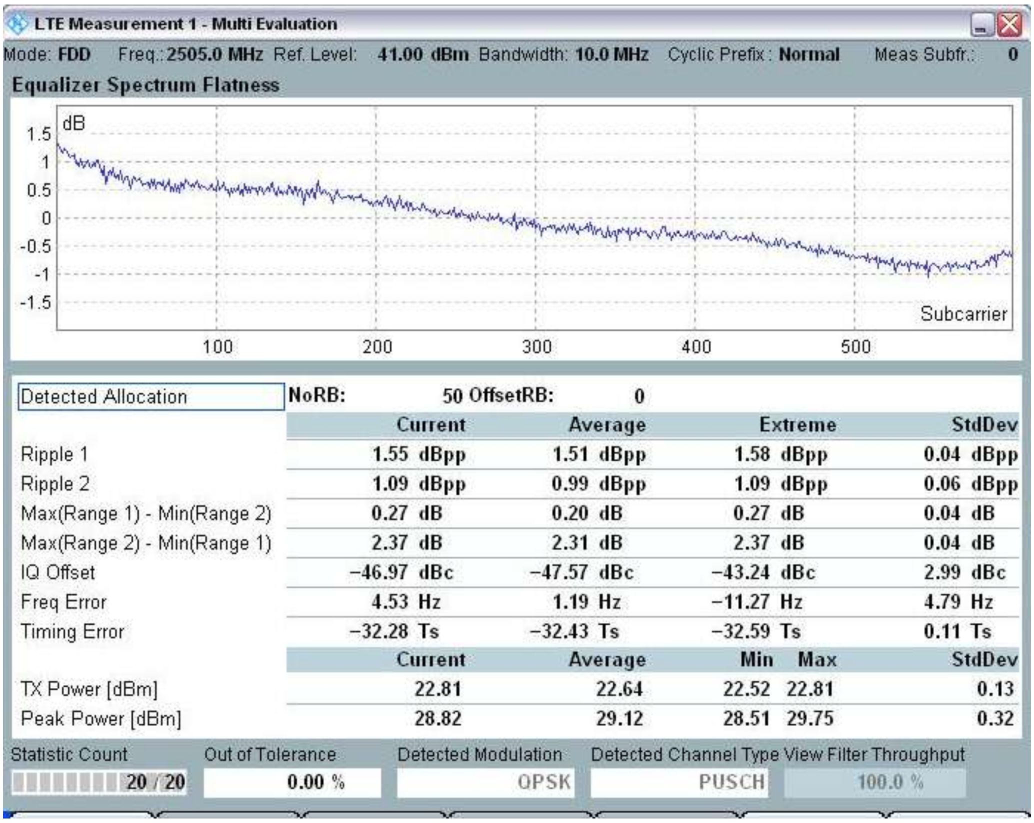



***Fig. 64: Measurement screen for the EVM equalizer spectrum, example 1: low-frequency channel, transmission bandwidth covers both Range 1 and Range 2.***

4. Set the *Downlink Channel* to *2535 MHz*, *# RB* to *100*, *RB Pos* to *Low*, and *Modulation* to *QPSK*.
5. Set *Active TPC Setup* to *Max Power* to ensure the UE power reaches its maximum.
6. Read the EVM equalizer spectrum flatness from the corresponding measurement screen as shown in Fig. 65.

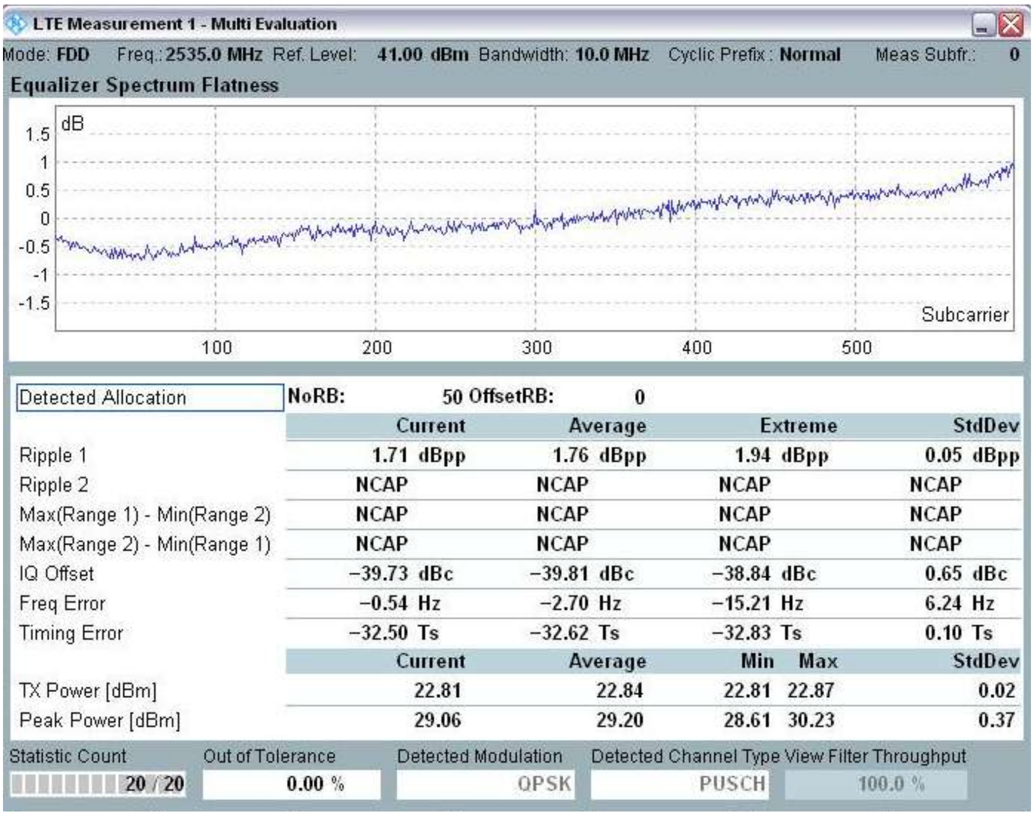



***Fig. 65: Measurement screen for EVM equalizer spectrum, example 2: mid-frequency channel, transmission bandwidth covering Range 1 only.***

## 2.18.3 Test Requirements

The requirements for this test are provided in Table 25.

| Frequency range | Maximum ripple [dB] |
|---|---|
| $F_{UL\_Meas} - F_{UL\_Low} \geq 3$ MHz and $F_{UL\_High} - F_{UL\_Meas} \geq 3$ MHz (Range 1) | 5.4 (p-p) |
| $F_{UL\_Meas} - F_{UL\_Low} < 3$ MHz or $F_{UL\_High} - F_{UL\_Meas} < 3$ MHz (Range 2) | 9.4 (p-p) |
| Note 1: $F_{UL\_Meas}$ refers to the subcarrier frequency for which the equalizer coefficient is evaluated<br>Note 2: $F_{UL\_Low}$ and $F_{UL\_High}$ refer to each E-UTRA frequency band specified in TS 36.521-1, Table 5.2-1 | |

***Table 25: Test requirements for EVM equalizer spectrum flatness under normal conditions (source: TS 36.521-1, Table 6.5.2.4.5-1)***

## 2.19 Occupied Bandwidth (TS 36.521, 6.6.1)

Occupied bandwidth is a measure of the bandwidth containing 99 % of the total integrated mean power of the transmitted spectrum on the assigned channel. The occupied channel bandwidth for all transmission bandwidth configurations (resource blocks) should be less than the channel bandwidth.

### 2.19.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.6.1.4.1-1.

For Band 7, the test is defined for 5 MHz, 10 MHz, 15 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.6.1.4.1-1 into account. Each bandwidth configuration should apply to middle-range channels. The purpose of the test is to verify the UE's occupied bandwidth using QPSK modulation and full RB allocation.

### 2.19.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

1. Set *# RB* to *100*, *RB Pos/Start RB* to *Low*, and *Modulation* to *QPSK*.
2. Set *Active TPC Setup* to *Max Power* so that the UE output power reaches $P_{UMAX}$.
3. Read the occupied bandwidth (*OBW*) in the tabular result screen (*16.928 MHz* in the example shown in Fig. 66).

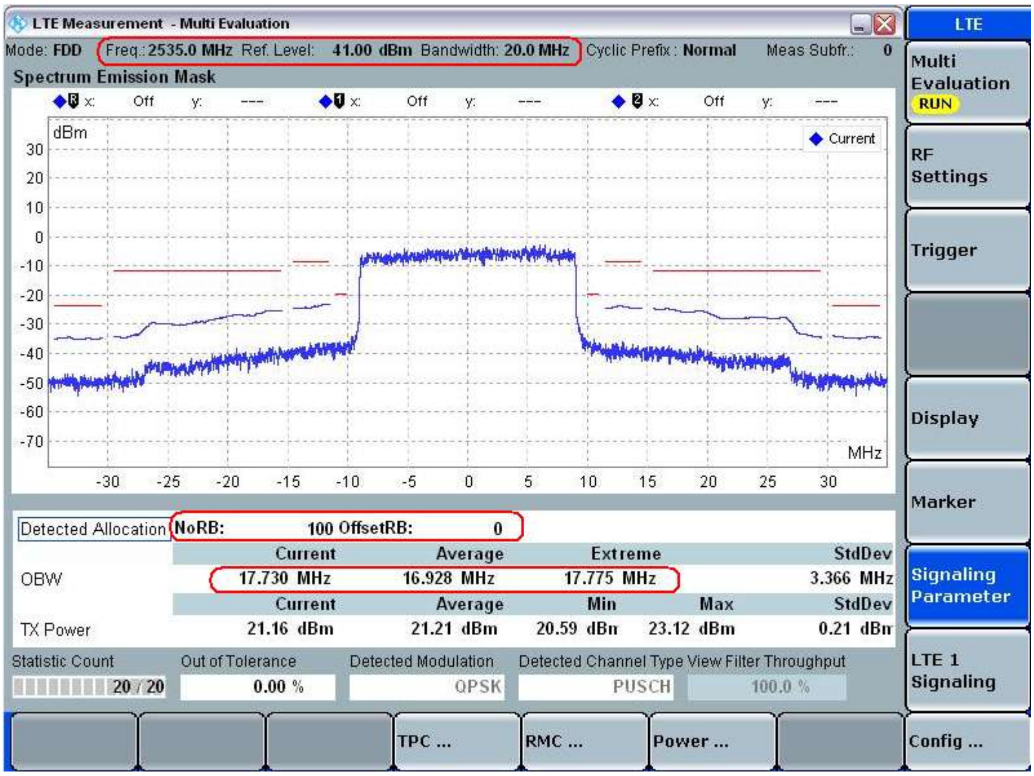



*Fig. 66: Tabular measurement results for the occupied bandwidth (OBW).*

## 2.19.3 Test Requirements

The measured occupied bandwidth must not exceed the values supplied in TS 36.521-1, Table 6.6.1.5-1 (reproduced here in Table 26).

| | Occupied channel bandwidth / Channel bandwidth | | | | | |
|---|---|---|---|---|---|---|
| | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** |
| **Channel bandwidth [MHz]** | 1.4 | 3 | 5 | 10 | 15 | 20 |

*Table 26: Occupied channel bandwidth (source: TS 36.521-1, Table 6.6.1.5-1).*

## 2.20 Spectrum Emission Mask (TS 36.521, 6.6.2.1)

Out-of-band emissions are unwanted emissions immediately outside the nominal channel. They result from the modulation process and from non-linearity in the transmitter, but they do not include spurious emissions.

The adjacent channel leakage [power] ratio (ACLR) and the spectrum emission mask (SEM) are part of the out-of-band emissions test. The two test cases qualify different aspects of the out-of-band performance: The SEM is for checking the performance point by point (RBW), and the ACLR is used to check the integration results (channel bandwidth).

The purpose of the spectrum emission mask test is to verify that the power of any UE emission will not exceed the specified level for the corresponding channel bandwidth.

### 2.20.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 6.6.2.1.4.1-1.

For Band 7, the test is defined for 5 MHz, 10 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 6.6.2.1.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of the test is to verify the quality of the transmitted signal for both QPSK and 16QAM, as well as for partial and full RB allocation. Also, different RB positions are to be taken into account.

### 2.20.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.
RMC, the RB position according to TS 36.521-1, Table 6.6.2.1.4.1-1, as well as output power conditions are listed in Fig. 67 for a 20 MHz channel bandwidth. Test Set 1 and Test Set 6 are used for this example.

Settings marked with red frames in Fig. 67 are important settings to take care of.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | **18** | **High** | **QPSK** | $P_{UMAX}$ |
| Test Set 2 | **18** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 3 | **18** | **High** | **16QAM** | $P_{UMAX}$ |
| Test Set 4 | **18** | **Low** | **16QAM** | $P_{UMAX}$ |
| Test Set 5 | **100** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 6 | **100** | **Low** | **16QAM** | $P_{UMAX}$ |

***Table 27: Test setup for the spectrum emission mask (middle range).***

Test Set 1:

1. Set *# RB* to 18, *RB Pos* to *High*, and *Modulation* to *QPSK*.
2. Set *Active TPC Setup* to *Max Power* until the UE output power reaches $P_{UMAX}$.
3. If Bandwidth is more than 10MHz, change *Active TPC Setup* to *Constant Power* before initiating the measurement.
4. Read the SEM result using the corresponding measurement screen as shown in Fig. 67.

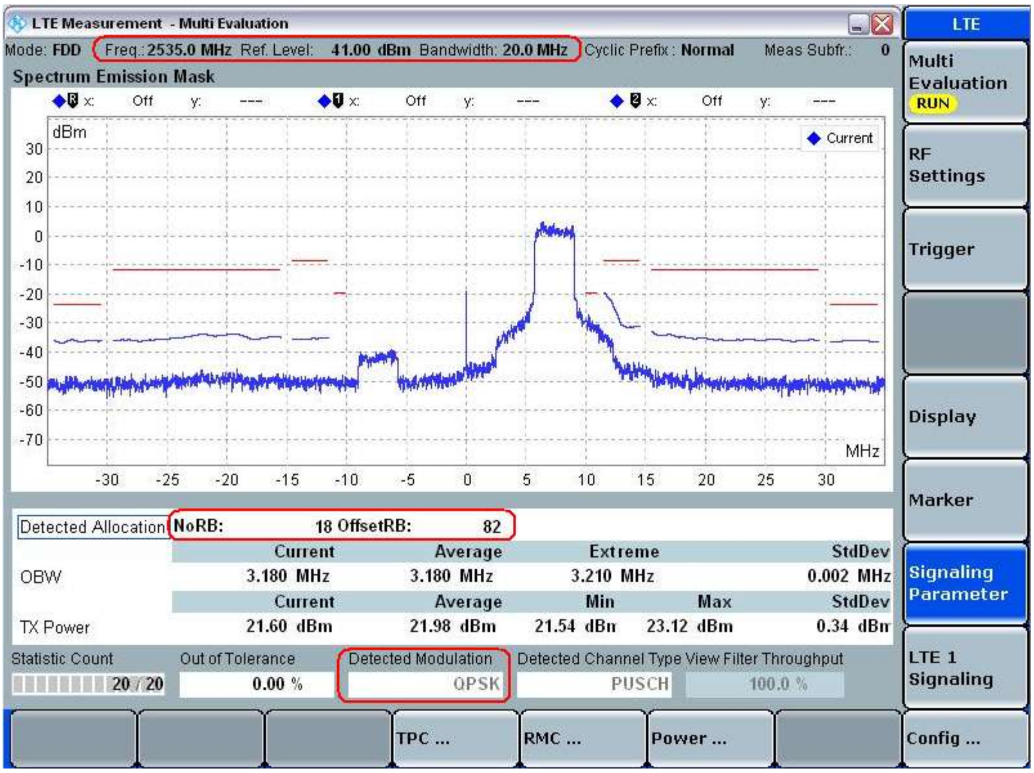



***Fig. 67: SEM measurement results for Test Set 1.***

Test Set 4:

5. Set *# RB* to *100*, *RB Pos* to *Low*, and *Modulation* to *16QAM*. (Also, don't forget to set the *Demodulation Signal* to *Auto* or to *16QAM*.)
6. Set *Active TPC Setup* to *Max Power* until the UE output power reaches $P_{UMAX}$.
7. If Bandwidth is more than 10MHz, change *Active TPC Setup* to be *Constant Power* before initiating the measurement.
8. Read the SEM result using the corresponding measurement screen as shown in Fig. 68.

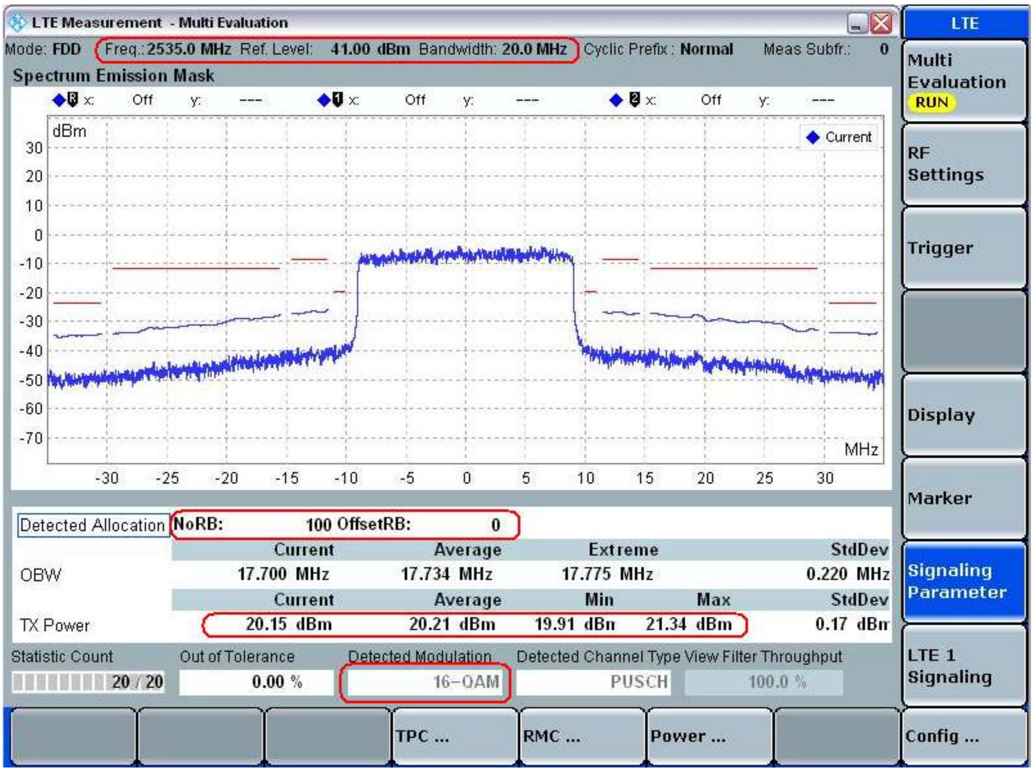



*Fig. 68: SEM measurement results for Test Set 4.*

## 2.20.3 Test Requirements

The requirements for this test are defined in Table 28. For frequency higher than 3GHz, the limits are relaxed by 0.3 dB.

| | Spectrum emission limit (dBm)/ Channel bandwidth | | | | | | |
|---|---|---|---|---|---|---|---|
| **$\Delta f_{OOB}$ (MHz)** | **1.4 MHz** | **3.0 MHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **Measurement bandwidth** |
| 0 – 1 | –8.5 | –11.5 | –13.5 | –16.5 | –18.5 | –19.5 | 30 kHz |
| 1 – 2.5 | –8.5 | | | | | | 1 MHz |
| 2.5 – 2.8 | –23.5 | –8.5 | –8.5 | –8.5 | –8.5 | –8.5 | 1 MHz |
| 2.8 – 5 | | | | | | | 1 MHz |
| 5 – 6 | | –23.5 | –11.5 | –11.5 | –11.5 | –11.5 | 1 MHz |
| 6 – 10 | | | –23.5 | | | | 1 MHz |
| 10 – 15 | | | | –23.5 | | | 1 MHz |
| 15 – 20 | | | | | –23.5 | | 1 MHz |
| 20 – 25 | | | | | | –23.5 | 1 MHz |

NOTE 1: The first and last measurement position with a 30 kHz filter is at $\Delta f_{OOB}$ equal to 0.015 MHz and 0.985 MHz.
NOTE 2: At the boundary of the spectrum emission limit, the first and last measurement position with a 1 MHz filter is the inside of +0.5MHz and –0.5MHz, respectively.
NOTE 3: The measurements are to be performed above the upper edge of the channel and below the lower edge of the channel.
NOTE 4: For the 2.5 MHz – 2.8 MHz offset range with 1.4 MHz channel bandwidth, the measurement position is at $\Delta f_{OOB}$ equal to 3 MHz.

*Table 28: General E-UTRA spectrum emission mask (TS 36.521-1, Table 6.6.2.1.5-1).*

This test requirement mainly specifies the absolute power level of the spectrum emission mask measurement results.

As a general rule, the R&S®CMW500's default limits are set according to the specification, so the simple method is to check to see if the blue result traces exceed the red limit lines. For frequency above 3GHz, adjustment of the limits may be required.

## 2.21 Additional Spectrum Emission Mask (TS 36.521-1, 6.6.2.2)

The purpose of this test is to verify that the power of any UE emission will not exceed the specified level for the corresponding channel bandwidth under the deployment scenarios for which additional requirements are specified.

### 2.21.1 Test Description

The network signal (NS) value is a key parameter for this test item. The A-MPR test description explains this parameter and how to set it. Please refer to that section for more details about NS.

NS has a fixed relationship with the operating band and with the channel bandwidth. Detailed information about this is provided in TS 36.521, Table 6.2.4.3-1. As that table indicates, only NS_03, NS_04, NS_06 and NS_07 are used for additional spectrum emission calculations. The other NS values are used for spurious emission tests.

### 2.21.2 Test Procedure

The test method used here is the same as with the spectrum emission mask (6.6.2.1) except that the corresponding NS value must be set and broadcasted on SIB2. Details on how to set the NS value on the R&S®CMW500 can be found in Section 2.4, "Additional Maximum Power Reduction (TS 36.521-1, 6.2.4)."

Different tables describe different RMC, RB position, frequency and bandwidth settings. The list provided in Table 29 shows the relationship between the NS values and the test configuration table.

| | Additional spectrum emission | Test configuration table in TS 36.521-1 |
|---|---|---|
| Table1 | **NS_03** | 6.6.2.2.4.1-1 |
| Table2 | **NS_04** | 6.6.2.2.4.1-4 |
| Table3 | **NS_06** | 6.6.2.2.4.1-2 |
| Table4 | **NS_07** | 6.6.2.2.4.1-3 |

***Table 29: Test configuration table for A-SEM in TS 36.521-1.***

### 2.21.3 Test Requirements

Different NS vales refer to different requirements. Table 30 lists the different test requirements and the tables in which they are found.

| Additional spectrum emission | Test requirement table in TS 36.521-1 |
|---|---|
| NS_03 | Table 6.6.2.2.5.1-1 |
| NS_04 | Table 6.6.2.2.5.2-1 |
| NS_06 | Table 6.6.2.2.5.3-1 |
| NS_07 | Table 6.6.2.2.5.3-1 |

***Table 30: Test requirements for A-SEM in TS 36.521-1.***

## 2.22 Adjacent Channel Leakage Power Ratio (TS 36.521, 6.6.2.3)

The purpose of this test is to verify that the UE transmitter does not cause unacceptable interference to adjacent channels. This is accomplished by determining the adjacent channel leakage [power] ratio (ACLR).

ACLR requirements are specified for two scenarios for adjacent E-UTRA$_{ACLR}$ and UTRA$_{ACLR1/2}$ channels as shown in Fig. 69.

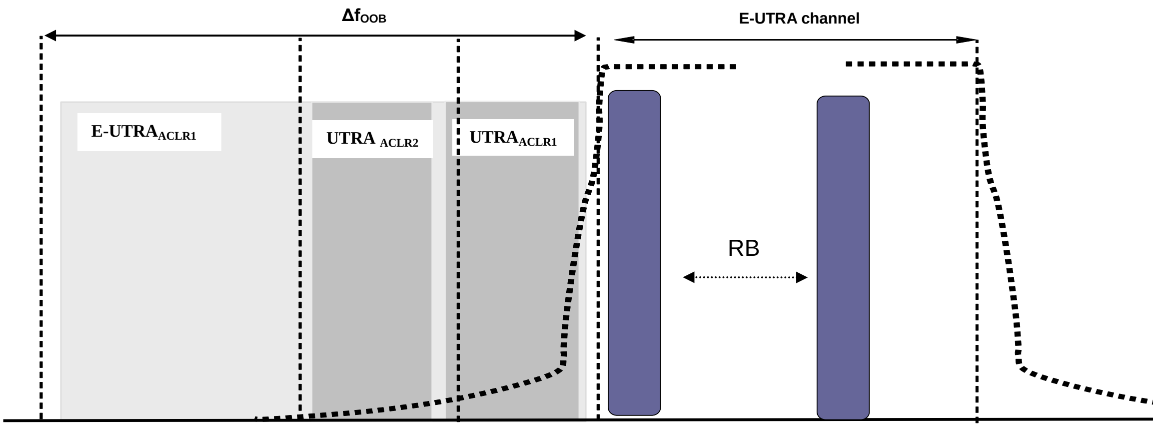



***Fig. 69: Requirements for the adjacent channel leakage power ratio (TS 36.521, Figure 6.6.2.3.3-1).***

### 2.22.1 Test Description

When the UE is transmitting at its max power in the E-UTRA channel, a rectangular filter is used to calculate the power leakage into adjacent E-UTRA channels. This calculation is performed to obtain the ACLR for E-UTRA. Furthermore, an RRC filter with a 3.84 MHz bandwidth is used to calculate the power leakage into adjacent UTRA channels.

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, and details on the RB allocations, are defined in TS 36.521, Table 6.6.2.3.4.1-1

For Band 7, the test is defined for the 5 MHz, 10 MHz and 20 MHz bandwidths, taking TS 36.521, Tables 5.4.2.1-1 and 6.6.2.3.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of the test is to verify the ACLR for QPSK and for 16QAM as well as for partial and full RB allocation. Also, different RB positions are to be taken into account.

## 2.22.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.
The RMC and RB position specified in TS 36.521-1, Table 6.6.2.3.4.1-1, as well as the output power conditions, are listed in Table 31 for a 20 MHz channel bandwidth. This example uses Test Set 6.

| | #RB | RB Pos/Start RB | Modulation | UE Output Power |
|---|---|---|---|---|
| Test Set 1 | **18** | **High** | **QPSK** | $P_{UMAX}$ |
| Test Set 2 | **18** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 3 | **18** | **High** | **16QAM** | $P_{UMAX}$ |
| Test Set 4 | **18** | **Low** | **16QAM** | $P_{UMAX}$ |
| Test Set 5 | **100** | **Low** | **QPSK** | $P_{UMAX}$ |
| Test Set 6 | 100 | **Low** | **16QAM** | $P_{UMAX}$ |

***Table 31: Test setup for ACLR (middle-range channel).***

Test Set 6:
1. Set *# RB* to *100*, *RB Pos* to *Low*, and *Modulation* to *16QAM*.
2. Set *Active TPC Setup* to *Max Power* until the UE output power reaches $P_{UMAX}$.
3. In R&S®CMW LTE V2.1.10, *Active TPC Setup* needs to be set as *Constant Power* before initiating the measurement.
4. Read the ACLR results using the corresponding measurement screen as shown in Fig. 70.

| | Adjacent channel frequency offset | Channel measurement BW | ACLR (dBc) Neg. | ACLR (dBc) Pos. |
|---|---|---|---|---|
| ACLR1_UTRA | ±7.5 MHz | 3.84 MHz | 40.89 | 40.66 |
| ACLR1_UTRA | ±12.5 MHz | 3.84 MHz | 42.99 | 42.19 |
| ACLR_EUTRA | ±10 MHz | 9 MHz | 36.88 | 36.17 |

***Table 32: General requirements for ACLR measurements.***

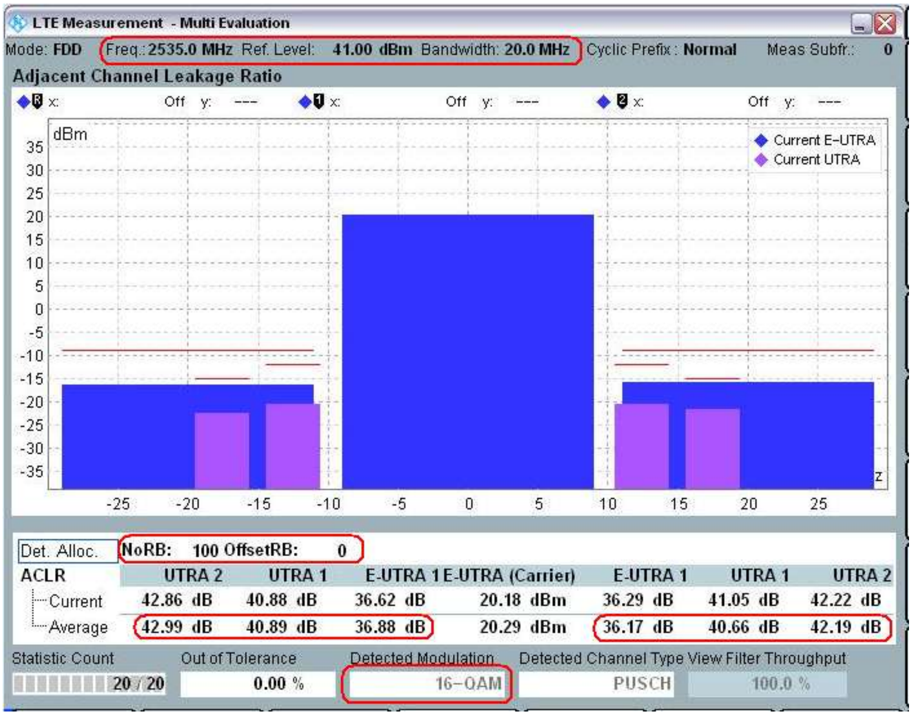



*Fig. 70: Measurement screen for reading the ACLR results.*

### 2.22.3 Test Requirement

For a 10 MHz bandwidth, the ACLR for UTRA and EUTRA should not exceed the limits defined in Table 33. For the other channel bandwidths, please refer to TS 36.521, Tables 6.6.2.3.5.1-1 and 6.6.2.3.5.1-2.

| | Adjacent channel frequency offset | Channel measurement BW | ACLR (dBc) |
|---|---|---|---|
| ACLR1_UTRA | ±7.5 MHz | 3.84 MHz | 32.2 |
| ACLR1_UTRA | ±12.5 MHz | 3.84 MHz | 35.2 |
| ACLR_EUTRA | ±10 MHz | 9 MHz | 29.2 |

*Table 33: ACLR limits for UTRA and EUTRA for a 10 MHz bandwidth.*

# 3 Receiver Characteristics

## 3.1 Generic Test Description for Receive Tests

### 3.1.1 External Interference Description

The receiver test items listed in Table 34 are described in this application note. The rest of the test items according to the specification are supported by the CMW500, but they are not listed in this application note, because external filters or spectrum analyzers are needed to perform them. Describing the relevant procedures would exceed the scope of this short application note. Users should contact their local sales agent regarding the pre-conformance / conformance test system that Rohde-Schwarz provides for those tests.

| | Section in TS 36.521-1 | Test case | *Extra Generator needed* |
|---|---|---|---|
| 1 | 7.3 | Reference sensitivity level | *No* |
| 2 | 7.4 | Maximum input level | *No* |
| 3 | 7.5 | Adjacent channel selectivity | *Yes/ LTE Signal* |
| 4 | 7.6.1 | In-band blocking | *Yes/ LTE Signal* |
| *5* | *7.6.3* | *Narrow band blocking* | *Yes/ CW Signal* |
| *6* | *7.8.1* | *Wide Band Intermodulation* | *Yes/CW & LTE Signal (4TRx required)* |

***Table 34: Receiver test cases described in this application note.***

Performing test cases 7.5, 7.6.1, 7.6.3 and 7.8.1 requires the presence of extra interference that coexists with the LTE communication signal. There are many ways to generate the required interference signal. It is possible to use, for instance, an external generator such as an R&S®SMU to generate the interference signal. Alternatively, it would be possible to use the R&S®CMW500's second channel to generate the interference signal so that no external instrument is required. When the R&S®CMW500 is equipped with an R&S®CMW500-H590D advanced front end, an even simpler option is available: You can even combine the signals internally so that no external combiner is required.

The following test case description uses the R&S®CMW500's second channel to generate the interference signal, and it employs an external combiner to combine the LTE communication signal with the interference signal. Fig. 71 shows the setup for this.

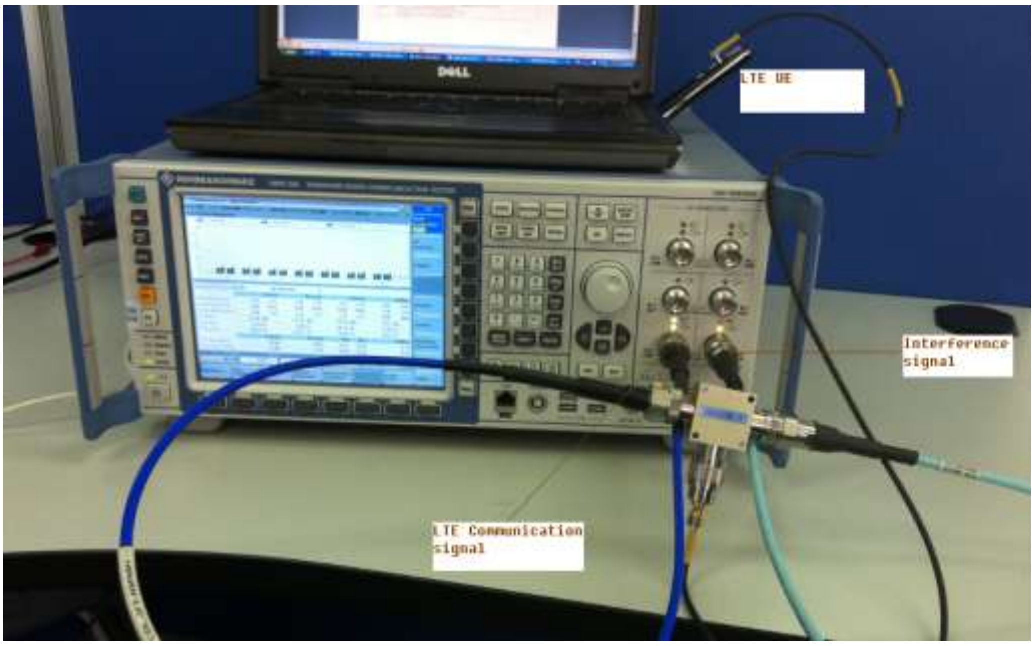



*Fig. 71: Setup for external interference testing.*

Detailed interference settings are described in the separate test steps for the test cases. Please note that, in test cases 7.5 and 7.6.1, the R&S®CMW500 should use the GPRF generator (ARB mode) to generate the interference signal. Consequently, some ARB files are needed. Furthermore, please pay close attention to the cable-loss calibration in this setup, because it differs depending on the type of combiner you are using.

For 7.8.1, two interference signals are required. One is CW signal, the other is ARB signal. Therefore, totally 3 RF signals need to be generated, including LTE signal. Only the CMWs equipped with 4 TRx channels can do this test. Detail of the setup refers to section 3.7.

### 3.1.2 Uplink Power Settings

A typical note for receiver test cases is “The transmitter shall be set to 4dB below $P_{CMAX\_L}$ at the minimum uplink configuration specified in Table 7.3.3-2 with $P_{CMAX\_L}$ as defined in clause 6.2.5”.

As for all the bands, the Uplink RB number specified in TS 36.521-1 Table 7.3.3-2 satisfies 1 dB maximum power reduction defined in TS 36.521-1 Table 6.2.3.3-1, the $P_{CMAX\_L}$ is 22 dBm if no additional maximum power reduction applies and when Note 2 in TS 36.521-1, Table 6.2.2.3-1, does not apply.

In all the test procedures for those test cases, it is mentioned “Send Uplink power control commands to the UE (less or equal to 1dB step size should be used), to ensure that the UE output power is within +0, - 3.4 dB of the target level in Table 7.5.5-2 (Case 1) for carrier frequency f ≤ 3.0GHz or within +0, -4.0 dB of the target level for carrier frequency 3.0GHz < f ≤ 4.2GHz, for at least the duration of the Throughput measurement”. Taking Band 7, 20M Bandwidth, middle range frequency as an example, this means the transmitter power should be within the range of 18dBm to 14.6dBm. According to the power control mechanism of CMW, the middle point of 18dBm and 14.6 dBm should be set as the close loop target power, which is 16.3dBm.

### 3.1.3 Filter Coefficient Setting

For all receiver tests the filter coefficient should be set as ‘fc8’. It can be changed in connected state.

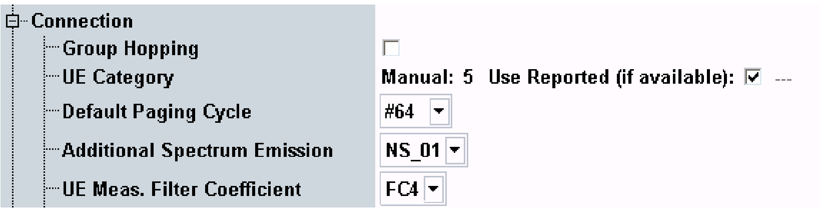



***Fig. 72: Filter Coefficient setting***

## 3.2 Reference Sensitivity Level (TS 36.521-1, 7.3)

The purpose of this test is to verify the UE’s ability to receive data at a given average throughput for a specified reference measurement channel under conditions that involve a low signal level, ideal propagation and no added noise.
A UE that is unable to meet the throughput requirement under these conditions will decrease an e-NodeB’s effective coverage area.

### 3.2.1 Test Description

For general test conditions and settings, please refer to paragraph 2.1 in this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.3.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 7.3.4.1-1 into account. Each bandwidth configuration should apply to low-range, middle-range and high-range channels. The purpose of the test is to verify QPSK modulation and full RB allocation in the downlink.

### 3.2.2 Test Procedure

Set the network signaling (NS) value to match the values specified in TS 36.521-1, Table 7.3.3-3. For bands not listed in this table (such as Band 7), use NS_01.

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell. After that, power on the LTE UE so that it attaches to the network. Then press *Connect* to establish the connection

The downlink and uplink *RMC* need to be configured according to TS 36.521-1, Table 7.3.4.1-1. Depending on the band being used, only the appropriate uplink *RB Allocation* value according to TS 36.521-1, Table 7.3.3-2, is tested for each channel bandwidth.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel. According to TS 36.521-1, Tables 7.3.4.1-1 and 7.3.3-2, only the downlink 100 RB allocation and uplink 75 RB allocation need to be set. Furthermore, the uplink RB position (*RB Pos*) should be high in order to be close to the downlink channel. *OCNG* should be enabled in the R&S®CMW500 in order to simulate the existence of other users.

Set *Active TPC Setup* to *Max Power* to ensure that the UE power reaches its maximum.

Set the downlink power level according to TS 36.521-1, Table 7.3.5-1. Please be aware that, in TS 36.521-1, Table 7.3.5-1, the power level is $P_{REFSENS}$. This has a fixed relationship with the *RS EPRE* (reference signal energy per resource element) used in the R&S®CMW500, which is:

| $P_{REFSENS}$ = RS EPRE + 10 * log10(N_RE) |
|---|

Where N_RE is the number of resource elements (12 *[number of RBs]), which depends on the DL cell bandwidth.
Consequently, in Band 7, a 20 MHz-bandwidth RS EPRE needs to be set to *–122.1 dBm* in order to reach the $P_{REFSENS}$ = –91.3 dBm. (–91.3 dBm – 10*log10(1200) = –122.1 dBm)

Measure the throughput that is achieved under these conditions. In this example, the throughput is *7884 kbps*, which represents 100 % of the scheduled throughput according to the *RMC* settings. This can be seen directly on the measurement screen. It can also be verified by checking TS 36.521-1, Table A.3.2-1.

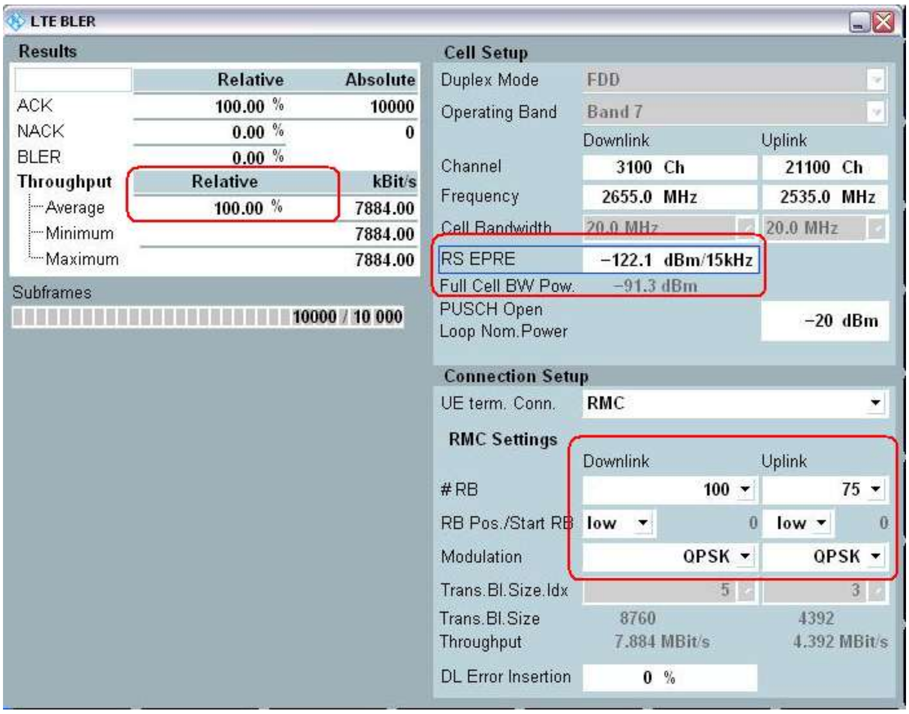



***Fig. 73: Measurement screen for the block error rate (BLER) test.***

### 3.2.3 Test Requirements

The throughput shall be ≥ 95 % of the reference measurement channels' maximum throughput. The maximum throughput for FDD is defined in TS 36.521-1, Annex A.2.2 and Table A.3.2.

## 3.3 Maximum Input Level (TS 36.521-1, 7.4)

The maximum input level test evaluates the UE's ability to receive data at a given average throughput for a specified reference measurement channel under conditions involving a high signal level, ideal propagation and no added noise.
A UE that is unable to meet the throughput requirement under these conditions will decrease the coverage area near an e-NodeB.

### 3.3.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.4.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 7.4.4.1-1 into account. Each bandwidth configuration should only apply to middle-range channels. In the Rel-9 specification, the downlink RB settings are set according to the UE category. UE categories are defined in TS36.306. (Category 1, for example, only supports diversity, and Category 5 supports a four-layer MIMO solution).

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

### 3.3.2 Test Procedure

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the R&S®CMW500. Then press *Connect* to establish the connection.

The downlink and uplink RMC need to be configured according to TS 36.521-1, Table 7.4.4.1-1.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel. The UE category here is 3. Therefore, according to TS 36.521-1, Table 7.4.4.1-1, the device must be set for an *RB Allocation* of *100* and *64QAM Modulation* for the downlink, and an *RB Allocation* of *75* and *QPSK Modulation* for the uplink. Moreover, according to TS 36.521-1, Table 7.4.4.1-1, *OCNG* should be enabled in the R&S®CMW to simulate the presence of another user.

The full cell bandwidth output power must be set to *–25.7 dBm* (if the frequency is higher than 3GHz,it should be -26 dBm). Consequently, *RS EPRE* must be set to *–56.5 dBm*, the *Active TPC Setup* to *Closed Loop*, and *Closed-Loop Target Power* to *16.3 dBm* (refers to section 3.1.2 for how this close loop target power is deduced).

Measure the throughput achieved under these conditions. In this example, the throughput is *55.36234 Mbps*, which represents 99.76 % of the scheduled throughput according to the *RMC* settings. This data can be found directly on the measurement screen. It can also be verified by checking TS 36.521-1, Table A.3.2-1.

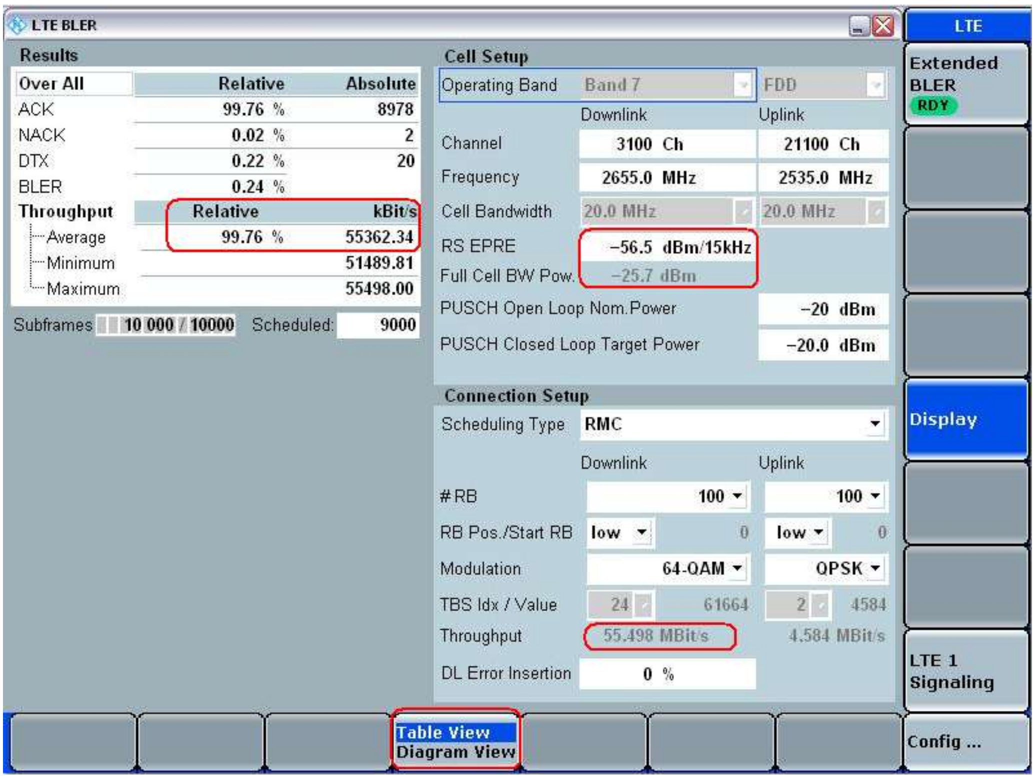



*Fig. 74: Measurement screen for throughput results.*

You can also choose the diagram view to see the throughput vs. subframes as shown in Fig. 75.

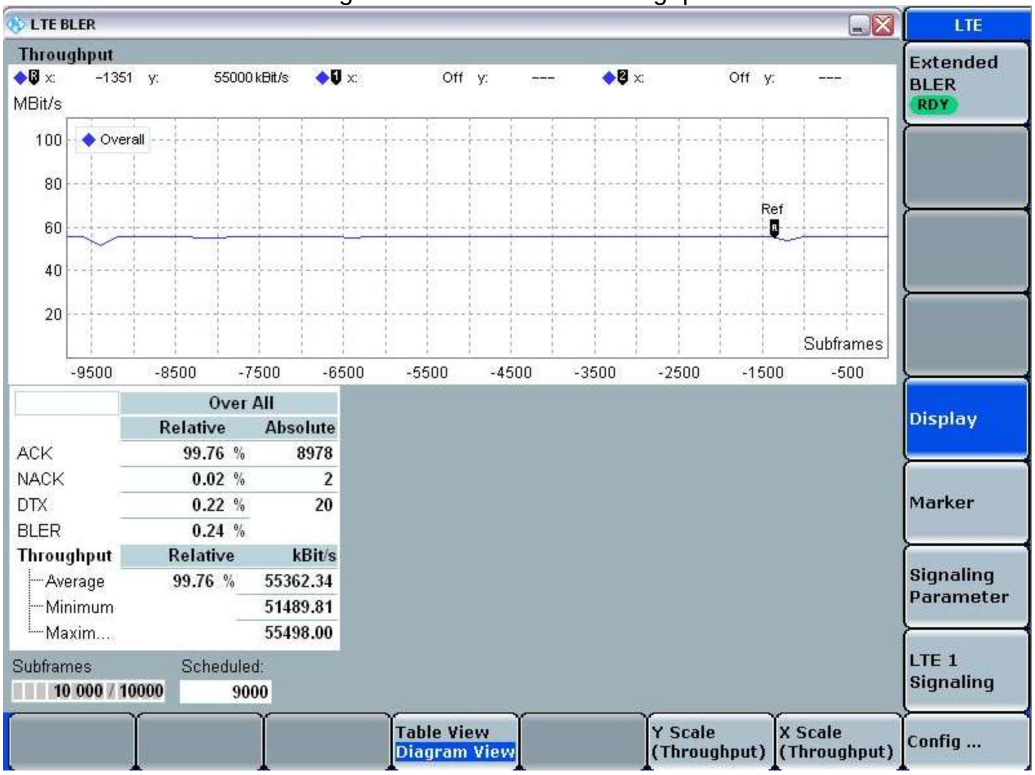



*Fig. 75: Diagram view showing throughput vs. subframes.*

### 3.3.3 Test Requirements

The throughput must be ≥ 95 % of the maximum throughput specified for the reference measurement channels in TS 36.521-1, Annex A.3.2, with the parameters specified in TS 36.521-1, Table 7.4.5-1.

## 3.4 Adjacent Channel Selectivity (TS 36.521-1, 7.5)

Adjacent channel selectivity (ACS) tests the UE's ability to receive data at a given average throughput for a specified reference measurement channel in the presence of an adjacent channel signal at a given frequency offset from the assigned channel's center frequency, under conditions of ideal propagation and without added noise.

A UE that is unable to meet the throughput requirement under these conditions will decrease the coverage area when other e-NodeB transmitters exist on the adjacent channel.

### 3.4.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.5.4.1-1.

For Band 7, the test is defined for 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 7.5.4.1-1 into account. Each bandwidth configuration should only apply to middle-range channels. The purpose of the test is to verify only *QPSK Modulation* and *Full RB Allocation* in the downlink; the uplink RMC settings are *QPSK* and *Partial RB*.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel. This test contains two test cases. It is necessary to confirm that the UE performs well for both test cases. Fig. 76 and Fig. 77 show the test case configuration. Also, please be aware that the uplink output power is different when performing the two test cases.

For case 1, set the *Active TPC Setup* to *Closed Loop*, and *Closed-Loop Target Power* to *16.3 dBm* (when Note 2 in Table 6.2.2.3-1 does not apply*)*. According to the specification, the UL Power should be 4 dB below $P_{CMAX\_L}$ with $P_{CMAX\_L}$ as defined in 3GPP 36.521, clause 6.2.5, and the powers are in the range of from 0 dB to –3.4 dB. To adapt the setting to the R&S CMW500 closed-loop power control mechanism, the target power should be 5.7 dB below the $P_{CMAX\_L.}$

For case 2, the *Closed-Loop Target Power* should be *–3.7 dBm* (when Note 2 in Table 6.2.2.3-1 does not apply*)*. According to the specification, the UL Power should be 24 dB below $P_{CMAX\_L}$, Section 3.1.2 explains how this close loop target power is deduced.

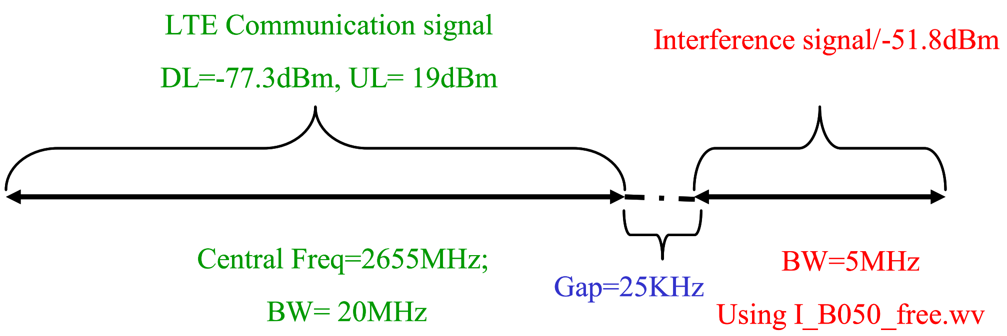



*Fig. 76: Configuration for Test Case 1.*

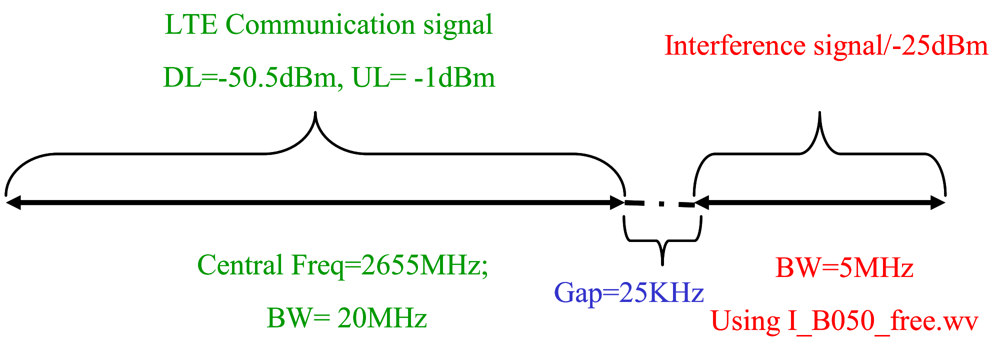



*Fig. 77: Configuration for Test Case 2.*

### 3.4.2 Test Procedure

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.5.4.1-1.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel. This test contains two subtests. Here, we list the two subtests and will use Subtest 2 as the example.

For details on setting up the interference signal, please refer to Section 3.1.1 of this application note. The detailed interference signal settings are as shown in Fig. 80 for Test Case 2.

1. Prepare the interferer signal:
   a. Activate *General Purpose RF Generator 1*
   b. Set the proper routing:

      The following examples correspond to different R&S®CMW500 hardware configurations.

      i. An R&S®CMW500 is used with two basic frontends – RF Frontend (Basic), R&S®CMW-B590A:
      The LTE uplink/downlink signal is routed to RF1 COM or RF2 COM during call setup. The Interference signal should be routed to RF3 Out or RF3 COM or RF4 COM.

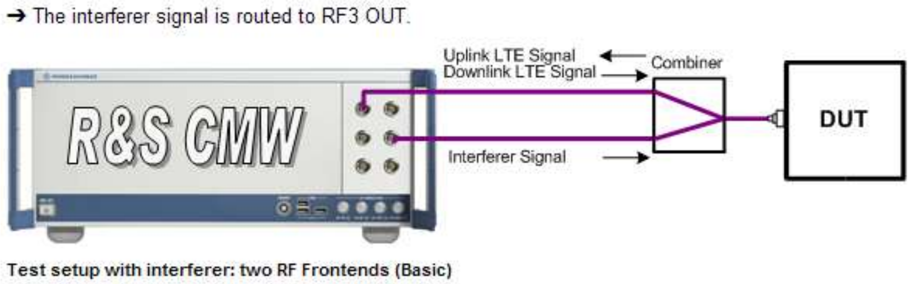



*Fig. 78: Hardware configuration with two basic frontends.*

ii. An R&S®CMW500 is used with one advanced frontend – RF Frontend (Advanced), R&S CMW-B590D:
The LTE uplink/downlink signal is routed to RF1 COM or RF2 COM during call setup.

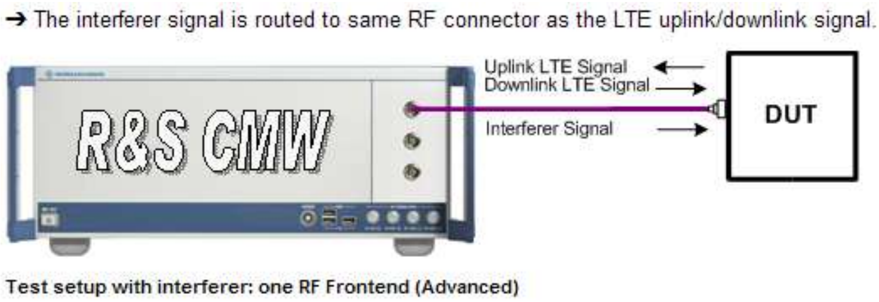



*Fig. 79: Hardware configuration with one advanced front end.*

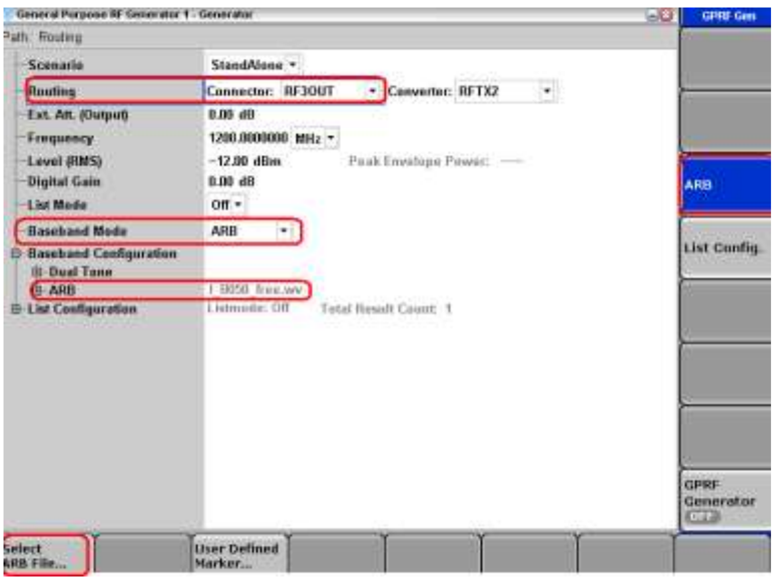



*Fig. 80: Settings for the interference signal, example 1: with two basic front ends, routing to RF3OUT.*

c. Load the waveform:

Set the *Baseband Mode* to *ARB*.
Load the interferer waveform according the bandwidth. Three free interferer waveforms are included with this application note package. You need to save them inside the R&S®CMW500:

I_B014_free.wv – Bandwidth = 1.4 MHz
I_B030_free.wv – Bandwidth = 3 MHz
I_B050_free.wv – Bandwidth = 5 MHZ

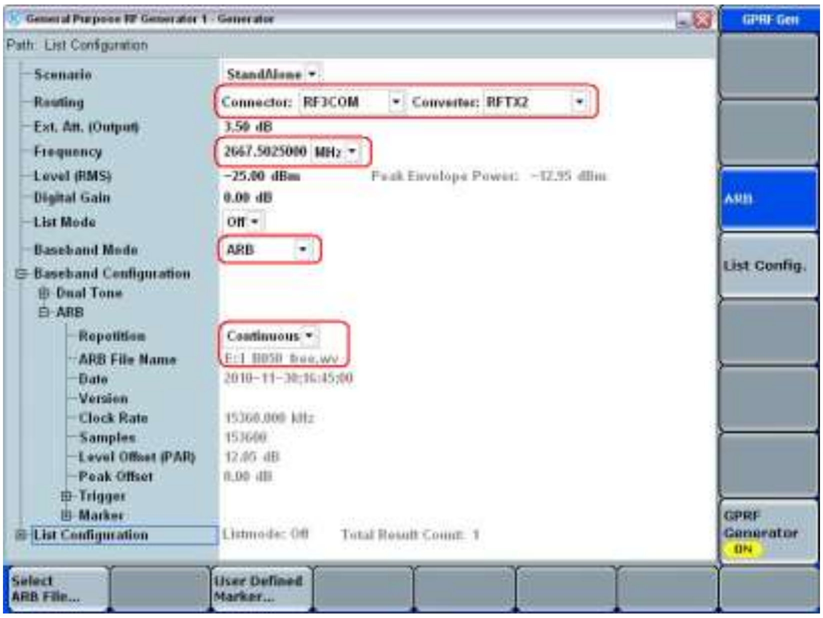



***Fig. 81: Additional settings for the interference signal, example 2: with two basic front ends, routing to RF3COM.***

2. Setup the downlink and uplink:
The downlink needs to be configured for an *RB allocation* of *100* with *Modulation* set to *QPSK*, and the uplink must be configured for an *RB allocation* of *75* with the *Modulation* set to *QPSK*. In addition, according to Table 7.5.4.1-1, *OCNG* should be enabled in the R&S®CMW500 in order to simulate the presence of another user.

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the R&S®CMW500. Then press *Connect* to establish the connection.

The full cell bandwidth output power must be set to *–50.5 dBm*. Therefore, *RS EPRE* must be set to *–81.3 dBm*, the *Active TPC Setup* to *Closed Loop*, and *Closed-Loop Target Power* to –*3.7 dBm* (Case 2).Section 3.1.2 explains how this close loop target power is deduced

Measure the throughput achieved under these conditions. In this example, the throughput has been measured at *7869.98 kbps*, which represents 99.82 % of the scheduled throughput. Consequently, these results pass this test.

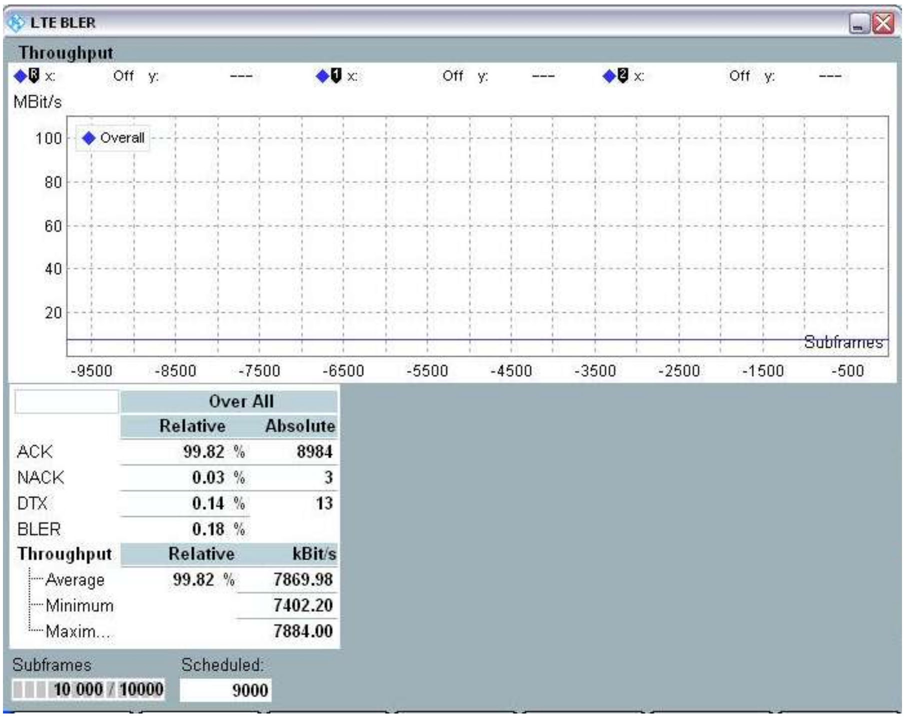



***Fig. 82: Throughput results for the adjacent channel selectivity test.***

### 3.4.3 Test Requirements

The throughput $R_{av}$ shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annex A.3.2 under the conditions specified in TS 36.521-1, Table 7.5.5-2, and also under the conditions specified in Table 7.5.5-3.

## 3.5 In-Band Blocking (TS 36.521-1, 7.6.1)

In-band blocking is defined for an unwanted interfering signal falling into the range that extends from 15 MHz below to 15 MHz above the UE receive band. Within this range, the relative throughput must meet or exceed the requirements for the specified measurement channels. The lack of in-band blocking capabilities will decrease the coverage area when other e-NodeB transmitters are present (except in the adjacent channels and the spurious response).

### 3.5.1 Test Description

In this test, the interference should be an LTE signal. The test points should be within +/– 15 MHz of the UE receive band. Furthermore, the frequency gap between the test points should be the interferer bandwidth.
The interference bandwidth is specified in TS 36.521-1, Table 7.6.1.3-1.
The interference frequency is the transmission band’s center frequency plus the offset defined in TS 36.521-1, Table 7.6.1.3-1.
The interference signal power is specified in TS 36.521-1, Table 7.6.1.3-2.
The UE transmitting power should be 4 dB lower than the max. power for its power class.

| Rx parameter | Units | Channel bandwidth | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1.4 MHz | 3 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Power in transmission bandwidth configuration | dBm | REFSENS + Channel bandwidth specific value below | | | | | |
| | | 6 | 6 | 6 | 6 | 7 | 9 |
| $BW_{Interferer}$ | MHz | 1.4 | 3 | 5 | 5 | 5 | 5 |
| $F_{Ioffset, case 1}$ | MHz | 2.1+0.0125 | 4.5+0.0075 | 7.5+0.0125 | 7.5+0.0025 | 7.5+0.0075 | 7.5+0.0125 |
| $F_{Ioffset, case 2}$ | MHz | 3.5+0.0075 | 7.5+0.0075 | 12.5+0.0075 | 12.5+0.0125 | 12.5+0.0025 | 12.5+0.0075 |
| NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L}$ at the minimum uplink configuration specified in TS 36.521-1, Table 7.3.3-2 with $P_{CMAX\_L}$ as defined in clause 6.2.5.<br>NOTE 2: The interferer consists of the reference measurement channel specified in Annex A.3.2 with one-sided dynamic OCNG Pattern OP.1 FDD/TDD as described in TS 36.521-1, Annex A.5.1.1/A.5.2.1 and set-up according to Annex C.3.1. | | | | | | | |

***Table 35: In-band blocking parameters (source: TS 36.521-1, Table 7.6.1.3-1).***

| E-UTRA band | Parameter | Units | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|---|
| | **$P_{Interferer}$** | **dBm** | **–56** | **–44** | **–30** |
| | $F_{Interferer}$ (Offset) | MHz | =–BW/2 – $F_{Ioffset, case 1}$ & =+BW/2 + $F_{Ioffset, case 1}$ | ≤ –BW/2 – $F_{Ioffset, case 2}$ & ≥ +BW/2 + $F_{Ioffset, case 2}$ | –BW/2 – 9 MHz & –BW/2 – 15 MHz |
| 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12, 13, 18, 19, 20, 21, 33,34,35,36,37,38,39,40, 41 | $F_{Interferer}$ | MHz | (Note 2) | $F_{DL\_low}$ –15 to $F_{DL\_high}$ +15 | |
| 17 | $F_{Interferer}$ | MHz | (Note 2) | $F_{DL\_low}$ –9.0 to $F_{DL\_high}$ +15 | $F_{DL\_low}$ –15 and $F_{DL\_low}$ –9.0 (Note 3) |
| Note 1: For certain bands, the unwanted modulated interfering signal may not fall inside the UE receive band, but within the first 15 MHz below or above the UE receive band.<br>Note 2: For each carrier frequency, the requirement is valid for two frequencies: the carrier frequency – BW/2 – FIoffset, Case 1, and the carrier frequency + BW/2 + FIoffset, case 1.<br>Note 3: $F_{interferer}$ range values for unwanted modulated interfering signal are interferer center frequencies.<br>Note 4: Case 3 only applies to an assigned UE channel bandwidth of 5 MHz. | | | | | |

***Table 36: In-band blocking (source: TS 36.521-1, Table 7.6.1.3-2).***

## 3.5.2 Test Procedure

For information on preparing the interferer signal, please refer to Section 3.5.1, Test Case 7.5. The details can also be seen in Fig. 83.

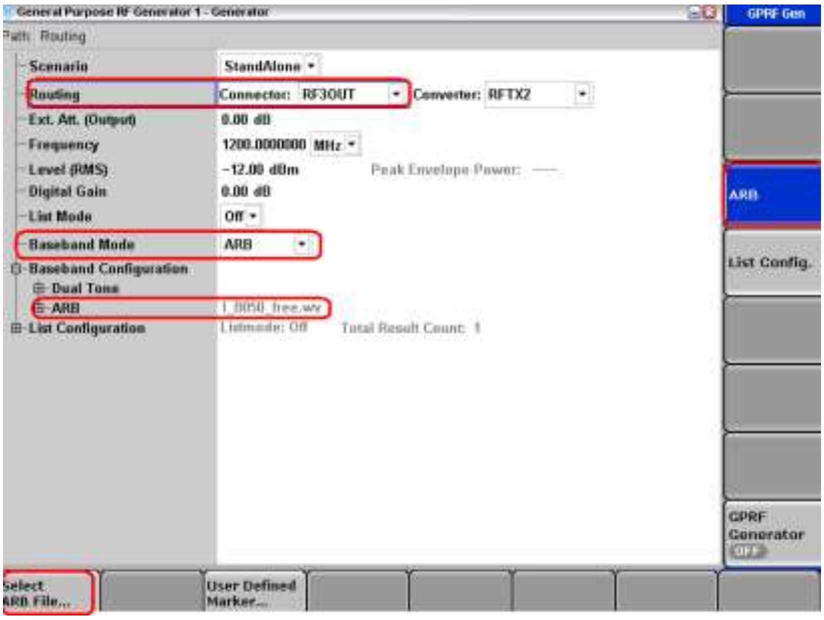



*Fig. 83: Preparing the interferer signal.*

Table 37 provides an example of the test points for Band 4, DL Channel 2000, at a frequency of 2115 MHz and a 10 MHz Bandwidth. Section 3.1.2 explains how this close loop target power is deduced.

| Case # - Testpoint | Interferer frequency (MHz) | Interferer bandwidth (MHz) | Interferer power (dBm) | RS EPRE (dBm) | UL power (closed loop) (dBm) | DL RB # / UL RB # |
|---|---|---|---|---|---|---|
| 1 - 1 | **2127.5025** | 5 | **–56** | –118.1 | 16.3 | 50 / 50 |
| 1 - 2 | **2102.4975** | 5 | **–56** | –118.1 | 16.3 | 50 / 50 |
| 2 – 1 | **2097.4875** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 2 | **2132.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 3 | **2137.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 4 | **2142.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 5 | **2147.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 6 | **2152.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 7 | **2157.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 8 | **2162.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |
| 2 – 9 | **2167.5125** | 5 | –44 | –118.1 | 16.3 | 50 / 50 |

*Table 37: Example test points.*

Depending on the frequency band, the *UL RB* may be set differently. See TS 36.521-1, Table 7.3.3-2 for details.

The test steps, including setting of the interferer signal, are the same as for Test Case 7.3.

## 3.5.3 Test Requirements

The throughput measurement defined in the test procedure must be ≥ 95% of the reference measurement channel’s maximum throughput, as specified in TS 36.521-1, Annex A.3.2.

## 3.6 Narrow-Band Blocking (TS 36.521-1, 7.6.3)

The purpose of this test is to verify a receiver's ability to receive an E-UTRA signal at its assigned channel frequency in the presence of an unwanted narrow-band continuous wave (CW) interferer at a frequency that is less than the nominal channel spacing.

The lack of narrow-band blocking capabilities will decrease the coverage area when other e-NodeB transmitters exist.

### 3.6.1 Test Description

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.6.3.4.1-1.

For Band 7, the test is defined for the 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 7.6.3.4.1-1 into account. Each bandwidth configuration should only apply to middle-range channels. The test will only verify *QPSK Modulation* and *Full RB Allocation* in the downlink; the uplink *RMC* settings are *QPSK* and *Partial RB Allocation* according to TS 36.521, Table 7.6.3.4.1-1.

This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

### 3.6.2 Test Procedure

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for the bandwidth, frequency and RMC, along with details on the RB allocations, are defined in TS 36.521, Table 7.6.3.4.1-1. This example will use Band 7, a 20 MHz bandwidth and a middle-range channel.

For the interference signal setup, please refer to Section 3.1.1 of this application note. The detailed interference signal settings are to be configured as shown in Fig. 84.

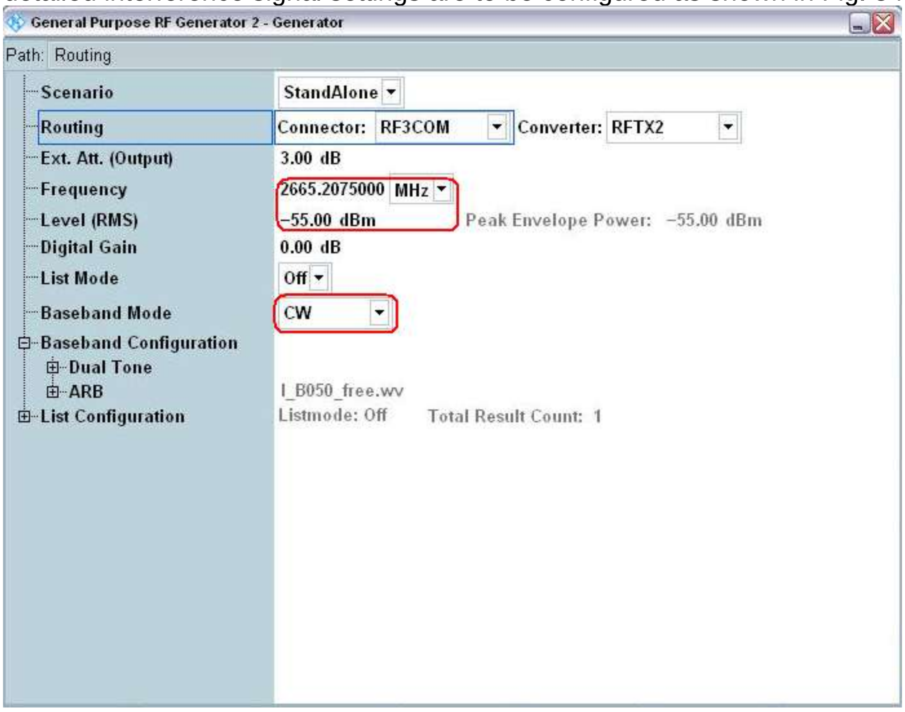



***Fig. 84: Interference signal settings for the narrow-band blocking test.***

The downlink must be set for an *RB Allocation* of *100* and *QPSK Modulation*, and the uplink must be set for an *RB Allocation* of *75 RB* and *QPSK Modulation*. Furthermore, according to TS 36.521-1, Table 7.6.3.4.1-1, *OCNG* should be enabled in R&S®CMW to simulate other users' existence.

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the R&S®CMW500. Then press *Connect* to establish the connection.

The full cell bandwidth output power must be set at *–75.3 dBm*. Therefore, the *RS EPRE* must be set to *–106.1 dBm*, the *Active TPC Setup* to *Closed Loop*, and the *Closed-Loop Target Power* to *16.3 dBm.* Section 3.1.2 explains how this close loop target power is deduced.

Measure the throughput achieved under these conditions. In this example, the measured throughput is *7870.86 kbps*, which represents 99.83 % of the scheduled throughput. Consequently, the test has been passed.

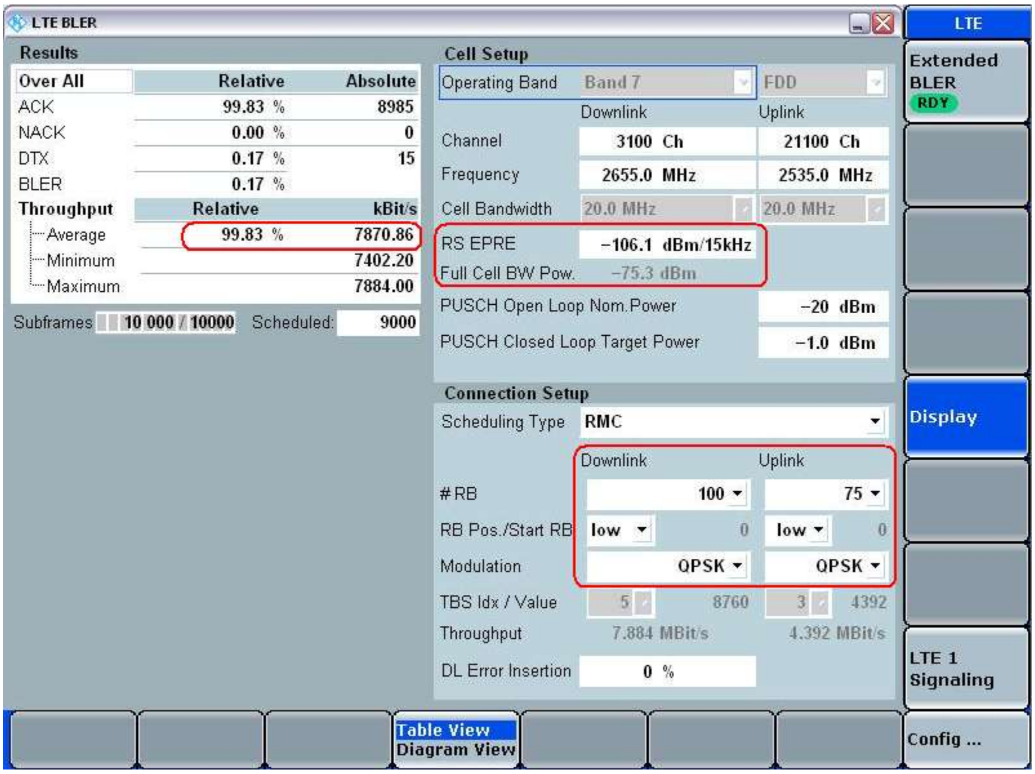



***Fig. 85: Measurement results for the narrow-band blocking test.***

### 3.6.3 Test Requirements

The throughput measurement derived using the test procedure shall be ≥ 95 % of the reference measurement channels' maximum throughput as specified in TS 36.521-1, Annex A.3.2, with the parameters specified in TS 36.521-1, Table 7.6.3.5-1.

# 3.7 Wide band Intermodulation (TS 36.521-1, 7.8.1)

## 3.7.1 Test Description

Intermodulation response tests the UE's ability to receive data with a given average throughput for a specified reference measurement channel, in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal, under conditions of ideal propagation and no added noise.

For general test conditions and settings, please refer to Section 2.1 of this application note.

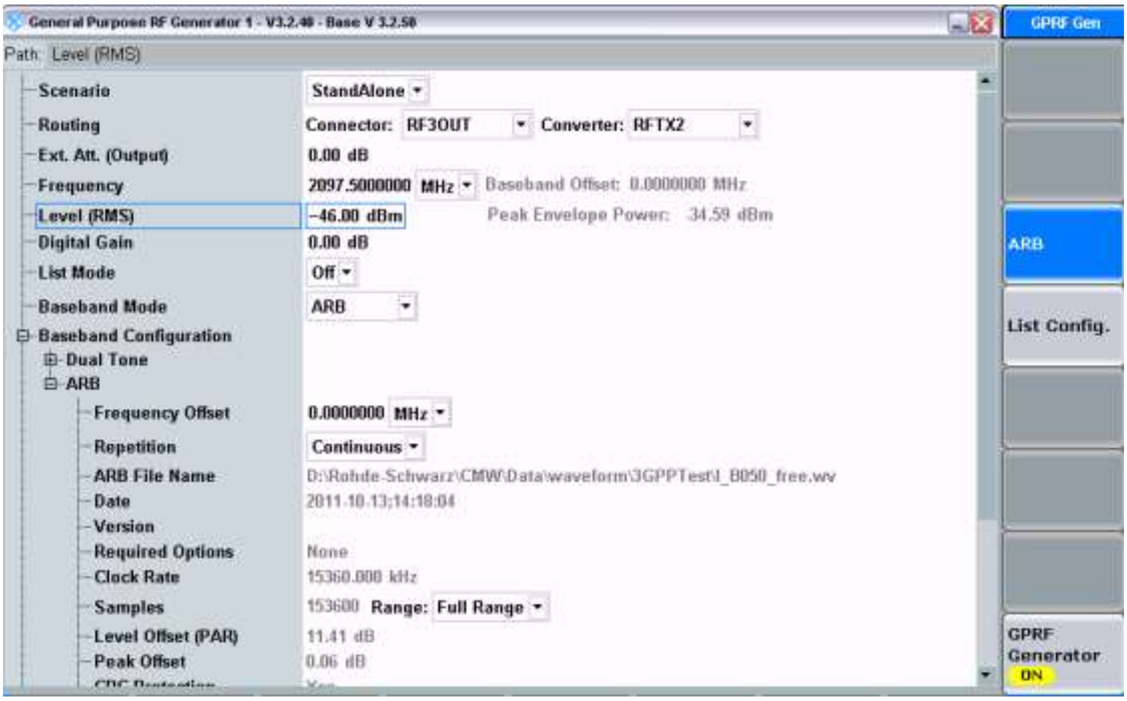
For Band 3, the test is defined for the 1.4M, 5 MHz and 20 MHz bandwidths taking TS 36.521, Tables 5.4.2.1-1 and 7.8.1.4.1-1 into account. Each bandwidth configuration should only apply to middle-range channels. The test will only verify *QPSK Modulation* and *Full RB Allocation* in the downlink; the uplink *RMC* settings are *QPSK* and *Partial RB Allocation* according to TS 36.521, Table 7.8.1.4.1-1.

## 3.7.2 Test Procedure

This test requires a CMW500 with 4 RF Channels, as it requires LTE signal plus two interference signals, CW signal and ARB signal. Only one B110 is required.

This example will use Band 3, a 20 MHz bandwidth and a middle-range channel.

The detail of the interference signal setup can be referred to Fig. 88.



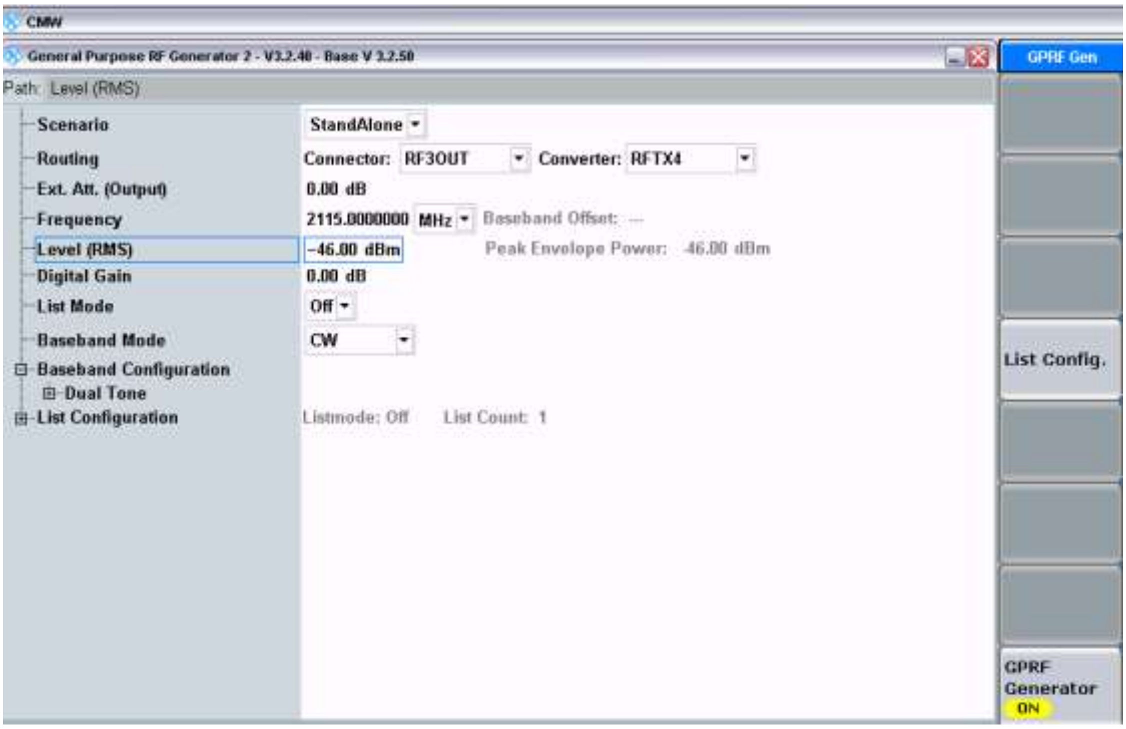



***Fig. 86: Gentral Purpose RF Generator 1 & 2 settings***

The downlink must be set for an *RB Allocation* of *100* and *QPSK Modulation*, and the uplink should be set for an *RB Allocation* of *100 RB* and *QPSK Modulation*. Furthermore, according to TS 36.521-1, Table 7.8.1.5-1, *OCNG* should be enabled in R&S®CMW to simulate other users' existence.

Connect the SS to the UE antenna connectors as shown in TS 36.508, Annex A, Figure A3. Enable the LTE cell, and power on the LTE UE so that it attaches to the R&S®CMW500. Then press *Connect* to establish the connection.

The full cell bandwidth output power must be set at *–84.3 dBm*. Therefore, the *RS EPRE* must be set to *–115.1 dBm*, the *Active TPC Setup* to *Closed Loop*, and the *Closed-Loop Target Power* to *16.3 dBm*. Section 3.1.2 explains how this close loop target power is deduced.

Measure the throughput achieved under these conditions.

### 3.7.3 Test Requirements

The throughput measurement derived using the test procedure shall be ≥ 95 % of the reference measurement channels' maximum throughput.

# 4 Literature

[1] 3GPP TS 36.521-1
Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception;
Part 1: Conformance testing

[2] 3GPP TS 36.508
Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Common test environments for User Equipment (UE) conformance testing

[3] R&S®CMW500 Wideband Radio Communication Tester Operating Manual

# 5 Additional Information

Please send your comments and suggestions regarding this application note to:
Jenny.Chen@rohde-schwarz.com or
Guenter.Pfeifer@rohde-schwarz.com

In addition, please visit the R&S®CMW500 web site at:
www.rohde-schwarz.com/product/CMW500

# 6 Ordering Information

Please visit our website www.rohde-schwarz.com, and contact your local Rohde & Schwarz sales office for further assistance.

| Ordering Information | | |
|---|---|---|
| **Name** | **Description** | **Order number** |
| R&S®CMW500 | Wideband Radio Communication Tester | 1201.0002K50 |
| R&S®CMW-PS503 | R&S®CMW500 Mainframe | 1208.7154.02 |
| R&S®CMW-S100A | Baseband Measurement Unit | 1202.4701.02 |
| R&S®CMW-S570B | RF Converter (TRX) | 1202.5008.03 |
| R&S®CMW-S550B | Baseband Interconnection Board (Flexible Link) | 1202.4801.03 |
| R&S® CMW-B570B | Extra RF Converter (TRX) | 1202.8659.03 |
| R&S®CMW-S590D | RF Front-End Module Advanced | 1202.5108.03 |
| R&S®CMW-S600B | Front Panel with Display/Keypad | 1201.0102.03 |
| R&S®CMW-B620A | Digital Video Interface (DVI) Module | 1202.5808.02 |
| R&S®CMW-B300B | Signalling Unit Wideband (SUW) | 1202.6304.03 |
| R&S®CMW-KS500 | LTE FDD Release 8, SISO, signalling/network emulation, basic functionality | 1203.6108.02 |
| R&S®CMW-KM500 | LTE FDD Release 8, TX measurement, uplink | 1203.5501.02 |
| R&S®CMW-KS550 | LTE TDD (TD-LTE) Release 8, signalling/network emulation, basic functionality | 1204.8904.02 |
| R&S®CMW-KM550 | LTE TDD (TD-LTE) Release 8, TX measurement, uplink | 1203.8952.02 |
| R&S®CMW-KS510 | LTE Release 8, SISO, signalling/network emulation, advanced functionality | 1203.9859.02 |
| R&S®CMW-KT055 | LTE, CMWrun sequencer software tool | 1207.2107.02 |
| R&S®CMW-Z04 | Mini-UICC Test Card, supporting 3GPP SIM/USIM/ISIM/CSIM applications | 1207.9901.02 |
| R&S® CMW-Z05 | Nano UICC Test Card, supporting 3GPP SIM/USIM/ISIM/CSIM applications | 1208.5651.02 |

# 7 Annex A

This chapter is dedicated to highlighting the precautions that must be taken during the test to avoid measurement errors, dropping of calls or synchronization errors.

## 7.1 Precautions for the ON/OFF Time Mask

To make the OFF power measurement accurate, Rohde & Schwarz recommends setting the *Reference Level* to *UE (PUSCH / PRACH / SRS ON Peak Power Level + 2 )*. If the OFF power is not within the R&S®CMW500's dynamic range, it could be wrong.

## 7.2 Automatic testing with CMWRun

CMWRun is a software platform in which the user can compose their own test sequence for automatic testing. Rohde & Schwarz provides a LTE3GPPTestv9.7.dll to support automatic testing according to 3GPP TS36.521-1 for all the test cases described in this application note.

A screenshot of the test property and measurement report is shown as below as an example:

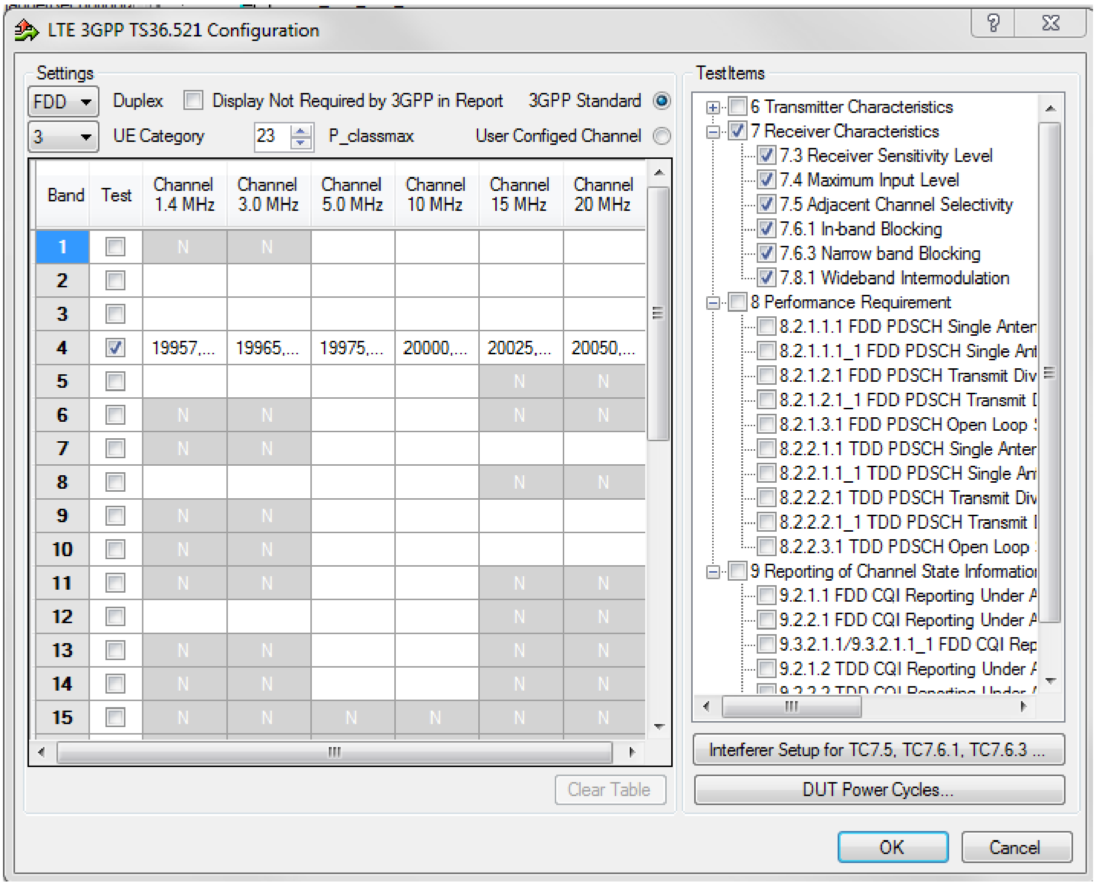



***Fig. 87: Configuration window for 36.521 tests in CMWrun***

LTE 3GPP V9.3 Test Cases: According to User Configuration

| 6.5.2.1 Error Vector Magnitude (EVM) for PUSCH | UL Modulation, #RB | Limit | Measured | Unit | Status |
|---|---|---|---|---|---|
| 6.5.2.1 Error Vector Magnitude (EVM) for PUSCH @ Band40 | | | | | |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 18 (RB_Pos:LOW) | <= 17.50 | 3.21 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 18 (RB_Pos:LOW) | <= 17.50 | 3.40 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 18 (RB_Pos:HIGH) | <= 17.50 | 2.99 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 18 (RB_Pos:HIGH) | <= 17.50 | 2.97 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 100 (RB_Pos:LOW) | <= 17.50 | 3.21 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | QPSK, 100 (RB_Pos:LOW) | <= 17.50 | 3.17 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 18 (RB_Pos:LOW) | <= 12.50 | 4.59 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 18 (RB_Pos:LOW) | <= 12.50 | 3.53 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 18 (RB_Pos:HIGH) | <= 12.50 | 4.54 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 18 (RB_Pos:HIGH) | <= 12.50 | 3.51 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 100 (RB_Pos:LOW) | <= 12.50 | 4.81 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: 23 dBm | Q16, 100 (RB_Pos:LOW) | <= 12.50 | 4.05 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 18 (RB_Pos:LOW) | <= 17.50 | 2.27 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 18 (RB_Pos:LOW) | <= 17.50 | 2.47 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 18 (RB_Pos:HIGH) | <= 17.50 | 2.42 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 18 (RB_Pos:HIGH) | <= 17.50 | 2.87 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 100 (RB_Pos:LOW) | <= 17.50 | 3.07 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | QPSK, 100 (RB_Pos:LOW) | <= 17.50 | 3.17 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 18 (RB_Pos:LOW) | <= 12.50 | 2.31 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 18 (RB_Pos:LOW) | <= 12.50 | 2.40 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 18 (RB_Pos:HIGH) | <= 12.50 | 2.47 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 18 (RB_Pos:HIGH) | <= 12.50 | 2.73 | % | Passed |
| PUSCH EVM: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 100 (RB_Pos:LOW) | <= 12.50 | 3.17 | % | Passed |
| PUSCH EVM DMRS: @ULCH: 39150, BW: 20 MHz, ULPower: -36.8 dBm | Q16, 100 (RB_Pos:LOW) | <= 12.50 | 3.29 | % | Passed |

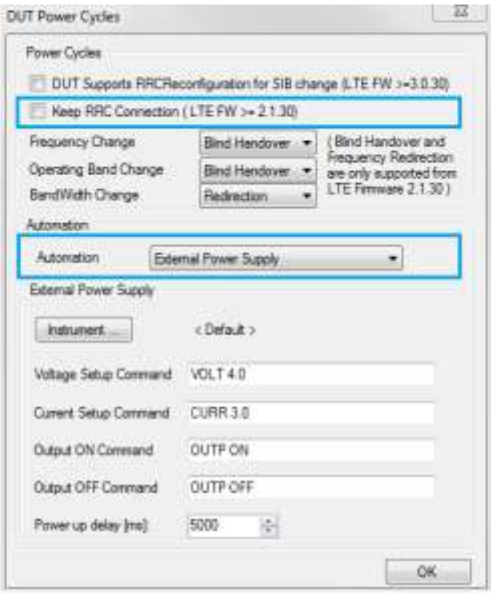
***Fig. 88: CMWrun measurement result report example***

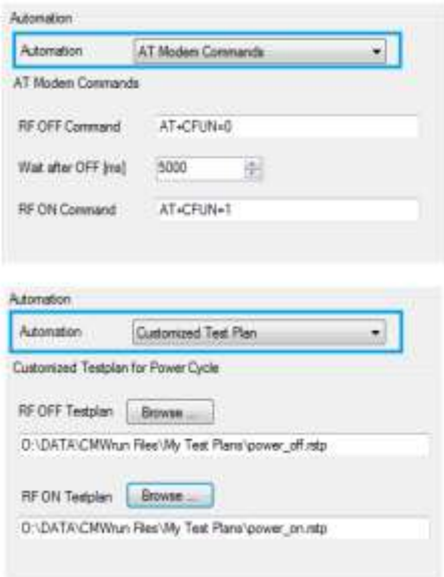
Pressing the *DUT Power Cycle* button will lead to a popup window as shown below.

If idle mode (deselect *Keep PRC Connection*) is activated, p-max change, NS change and all those open loop power test parameters can be changed at RRC Idle mode, which requires no DUT power cycle.

If the *DUT Supports RRCReconfiguration* is selected, the p-max change and NS change will be done at RRC Connected mode via RRCReconfiguration procedure. Please be noted that this feature may not be supported by every mobile.

In case power cycle is still needed due to different reasons, automation can be done with the right selection, as shown below.




LTE3GPPTestv9.7.dll and LTE3GPPCustomilze.dll are released in 2012.
LTE3GPPCustomize.dll allows the user to configure all the testcases with their own testpoints, including user defined bands.
LTE3GPPTestv9.7.dll also includes now bands beyond 3GHz and updated limits accordingly.
Chapter 8 and 9 tests are also added in LTE3GPPTestv9.7.dll.
Usually, the above dlls are used together with LTECallSetup.dll. The *Scenario, Network parameters* should be configured properly in LTECallSetup.dll.
The latest CMWRun software can be downloaded from Rohdes & Schwarz Gloris:
https://extranet.rohde-schwarz.com/live/rs/extranet/

Please be noted that KT055 software option is required to run the LTE3GPPTestv9.7.dll and other related LTE test dlls.

**About Rohde & Schwarz**
Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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