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

# **Application Note**

# Products:

| R&S<sup>®</sup>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<sup>®</sup>CMW500 wideband radio communication tester to perform LTE R8 transmitter and receiver measurements according to this test specification.



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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.

S Save Parcall								Save-Recall
Patt: E.S.							1	
G-CD:Rahd	n Schwarz CNW File000.dfl	Data Save	2	296 KB	30,11	2010-09:28:34		Li Save
B E-ADSB	10							H Sucul
								Partial Bavo
								e Partial Marcal
	a.v		-		144		111.100%	
Add folder	ZRansma.	<b>B</b> CHIT	Enab	× 0	iato	Sheve		

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

Cell set up	3GPP TS 36.508, Sub Clause 4.4.3
Propagation conditions	3GPP TS 36.521, Annex B.0
Uplink reference measurement	3GPP TS 36.521, Annex A.2
Configuration of PDSCH and	3GPP TS 36.521, Annex C.2
PDCCH before measurement	
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

The following parameters are set according to these specifications:

#### 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.

th Shortcut Softkey	
Duplex Mode	FDO
Scenario	Standard Cell +
-RF Settings	
J-Downlink Power Levels	
-RS EPRE	-85.0 dBm/15kHz Full Cell BW Power: -57.2 dBm
-PSS Power Offset	0.0 dB
-SSS Pewer Offset	0.0 dB
-PBCH Power Offset	0.0 dB
-PCFICH Power Offset	0.0 dB
	0.0 dB
-PDCCH Power Offset	8b 0.0
-OCNG	D
D PDSCH	
-Power Offset PA	0 dB • thoA: 0 dB
-Power Ratio Index PB	0 rhoBirhoA: 1
AWGN	☐ -98.0 dBm/15kHz
Uplink Power Control	
B Physical Cell Setup	
B Network	
Connection	
2 OE Measurement Report	

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 <sub>UL</sub>	Frequency of Uplink [MHz]	N <sub>DL</sub>	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.

Path: RF Settings/RF Power Uplink/Exp. No	ominal Power Mode
Duplex Mode Scenario ⊟-RF Settings ⊞-RF Output ⊞-RF Input ⊞-RF Frequency ⊟-RF Power Uplink	Standard Cell
	According to UL Power Control Settings 💌
-Exp. Nominal Power Margin Downlink Power Levels Uplink Power Control Physical Cell Setup Network Connection UE Measurement Report Shortcut Softkey	-10.00 dBm Ref.Level: 2.00 dBm 12.00 dB

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.

Duplex Mode	FDD -
Scenario	Combined Signal Path 🔹
Controlled by	LTE Sig1 🔹

#### 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.

TE Multi Evaluation Configuration		1
Measurement Control/PUCCH i	Format	
Measurement Control		
Repetition	SingleShot -	
Stop Condition	None -	
Measure on Exception	C.	
-Frame Structure	Type 1	
Cyclic Prefix	Normal	
Channel Bandwidth	20.0 884	
Channel Tunn	AUTO -	
Channel Type	ABIO	
PUCCH Format	F1	
-Network Signaled Value	NS_01 +	
D View Filter		
NRB		
Channel Type	F PUSCH -	
CRB Allocation		
Auto	R	
No RB	50	
Offset RB	0	
Physical Cell ID		(E) *
- Modulation		
	Auto 🔻	

# 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*.

CMW								6/2/2
LTE Meetur	ement - 93,8,29 - 13	Measurement					LIE	DESET
Multi Ev	valuation PR	IACH SRS Inf Lover: 5.00 ef	im Bactwilli	10.0 MHz Cyck	Prefix Normal	Meas Sut N 0	Multi Evaluation	ano neo
EVM			EVM vs Su	hcarrier			CLLP.	SAVE
۹.		55-7044 Symbol	×			Subcarner	RF Bettinos	SETUP
Magnitude	Error		Inband En	issions			autungs	PRINT
3	0.1	SC POWA Pyrebul	11	1.1.1		Response Mark	Trigger	HELP
Phase Erro	5.		Equalizer	Spectrum Flatr	ess			
		SC FOMA Byrden	4			laborer	(n)	DEVLE
Power Dyn	amics		1	10				WIZARD
ater,			1	8	1		E.os	MEW
Power Mor	itter	Charles and the second second	Spectrum	ACLR	199.12		Display	MEASURE
allers .		National (TT)	¢ ins			Mis	0	SIGNAL GEN
RB Allecati	ion Table		Spectrum	Emission Mask	÷			I ON
Peterte Bick	9	Saffwree (TT)	din .			699		CORESTAR?
TX Measur	ementCurrent:						Parameter	STOP
TX Power - EVM RMS I - IQ Offset - Freq Error -						1000	TASKS	
🚱 PS	RRC State:	in-					LTE Signaling ON	
Cell Setup	Connection Setup		DL Error Josertion	TPC	Power	Enable CQI Reporting	Config	

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.

S LTE Signaling Configuration			
Path Physical Cell Setup/TDD/Special Subfra	me		
PUSCH     Open Loop Nominal Power     D TX Power Control (TPC)	<b>~2 dBm @</b> Full R8 Alloc	ation	
Active TPC Setup	Constant Power		
Closed Loop Target Power Single Pattern S-User defined Pattern PUCCH	20.0 dBm		
Max. allowed Power P-Max	23 dBm		
Physical Cell Setup			
DL Cell Bandwidth	20.0 MHz - //REI Max:	100	
UL Cell Bandwidth	20.0 MHz		
- Physical Cell ID	0		
-Cyclic Prefix	Normai		
- Sounding RS (SRS)	E.		
E-TDD Uplink Downlink Configuration	1		
Special Subframe	5		
B-PRACH			
-Network			
Connection			
B-UE Measurement Report			
Messaging (SMS)			

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: *IRB* 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.

LTE Signate	ng 1 - V3.8.20				- 22	LTE
Connection Cell Packet Switch	e Status	Cell Setup Operating Band	Cell Setup Operating Band Band 7 • Downlink			LTE 1 TX Meas.
RRC State	Connected	Channel	2850	Ch	20850 Ch	LTE 1
-		Frequency	2638.0	MHz	2510.0 MHz	ERT.BLCA
Event Log	tate "Connection Futublished"	_ Cell Bandwidth	28.0 MHz	22	20.0 MHz	Constant of the second
00:10:23 0 E	PS Dedicated Dearse Established Jate "Attached"	RS EPRE Full Cell BW Pow	-85.0 (	<mark>IBm/15kHz</mark> IBm		Go to
RE1821 0 E	PS Dedicated Binarier Reloased tale "Connection Established"	PUSCH Open Los	PUSCH Open Loop Nom Power -20 dBm PUSCH Closed Loop Target Power -20.0 dBm			Duration
08:10:10 0 E	PS Ordicated Bearer Established Lane Atlanched PS Defend Hourse Established	PUSCH Clased La				Routing
UE Info	•	Connection Set	up			1
IMEI IMSI UE IPv4 Add	001027009090900 001010123450063 ress[0] 192.168.48.520	- Scheduing KMC	Downlink		plink	
UE IPv6 Pref	f#[0] —	#RB	<u> </u>	100 -	100 +	1
		RB Pos./Start RB	lew *	.0	low • 0	
		Modulation		OPSK •	QPSK +	C.
		TBS ldx / Value Throughput	5 7.884 (	8760 Miliit/s	2 1 4584 4.584 Mbitts	Signaling ON
Detach	Disconnect		Sei	nd SMS	Handover	Confin
				100000	and the second second	

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<sub>UMAX</sub>.
- 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 <sub>UMAX</sub>
Test Set 2	18	High	QPSK	P <sub>UMAX</sub>
Test Set 3	18	Low	16QAM	P <sub>UMAX</sub>
Test Set 4	18	High	16QAM	P <sub>UMAX</sub>
Test Set 5	100	Low	QPSK	P <sub>UMAX</sub>
Test Set 6	100	Low	16QAM	P <sub>UMAX</sub>

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<sub>UMAX</sub>.
- 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	16QAM, partial RB allocation	16QAM, full RB allocation tol. (dB)
		(UD)		(ub)
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<sup>®</sup>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.

🚸 LTE Signaling Configuration	E
Path: Connection/Additional Spectrum Emissi	ion
Duplex Mode	FDD Z
Scenario	Standard Cell 🔹
-Enable Data end to end	V
⊞RF Settings	
🕀 Downlink Power Levels	
Uplink Power Control	
Physical Cell Setup	
UE Category	Manual: 5 Use Reported (if available): M
Default Paging Cycle	#64 •
	NS_01 -
	FC4 💌
Connection Type	Testmode •
ide − Testmode	
	Unacknowledged 🕢
SIB Reconfiguration	SIB Paging 🔹
-Keep RRC Connection	
-Downlink MAC Padding	
- Downlink MAC Error Insertion	0 %
Send DNS PCO	<b>V</b>

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
Б	NS 07	6.6.2.2.3.3	13
5	NO_07	6.6.3.3.3.2	
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<sup>®</sup>CMW500 from *NS\_01* to *NS\_05* as shown in Fig. 19 at Cell ON state.

🊸 LTE Signaling Configuration	
Path: Connection/Additional Spectrum Emis	sion
Duplex Mode     Duplex Mode     P.RF Settings     Downlink Power Levels     Uplink Power Control     Physical Cell Setup     Network     H-Identity     Security Settings     UE Identity     Connection     Testmode     Downlink Error Insertion     Downlink Padding     Additional Spectrum Emission	FDD 0 % 2 NS 05 V
UE Meas. Filter Coefficient —UE terminated Conn. Type ⊞-RMC ⊞-Shortcut Softkey	FC4 V RMC V

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	#RB	RB Pos/Start RB	Modulation	UE Output Power
3	1	Low & High	QPSK	P <sub>UMAX</sub>
4	12	Low & High	QPSK	PUMAX
5	48	Low & High	QPSK	P <sub>UMAX</sub>
6	50	Low	QPSK	PUMAX
7	50	Low	16QAM	P <sub>UMAX</sub>

#### 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<sub>UMAX</sub>.
- 2. Measure the average UE output power (*21.78 dBm* in this example) in the tabular result screen as shown in Fig. 20.

Detected Allocation	NoRB:	1	OffsetRB:	0				
		Current	A	werage	E	xtreme		StdDev
EVM RMS [%] I/h	1.90	2.04	1.90	2.04	2.81	2.76	0.00	0.00
EVM Peak [%] I/h	4.75	5.45	4.75	5.45	8.85	9.16	0.00	0.00
EVM DMRS [%] I/h	1.82	1.77	1.82	1.77	3.48	3.29	0.00	0.00
MErr RMS [%] I/h	1.22	1.28	1.22	1.28	1.83	1.86	0.00	0.00
MErr Peak [%] I/h	-4.39	-4.36	4.39	4.36	-7.74	-8,43	0.00	0.00
MErr DMRS [%] I/h	1.47	1.32	1.47	1.32	2.81	2.61	0.00	0.00
PhErr RMS [*] I/h	0.84	0.91	0.84	0.91	1.26	1.19	0.00	0.00
PhEir Peak [*] I/h	1.78	2.67	1.78	2.67	4.25	-3.77	0.00	0.00
PhErr DMRS ["] Vh	0.62	0,68	0.62	0.68	1,49	1.46	0.00	0.00
IQ Offset	-44.48 d	IB	-44.48 d	8	-44.25	18	0.00 d	6
Freq Error	4.65 1	1z	4.65 H	z	14.99	1z	0.00 H	z
Timing Error	29.05 \$	sym	29.05 S	ym	29.67	29.67 Sym		ym
OBW	0.23 h	AHz	0.23 MHz		0.23	MHz	0.00 M	Hz
220.051		Current	. A	verage	Min	Max		StdDev
TX Power [dBm]		21.78		21.78	21.66	21.82		0.00
Peak Power [dBm]		26.53		26.53	26.50	26,86		0.00
RB Power [dBm]		21.65		24.65	21.60	21.73		0.00

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<sub>UMAX</sub>.
- 4. Measure the average UE output power (19.03 dBm in this example) as shown in Fig. 21.

Detected Allocation	NoRB:	50	OffsetRB:	0				
11/12/15 - 20-20-17 - 20-20-		Current	1	Average		Extreme		StdDe
EVM RMS [%] I/h	2.64	2.78	2.64	2.78	2.96	3.04	0.00	0.0
EVM Peak [%] I/h	12.10	24.12	12.10	24.12	27.44	37.12	0.00	0.99
EVM DMRS [%] Vh	2.36	2.77	2.36	2.77	3.34	3.55	0.00	0.0
MErr RMS [%] Vh	1.54	1.68	1.54	1.68	1.64	1.97	0.00	0.0
MErr Peak [%] I/h	-12.09	-20.79	12.09	20.79	-27.38	-35.52	0.00	0.0
MErr DMRS [%] I/h	1.65	1.95	1.65	1.95	2.17	2.38	0.00	0.0
PhErr RMS ["] Vh	1.23	1.27	1.23	1.27	1.42	1.44	0.00	0.0
PhErr Peak ["] I/h	~5.84	-10.73	5,84	10,73	-10.42	-15.47	0.00	0.0
PhErr DMRS [*] I/h	0.97	1.13	0.97	1.13	1.59	1.65	0.00	0.0
IQ Offset	-44.94	dB	-44.94	dB	-43.63	dB	0.00 d	В
Freq Error	5.35	Hz	5.35	Hz	10.91	Hz	0.00 H	z
Timing Error	24.15	Sym	24.15	Sym	25.02	Sym	0.00 \$	ym
OBW	8.89	MHz	8,89	MHz	8.89	MHz	0.00 M	Hz
		Current	e constant	Average	Min	Мах		StdDe
TX Power [dBm]		19.03		19.03	19.03	19.20		0.0
Peak Power [dBm]		26.03		26.03	25,46	26.31		0.0
RB Power [dBm]		2.07		2.07	2.07	2.25		0.00

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.

Cor (TS 3	nfigurati 36.521-	ion table for NS 1, Table 6.2.4.	Configura- tion	Test requir for N (TS 36.52 6.2.4	ement table IS_05 21-1, Table 4.5-4)	
Bandwidth	#RB	RB Position	Modulation	U	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.

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

# 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<sup>®</sup>CMW500's signaling configuration as shown in Fig. 22.

LTE Signaling Configuration		
ath: Uplink Power Control/Max. allowed I	Power P-Max	
─Duplex Mode □-RF Settings 申-RF Output ⊕-RF Input	FDD	
	Band 7 v 3100 Ch 2655.0 MHz 21100 Ch 2535.0 MHz 120 MHz	
B−RF Power Uplink Downlink Power Levels Uplink Power Control B−PUSCH		
	-10 dBm	
Ð-Network Ð-Connection Ð-Shortcut Softkey		

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	Modulation	p-Max
		RB		
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).

TX Measurement	5.0 MHZ Ref. L	evel. 27.	Bandwi	uth. 20.01	IVIPIZ	Cyclic Fre	ana Normai	Weas ou	birt.
Detected Allocation	NoRB:	18	3 OffsetRB:	0					
		Curren	t i	Average		1	Extreme		StdDev
EVM RMS [%] I/h	3.21	3.31	3.14	3.13		3.37	3.35	0.12	0.10
EVM Peak [%] I/h	8.59	13.69	11.84	11.03		17.39	15.51	2.58	2.34
EVM DMRS [%] I/h	3.39	3.47	3.20	3.13		3.69	3.69	0.27	0.28
MErr RMS [%] I/h	NCAP	NCAF	NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
MErr Peak [%] I/h	NCAP	NCAF	NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
MErr DMRS [%] I/h	NCAP	NCAF	NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
PhErr RMS [°] I/h	NCAP	NCAF	NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
PhErr Peak [°] l/h	NCAP	NCAF	P NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
PhErr DMRS [°] I/h	NCAP	NCAF	NCAP	NCAP		NCAP	NCAP	NCAP	NCAF
IQ Offset	-28.28	dB	-28.30	IB		-28.05	dB	0.11	IB
Freq Error	-5.05	Hz	-0.86	-0.86 Hz -8.6 48.87 Sym 49.0		-8.68	Hz	4.96 Hz	
Timing Error	49.05	Sym	48.87			49.06 Sym		0.13 Sym	
OBW	4.78	MHz	4.40	MHz		5.32	MHz	0.52 MHz	
		Curren	t .	Average		Min	Max		StdDev
TX Power [dBm]		-10.55	i i	-10.56	_	-10.58	-10.54		0.01
Peak Power [dBm]		-3.79	Ē	-3.71		-4.08	-3.32		0.22
RB Power [dBm]		-23.11		-23.11		-23.11	-23.10		0.00
			_	1000 V20					200.22
Statistic Count	Out of Toleran	ce	Detected Modula	tion De	etecter	d Channel	Type View Fil	ter Through	out
20 / 20		0.00 %	0	r SN		P05	CH	100.0	70

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 MH <del>7</del>	3.0 MH7	5 MH7	10 MHz	15 MHz	20 MH7
Measured UE output power test point 1	For carrier frequency $f \le 3.0$ GHz: -10 dBm ± 7.7 For carrier frequency $3.0$ GHz < $f \le 4.2$ GHz: -10 dBm ± 8.0					
Measured UE output power test point 2	For carrier frequency f $\leq$ 3.0GHz: 10 dBm ± 6.7 For carrier frequency 3.0GHz < f $\leq$ 4.2GHz: 10 dBm ± 7.0					7.0
Measured UE output power test point 3	For carrier frequency f $\leq$ 3.0GHz: 15 dBm ± 5.7 For carrier frequency 3.0GHz < f $\leq$ 4.2GHz: 15 dBm ± 6.0					6.0
Note: In addition note 2 in Table 6.2.2.3-1 shall apply to the tolerances.						

Table 9: P<sub>CMAX</sub> 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).

LTE Measurement	- Multi Evaluation							1-18
de FDD Freq. 25	35.0 MHz. Ref Le	vel: -38.00 dB	m Bandwit	III: 20.0 M	Hz Cyclic Pre	for. Normal	Meas Sub	n/
◆Ø x:0 Sym high	Y: 4.13%	♦ 🗑 🗠 0 Sym	high y:	4.13 %	♦Ø x:0 Sym	high v:	4.13 %	
<b>%</b>							• Ci • A • M	verage soman
8								Symbol
1 0 1	1 1 1 1	1 2 h	1 3	h	4.11	1 § h	161	
Detected Allocation	NoRB:	100 Offse	tRB:	0				
	13	Current	4	werage	1	xtreme		StdDev
EVM RMS [%] I/h	4.05	4.19	4.12	4.20	4.30	4.40	0.08	0.08
EVM Peak [%] I/h	15.59	37,51	15.71	35.50	22.47	41.90	2.93	3,28
EVM DMRS [%] I/h	4.26	4.36	4.20	4.26	4.49	4.57	0.13	0.15
IQ Offset	-18.56	B	-18.55 d	B	-18.49	IB	0.03 d	B
Freq Error	-1.02 H	z	-2.57 H	lz	-10.19 H	łz	5,39 H	7
Timing Error	47.24 5	iym	47.15 \$	iym	47.50	\$ym	0.19 S	ym
Second and a second second		Current	1	verage	Min	Max		StdDev
TX Power [dBm]		-45.71		-45.70	-45.71	-45.69		0.00
Peak Power [dBm]		-38.00		-38.44	-38.80	-38.00		0.29
tatistic Count 20 / 20	Out of Tolerance	.00 % Detec	teid Modulat ()	Deta PSK	cled Channel PUS	Type View F CH	itter Througho 100.0	ut

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).

	Channe	Channel bandwidth / minimum output power / measurement bandwidth				
	1.4	3.0	5	10	15	20
	IVIHZ	IVIHZ	IVIHZ	IVIHZ	IVIHZ	IVIHZ
Minimum output	nimum output For carrier frequency $f \le 3.0$ GHz: $\le -39$ dBm					
power	For	carrier frequ	ency 3.0GHz	z < f ≤ 4.2Gł	Hz: ≤ -38.7 dE	Зm
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				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 MH7	5 MH7	10 MHz	15 MH <del>7</del>	20 MH7
Transmit OFF power	For carrier frequency $f \le 3.0$ GHz: $\le -48.5$ dBm For carrier frequency $3.0$ GHz $< f \le 4.2$ GHz: $\le -48.2$ dBm					3m
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) (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.

DL Stream1 DL	Stream2 UL	DL Follow Wi	3			,
<mark>TTI Copy</mark>	0 • -> 4	AII 🔻 🔼 Co	ру			
	0 - DL	1 - Special	2 - UL	3 - UL	4 - DL	
# RB	0	0			0	
- Start RB	0	0			0	
Mod.	QPSK 🔻	QPSK 🔻			QPSK 🔻	
TBS Idx	5	5			5	
TBS	0	0			0	
CodeRate	0.00000	0.00000			0.00000	
	5 - DL	6 - Special	7 - UL	8 - UL	9 - DL	
# RB	U	U			U	
Start RB	U	U			U	
Mod.	QPSK -	QPSK -			QPSK -	
TBS Idx	5	5			5	
- IBS CodePate	0 00000	U 0.00000			0 00000	
	0.00000	0.00000			0.00000	-
DL Stream1 DL	Stream2	DL Follow We	5			_
—TTI Сору	3 ▼> 4	All 🔻 Co	ру			
Ė <b>⊶T</b> TI	0 - DL	1 - Special	2 - UL	3 - UL	4 - DL	
# RB				0		
Start RB			U	U		
Mod.			QPSK 🝷	QPSK 🔻		
TBS Idx			2	2		
TBS			4584	0		
	5 DI	6 Special	0.10000	8 111	9 DI	
# RB	3 - DL	o - Special	0	0	3-DL	
Start RB			0	0 0		
Mod.			OPSK -	OPSK -		
TBS Idx			2	2		
TBS			0	0		
CodeRate			0.00000	0.00000		
Throughput	0.458 Mbit/s					-
RB					📃 QPSK	
50					= 16-QAI	
-					Fotth	

# 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<sup>®</sup>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.

	Channe	Channel bandwidth / minimum output power / measurement bandwidth				
	1.4	3.0	5	10	15	20
Transmit OFF	IVIHZ					MHZ
	_	For carrier	frequency f	≤ 3.0GHZ: ≤	-48.5 dBm	_
power	For	carrier frequ	ency 3.0GHz	$z < f \le 4.2Gl$	lz: ≤ -48.2 dl	<u>3m</u>
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 $f \le 3.0GHz$ $3.0GHz < f \le$ 4.2GHz	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 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*.

⊒-Physical Cell Setup					
DL Cell Bandwidth	20.0 MHz 🔻 #RB Max: 100				
UL Cell Bandwidth	20.0 MHz 🕜				
Physical Cell ID	0				
Cyclic Prefix	Normal 🚽				
-Sounding RS (SRS)					
tDD					
⊡PRACH					
-No Response to Preambles					
-Power Ramping Step	0 dB 🔻				
Configuration Index	3				
Frequency Offset	0				
-Logical Root Sequ.ldx	123				
Zero Corr. Zone Conf.	9				
Zero Corr. Zone Conf.	9				

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<sup>®</sup>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* 

	Chan	Channel bandwidth / Output Power [dBm] / Measurement bandwidth					
	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
Transmit OFF power	ransmit OFF ≤ –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 <b>±</b> 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*.

🛱 Physical Cell Setup	
DL Cell Bandwidth	20.0 MHz 🔻 #RB Max: 100
UL Cell Bandwidth	20.0 MHz 💎
- Physical Cell ID	0
	Normal 🔝
-Sounding RS (SRS)	

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)
	(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<sup>®</sup>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.

<b>⊨</b> -Connection	
-Additional Spectrum Emission	NS_01 -
-UE Meas. Filter Coefficient	FC4 🖙
- Connection Type	Testmode 🔹
⊞≖Testmode	
Downlink MAC Padding	
- Downlink MAC Error Insertion	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.



a) SRS Measurement result for FDD



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.

	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	For carrier frequency f $\leq$ 3.0GHz: $\leq$ -48.5 dBm For carrier frequency 3.0GHz < f $\leq$ 4.2GHz: $\leq$ -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 $f \le 3.0GHz$ $3.0GHz < f \le$ 4.2GHz	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB	± 7.5dB ± 7.8dB		

The test requirements are defined in Table 14.

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	Open loop Nominal Power
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.

ļ 🗗	RF Power Uplink	
	-Exp. Nominal Power Mode	According to UL Power Control Settings 🔻
	Exp. Nominal Power	11.80 dBm Ref.Level: 23.80 dBm
	Margin	12.00 dB
	Mixer Level Offset	0 dB
⊡⊡Do	wnlink Power Levels	
⊟−Up	link Power Control	
	Open Loop Nominal Power	@ Full RB Allocation
- P	Advanced PRACH/OL Power	
	Enable Advanced Settings	
	-Reference Signal Power	18 dBm
	Preamble Initial Received Target	-104 dBm
	- PO Nominal PUSCH	-105 dBm
	-Pathloss Compensation Alpha	0.8 -
	Pathloss	103.0 dB
	Expected PRACH Preamble Power	-1.0 dBm
	Expected OL Power	-2.6 dBm
þ	TX Power Control (TPC)	
	-Active TPC Setup	Constant Power 🔹

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<sup>®</sup>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).

LTE Measurement	- Mutti Evaluation	ř.			_			- 6
de FOD Freq 25	S.0 MHz Ref La	wei: 12.00	dBm Bandw	ittin: 20.0 N	HZ Cyclic Pr	etic, Norma	Meas St	nic ()
nor Vector Magni	ude	A 10 - 0.0						
•U x o syn high	X	•Ux:0Sy	wingo y		A x 0 3M	ngn y.		
%								
6								
2								
ō								
1 1 1 1 1								
6						1.1		
2								Sumbol
								Dânan (1
Since Vice	Low and the second	-	1	2.11	-	1 9 11	1.0.1	_
etected Allocation	NoRB:	100 Off	isetRB:	0)				
	n - N	Current		Average	1	xtreme		StdDe
EVM RMS [%] Vh	4.32	4.15	3,82	3.78	4.32	4.23	0.23	0.2
WM Peak [%] Vh	24.29	14.14	26,40	17.80	36.40	32.19	5.24	4.25
WM DMRS [%] I/h	4.81	4.58	4.08	3.99	5.72	5.82	0.53	0.57
Q Offset	-32.23 (	Bc	-32.23	dBc	-31.86	lB¢	0.14	lB-c
req Error	2.20 1	fr	-1.23 1	Hz	-9.33 1	47	2.78 1	łz
iming Error	-37.76 1	16	-37.79	Ts.	-40.62 1	le :	0.93	6
	1	Current	3	Average	Min	Max		StdDe
X Power [dBm]		-5.24	C	-5.23	-5.25	-5.02		0.01
Peak Power (dBm)		1.61		1.79	1.49	2.25		0.15
whethe Count	Out of Toleranc	e Deb	ected Modula	dan Dete	cted Channel	Type View F	Hier Through	put
20 / 20	0.00	56	0	PSK	PUS	CH	100.0 %	
2.00		1000	101	1000	0	and the second se		

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).

81	TE Measurement	Mutte Evaluation	1			-				-8
Ande	E FOD (Freq. 250	5.0 MHz Rafit	evel 22	2.00 dBm Ban	dwidth: 2	0.0 MHz	Cyclic P	rela: Norma	Meas S	ubli D
Em	nr Vector Magnit	ude								
	◆◎ × 0 Sym high	γ —	<b>◆</b> Ū ≍	0 Synthigh y	-	- 4	St 0 Sy	πhigh γ:		
	5				1	_			1.6	
16	1									
122										
12										111/0
6						-		1		
								<b>1</b>	10.00	and the second
24										Symbol
_	1 6 1	1 1 1	1	2 1 1	3.0	1.4	1.0	1 5 n	1.6 h	
De	tected Allocation	NoRB:	100	OffsetRB:		0		11.1.1		
-		1	Current		Avera	ge		Extreme		StdDev
EV	M RMS [%] Vh	3,77	3.72	3.6	4 3.	.58	4.06	3.96	0.17	0.16
Ey	M Peak [%] Vh	26.19	15.49	27.0	8 16.	.91	32.59	29.01	2.81	2.98
EV	M DMRS [%] th	4.49	4,32	4.2	3 4.	.09	6.17	5.77	0.71	9.70
IQ.	Offset	-32.84	dBc	-32.9	5 dBc		-32.64	dBc	0.09	dBc
Fre	eq Error	-0.63	Hz	-1.2	4 Hz		-11.47	Hz	2.33	Hz
Te	ning Error	-27.76	Ts	-26.3	8 Ts		-27.98	Ts	1.05	Ts
			Current	t.	Avera	ge	Min	Max		StdDev
TX	Power [dBm]		6.05	i -	6.	.07	6.05	6.17	)	0.02
Pe	ak Power [dBm]		12.91		12	86	12.68	13.22	10	0.10
Stat	istic Count	Out of Tolerand	e i	Detected Mod	ulation	Detecte	o Channe	I Type View I	Filter Through	but
10	20 20	0.00	0%		OPSK		PU	SCH	100.0 %	
		143-54		4		the second se		and the second se		

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.

	Cha	annel bandv	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 $f \le 3.0 \text{GHz}$ $3.0 \text{GHz} < f \le$ 4.2 GHz	± 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 $f \le 3.0 \text{GHz}$ $3.0 \text{GHz} < f \le$ 4.2 GHz	± 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	r power limit s de	shall not exc efined in sub	eed the mini -clause 6.3.2	mum output 2.3	power requir	ements			
	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 $f \le 3.0$ GHz $3.0$ GHz < $f \le$ 4.2GHz	± 10.0dB ± 10.4dB	± 10.0dB ± 10.4dB	± 10.0dB ± 10.4dB	± 10.0dB ± 10.4dB	± 10.0dB ± 10.4dB	± 10.0dB ±			
7.20112						10.4dB			
Expected Measured power Extreme conditions	-2.8 dBm	1.2 dBm	3.4 dBm	6.4 dBm	8.2 dBm	10.4dB 9.4 dBm			
Expected Measured power Extreme conditions Power tolerance $f \le 3.0$ GHz $3.0$ GHz < $f \le$ 4.2GHz	-2.8 dBm ± 13.0dB ± 13.4dB	1.2 dBm ± 13.0dB ± 13.4dB	3.4 dBm ± 13.0dB ± 13.4dB	6.4 dBm ± 13.0dB ± 13.4dB	8.2 dBm ± 13.0dB ± 13.4dB	10.4dB 9.4 dBm ± 13.0dB ± 13.4dB			

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  $\leq 20$  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.

🚸 Signaling TPC				<b>X</b>	
TX Power Control (TPC)					
-Active TPC Setup	3GPP	Relative Powe	r Control 🛛 🔻	Execute	
G-3GPP Rel. Pow. Ctrl. Patter	n				Signaling
Pattern	Ramp	oing Up A 🛛 🔻		Parameter	
Closed Loop Target Power	0.0 dE	Bm		LTE	
					Signaling
Connection Setup	DL Error Insertion	трс	Power	Enable	Config

Fig. 38 Choose 3GPP relatevie power control test pattern



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:

- 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  $\pm$ 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 noncontiguous 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  $\Delta f$  results must fulfill this test requirement:

 $|\Delta f| \leq (0.1 \text{ PPM} + 15 \text{ Hz})$ 

Consequently, for Band 7 in the low range,  $|\Delta f|$  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.

	<b>400</b>		Madulation	
	#KB	RB Pos/Start	wodulation	UE Output
		RB		Power
Test Set 1	18	Low	QPSK	P <sub>UMAX</sub>
Test Set 2	18	High	QPSK	PUMAX
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	PUMAX
Test Set 6	18	High	16QAM	PUMAX
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 <sub>UMAX</sub>
Test Set 10	100	Low	QPSK	-36.8±3.2dBm
Test Set 11	100	Low	16QAM	PUMAX
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 % , EVM  $_{\it DMRS}$  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 I/h = 2.73 % / 2.79 %, *EVM* <sub>DMRS</sub> I/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  $\theta$  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.

/		Do۱	vnlink	UE Output Power			
	1.4M	3M	5M	10M	15M	20M	
1	2	4	0	16	25	20	PMAX
2	3	4	0	10	25	30	–36.8 ±3.2 dBm

Table 19: Details for PUCCH EVM.

🚯 LTE Measurement	1 - Multi Ev	aluation								
lode: FDD (Freq.: 25.	35.0 MHz	Ref. Level	37.00 dB	m Bandv	vidth: 20.0 N	AHz )	Cyclic Prefit	<: Normal	Meas Su	ubfr.: (
Error Vector Magni	tude		_							
🔷 🕼 x: 0 Sym high	у: -	4	🕽 🕄 0 Sym h	igh y:	2 <del>1111</del>	<b>\$</b>	x: 0 Sym hig	gh y:		
%		1	1			1			1	
16										
12		1				1		1		
10		1								
6		-								
								-		
2			-						and pro-	Symbol
1 0 1	1 I	1 h	1 2 h	Г	3 h	4	h 1	5 h	1 6 h	
E L L AN L	N. DD.		4.04		5					
Detected Allocation	NORD:	6	1 Onse	(КВ:	5		-			C. 10
5 M 5 M 5 M 1 M		U	Irrent	4.00	Average	<u>.</u>	EX	treme		Stabey
EVM RMS [%] I/h	_	1.22	1.23	1.22	1.23	J	2.42	2.41	0.00	0.00
EVM Peak [%] I/h		3.43	3.00	3.43	3.00	-	7.99	7.95	0.00	0.00
EVM DMRS [%] I/h		1.14	1.22	1.14	1.22		2.81	2.81	0.00	0.00
IQ Offset	-5	5.03 dB	2	-55.03	dBc	1	-38.39 dB	с	0.00	dBc
Freq Error		5.49 Hz		5.49	Hz		17.47 Hz		0.00	Hz
Timing Error	-4	4.34 Ts		-44.34	Ts	3	-45.22 Ts		0.00	Ts
		Ci	irrent		Average		Min	Max		StdDev
TX Power [dBm]		- (	21.25		21.25		0.21	21.90		0.00
			21.21		24 24		4.65	26.95		0.00
Peak Power [dBm]			24.24		LTILT		10000	20.00		1100000
Peak Power [dBm] Statistic Count	Out of To	lerance	Detect	ed Modula	ation Det	ected	Channel Ty	pe View Fill	ter Through	put

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 / - <mark>63</mark>	4 / <del>5</del> 3	-120	–31 dBm
Test Point 2		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.

de FDD Freq.1	930.0 MHz 1 nitude	Ref. Le	evel: 0	.00 dBm	Bandy	width: 20.	0 MHz	Preamble	Form	at: 0		
<b>◆</b> ₿ x 0	ft y:	-	<b>♦</b> ₽ ×:	Off	γ.		<b>0</b>	x	Off )	r		
%		8	1		-		1					Current
25												
		2	1		1		1	1				1
20				******			1					
15			ana a A									
			-				÷.					1
0							· · · · · · · ·					
5					- És							
5 100	gh <del>manatat</del> h ) 21		<b>hrytnorth</b> a 30	w/~w/~s6-4) 0	400	www.	500	hanhanh 60	Mhwrud O	700	why when	9 <b>614056</b> 1 800
5 ////h.a.///////// 100	9)**************** ) 21	00	Current	w/~white-d/ 0	400	Average	500	<u>наму, на</u> 60 Е	Nyrud D	www.w/U 700	WWHYME	g <b>illiga Sid</b> 800 StdDe
5 100 EVM RMS [%] //h	() <sup>144</sup> 11441141 ) 21	00 1.63	Current 1.63	и,	400	Average	500	<u>რაფერატი</u> 60 E 1.68	o xtrem 1.6	₩₩₩₩₩ 700 € 8	0.02	BOO StdDer 0.02
5 VIALAUVVIIIM 100 EVM RMS [%] Vh EVM RMS [%] Vh	90 <sup>1-4</sup> 1-41-10 ) 21	1.63 4.10	Current 1.63 4.10	μ(πολημική) Ο	400 1.63 3.78	Average 1.63 3.78	500	60 60 1.68 4.11	xtrem 1.6 4.1	₩₩₩₩₩₩ 700 0 8 1	0.02	800 StdDer 0.02 0.18
5 100 EVM RMS [%] I/h EVM Peak [%] I/h Freq Error	() <sup>14</sup> 414 <sup>1</sup> 0111111 ) 21	1.63 4.10 3.24 1	Current 1.63 4.10	μογουντικά στη τη του Ο Ι	400 1.63 3.78 -0.72	Average 1.63 3.78 Hz	500	60 60 1.68 4.11 3.78 1	0 xtrem 1.6 4.1 1z	₩₩₩₩₩₩ 700 e 8 1	0.02 0.18 1.75	BOO StdDer 0.02 0.18 Hz
5 100 EVM RMS [%] //h EVM Peak [%] //h Freq Error Firming Error	() <sup>144</sup> 404 <sup>(</sup> 018 <sup>(</sup> 01 <sup>(</sup> )) 21   	1.63 4.10 3.24 F	Current 1.63 4.10 Hz Fs	и, тулці, - () 0 1 -	400 1.63 3.78 0.72 0.66	Average 1.63 3.78 Hz Ts	500	60 60 1.68 4.11 3.78 H 1.41 T	Abyrod Strem 1.64 4.1 1z Fs	e 8 1	0.02 0.18 1.75 0.52	800 StdDer 0.02 0.18 Hz Ts
5 100 EVM RMS [%] Vh EVM Peak [%] Vh Freq Error Firming Error	() <sup>4*</sup> ***********************************	1.63 4.10 3.24 F 0.56 T	Current 1.63 4.10 Hz Current	μιγηγλημική) Ο Ι Ι	400 1.63 3.78 -0.72 0.66	Average 1.63 3.78 Hz Ts Average	500	60 E 1.68 4.11 3.78 I 1.41 1 Min	Ahmud D xtrem 1.61 4.1 1z fs Ma	e 8 1	0.02 0.18 1.75 0.52	800 StdDev 0.02 0.18 Hz Ts StdDev
5 100 EVM RMS [%] //h EVM Peak [%] //h Freq Error Fining Error IX Power [dBm]	()************************************	1.63 4.10 3.24 F 0.56 T	Current 1.63 4.10 Hz Current -7.99	μ,γηγλημι λ) Ο Ι Ι	400 1.63 3.78 0.72 0.66	Average 1.63 3.78 Hz Ts Average -7.99	500	60 60 1.68 4.11 3.78 H 1.41 T Min -8.01	xtrem 1.6 4.1 iz fs Ma -7.9	**************************************	0.02 0.18 1.75 0.52	800 StdDev 0.02 0.18 Hz Ts StdDev 0.00
5 VM RMS [%] Vh EVM RMS [%] Vh EVM Peak [%] Vh Freq Error Finning Error EX Power [dBm] Peak Power [dBm]	()************************************	1.63 4.10 3.24 H 9.56 T	30 Current 1.63 4.10 Hz Ts Current -7.99 -3.45	ω, γογλημό Αζι Ο Ι Ι	400 1.63 3.78 -0.72 0.66	Average 1.63 3.78 Hz Ts Average -7.99 -3.46	500	60 1.68 4.11 3.78 I 1.41 T Min -8.01 -3.48	xtrem 1.6 4.1 1z fs Ma -7.9 -3.4	**************************************	0.02 0.18 1.75 0.52	800 StdDev 0.02 0.18 Hz Ts StdDev 0.00 0.01
5 VM RMS [%] Vh EVM RMS [%] Vh EVM Peak [%] I/h Freq Error Friming Error IX Power [dBm] Peak Power [dBm] atistic Count	ցի#Կոզատեղել ) 21	1.63 4.10 3.24 F 0.56 T	Current 1.63 4.10 Hz Ts Current -7.99 -3.45 e 1	wywheely o i I Det PRAC	400 1.63 3.78 0.72 0.66	Average 1.63 3.78 Hz Ts Average -7.95 -3.46 q. Offset	500	60 60 1.68 4.11 3.78 H 1.41 T Min -8.01 -3.48 quence k	2 xtrem 1.64 4.1 1z 1s Ma -7.9 -3.4	e 8 1 x 9 5 5 Sequence	0.02 0.18 1.75 0.52	800 StdDev 0.02 0.18 Hz Ts StdDev 0.00 0.01 elation

Fig. 54: PRACH EVM measurement results.

#### 2.14.3 Test Requirements

The PUSCH EVM and  $\mathit{EVM}_{\mathit{DMRS}}$  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 Uplink configuration configuration							
Ch BW	N/A	Modulation	RB allo	cation			
			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<sup>®</sup>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 =  $25\mu s$ , Lagging =  $25\mu s$
  - b. Subframe = 3, Leading =  $25\mu s$ , Lagging =  $5\mu s$
  - **C.** Subframe = 7, Leading =  $25\mu s$ , Lagging =  $25\mu s$
  - d. Subframe = 8, Leading =  $25\mu s$ , Lagging =  $5\mu s$



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.

Streasurement - Adde: FDD Freq.: 253	Multi Evaluation 5.0 MHz Ref. Le	vel: 15.00 dBi	<b>n</b> Bandwid	th: 20.0 MH	lz Cyclic Pre	fix:: Normal	Meas Sub	ofr.: (
Error Vector Magnitu	ıde	A. 17			<b>AR</b>			
♥♥ x: 0 Sym high	Y:	<b>♥</b> ♥ x:0 Sym	high y:	S <del>1023</del>	<b>♥</b> ♥ x:0 Sym	high y:	/***	
%			·}				🔶 Ci	urrent
16							🔶 A	verage
10			í.			1	🔷 M	aximum
10								
6								
2								
							A 1-3	Symbol
loh	1 <u>1</u> h	I 2 h	13	h I	4 h	1 5 h	1 6 h	
Detected Allocation	NoRB:	18 Offse	tRB:	0				
		Current	A	verage	E	xtreme		StdDev
EVM RMS [%] I/h	2.68	2.50	2.50	2.40	2.74	2.61	0.14	0.12
EVM Peak [%] I/h	14.28	7.54	13.21	8.53	15.07	10.41	1.53	0.80
EVM DMRS [%] I/h	2.75	2.72	2.53	2.37	3.05	3.09	0.26	0.28
IQ Offset	-28.04 0	IB	-28.05 d	в	-28.00 d	В	0.02 d	в
Freq Error	-5.14 t	Iz	-1.77 H	2	-12.26 H	z	5.34 H	z
Timing Error	47.66	iym 🛛	47.56 S	ym	47.83 S	ym	0.13 S	ym
		Current	A	verage	Min	Max		StdDev
TX Power [dBm]		3.74		3.74	3.71	3.76		0.01
Peak Power [dBm]		11.08		11.34	11.05	11.62		0.25
Statistic Count	Out of Toleranc	e Detect	ted Modulat	ion Dete	cted Channel	Type View Fi	ilter Throughp	ut
20 / 20		.00 %	10	PSK	PUS	CH	100.0	0%

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	Modulation	UE Output Power
		RB		
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<sup>®</sup>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<sup>®</sup>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 <sub>UL_Mea</sub>	$_{\text{Is}}$ – $F_{\text{UL}_{\text{Low}}}$ ≥ 3 MHz and $F_{\text{UL}_{\text{High}}}$ – $F_{\text{UL}_{\text{Meas}}}$ ≥ 3 MHz	5.4 (p-p)
	(Range 1)	
F <sub>UL_Me</sub>	$_{as}$ – F <sub>UL_Low</sub> < 3 MHz or F <sub>UL_High</sub> – F <sub>UL_Meas</sub> < 3 MHz	9.4 (p-p)
	(Range 2)	
Note 1:	F <sub>UL_Meas</sub> refers to the subcarrier frequency for which t evaluated	he equalizer coefficient is
Note 2:	$F_{UL\_Low}$ and $F_{UL\_High}$ refer to each E-UTRA frequency TS 36.521-1, Table 5.2-1	band specified in

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	Modulation	UE Output Power	
		RB			
Test Set 1	18	High	QPSK	P <sub>UMAX</sub>	
Test Set 2	18	Low	QPSK	P <sub>UMAX</sub>	
Test Set 3	18	High	16QAM	P <sub>UMAX</sub>	
Test Set 4	18	Low	16QAM	P <sub>UMAX</sub>	
Test Set 5	100	Low	QPSK	P <sub>UMAX</sub>	
Test Set 6	100	Low	16QAM	P <sub>UMAX</sub>	

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 PUMAX.
- 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.

		Spectro	um emissi	on limit (d	Bm)/ Char	nnel bandv	width
Δf <sub>OOB</sub>	1.4	3.0	5	10	15	20	Measurement
(MHz)	MHz	MHz	MHz	MHz	MHz	MHz	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: Th	e first and	l last meas	urement po	osition with	a 30 kHz f	ilter is at Δ	f <sub>оов</sub> equal to
0	.015 MHz	and 0.985	MHz.				
NOTE 2: At	the bound	lary of the	spectrum e	emission lin	nit, the first	and last m	neasurement
p	osition wit	h a 1 MHz	filter is the	inside of +	-0.5MHz ar	nd –0.5MH	z, respectively.
NOTE 3: Th	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: Fo	r the 2.5 M	ИHz – 2.8 I	MHz offset	range with	1.4 MHz c	hannel bar	ndwidth, the
l m	neasureme	ent positior	n is at Λfoo	equal to 3	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<sup>®</sup>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<sup>®</sup>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<sub>ACLR</sub> and UTRA<sub>ACLR1/2</sub> 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 <sub>UMAX</sub>
Test Set 2	18	Low	QPSK	P <sub>UMAX</sub>
Test Set 3	18	High	16QAM	P <sub>UMAX</sub>
Test Set 4	18	Low	16QAM	P <sub>UMAX</sub>
Test Set 5	100	Low	QPSK	P <sub>UMAX</sub>
Test Set 6	100	Low	16QAM	P <sub>UMAX</sub>

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 PUMAX.
- 3. In R&S<sup>®</sup>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<sup>®</sup>SMU to generate the interference signal. Alternatively, it would be possible to use the R&S<sup>®</sup>CMW500's second channel to generate the interference signal so that no external instrument is required. When the R&S<sup>®</sup>CMW500 is equipped with an R&S<sup>®</sup>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<sup>®</sup>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<sup>®</sup>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<sub>CMAX\_L</sub> 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  $\leq$  3.0GHz or within +0, -4.0 dB of the target level for carrier frequency 3.0GHz < f  $\leq$  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.

<b>ģ</b>	Connection	
	-Group Hopping	
	UE Category	Manual: 5 Use Reported (if available): 🗹
	Default Paging Cycle	#64 🔻
	-Additional Spectrum Emission	NS_01 -
	UE Meas. Filter Coefficient	FC4 •

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<sup>®</sup>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<sup>®</sup>CMW500, which is:

```
P<sub>REFSENS</sub> = 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<sub>REFSENS</sub> = -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.

Results			Cell Setup				
	Relative	Absolute	Duplex Mode	FDD			1
ACK	100.00 %	10000	Operating Band	Band 7			1
NACK	0.00 %	0		Downlink		Uplink	
BLER	0.00 %		Channel	3100	Ch	21100	Ch
Throughput	Relative	kBit/s	Frequency	2655.0	MHz	2535.0	MHz
Average	100.00 %	7884.00	Coll Dondwidth	20.0 MH-		20.0 MH-	
Minimum _		7884.00		20.01 10112	-	20.0 19112	
Maximum		7884.00	RS EPRE	-122.1	dBm/15kHz	1	
	10	000 / 10 000	PUSCH Open Loop Nom.Power	ID		-20	dBm
	10	000 / 10 000	Connection Setu UE term. Conn. RMC Settings	RMC		-20	dBm ★
	10	000 / 10 000	PUSCH Open Loop Nom.Power Connection Setu UE term. Conn. RMC Settings #RB	P RMC Downlink	100 -	<b>-20</b> Uplink	dBm ▼ 75 ▼
	10	000 / 10 000	PUSCH Open Loop Nom.Power Connection Setu UE term. Conn. RMC Settings #RB RB Pos./Start RB	IP RMC Downlink	100 <b>-</b> 0	-20 Uplink Iow ▼	dBm ▼ 75 ▼ 0
		000 / 10 000	PUSCH Open Loop Nom.Power Connection Setu UE term. Conn. RMC Settings #RB RB Pos./Start RB Modulation	IP RMC Downlink	100 ▼ 0 QPSK ▼	-20 Uplink Iow ▼ QF	dBm • 75 • 0 PSK •
		000 / 10 000	PUSCH Open Loop Nom.Power Connection Setu UE term. Conn. RMC Settings #RB RB Pos./Start RB Modulation Trans.Bl.Size.ldx	RMC Downlink	100 ▼ 0 0PSK ▼ 5	−20 Uplink Iow ▼ QF	dBm ▼ 75 ▼ 0 2SK ▼ 3 2
		000 / 10 000	PUSCH Open Loop Nom.Power Connection Setu UE term. Conn. RMC Settings # RB RB Pos./Start RB Modulation Trans.Bl.Size.Idx Trans.Bl.Size Throughput	P RMC Downlink Iow T 8760 7.884	100 ▼ 0 OPSK ▼ 5 MBit/s	-20 Uplink Iow • QP 4392 4.392	dBm ▼ 75 ▼ 0 °SK ▼ 3 2 MBit/s

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

#### 3.2.3 Test Requirements

The throughput shall be  $\geq$  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 middlerange 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<sup>®</sup>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<sup>®</sup>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.

> LTE BLER								LTE
Results			Cell Setup					Extended
Over All	Relative	Absolute	Operating Band	Band 7		FDD	~	BLER
ACK	99.76 %	8978	-	Downlink		Uplink		RDY
NACK	0.02 %	2	Channel	3100	Ch	21100	Ch	
DTX	0.22 %	20	Frequency	2055.0	MU-	2525.0	MUs	
BLER	0.24 %		riequency	2055.0		2555.0	МПZ	
Throughput	Relative	kBit/s	Cell Bandwidth	20.0 MHz		20.0 MH:	z 🧭	<u>}</u>
Average	99.76 %	55362.34	RS EPRE	-56.5	dBm/15kHz	Ì		
Minimum	-	51489.81	Full Cell BW Pow.	-25.7	dBm			
Maximum		55498.00	PUSCH Open Loop	n Nom Pov	ver	-20	dBm	
Subframes 📒 10	000 / 10000 Scheduled:	9000						
			PUSCH Closed Lo	op larget i	Power	-20.0	dBm	
			Connection Setu					
			Connection Setu	PMC			-	Disnlay
			Scheduling Type	RIVIC			<u> </u>	
				Downlink		Uplink		
			#RB		100 🔻		100 -	
			RB Pos./Start RB	low 🔻	0	low <del>•</del>	0	
			Modulation		64-QAM 👻	Q	PSK 🕶	
			TBS Idx / Value	24	61664	2	4584	
			Throughput	55.498	MBit/s	4,584	MBit/s	
			DI. Error Insertion		9%			LTE 1
			De Entre insettion	, v	<u>e</u>			Signaling
		Tab	le View	Ϋ́		Ŷ		Ì.
								Config

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  $\geq$  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<sub>CMAX\_L</sub>, Section 3.1.2 explains how this close loop target power is deduced.



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<sup>®</sup>CMW500 hardware configurations.

i. An R&S<sup>®</sup>CMW500 is used with two basic frontends – RF Frontend (Basic), R&S<sup>®</sup>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.

→ The interferer signal is routed to RF3 OUT.



Test setup with interferer: two RF Frontends (Basic)

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

ii. An R&S<sup>®</sup>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.

→ The interferer signal is routed to same RF connector as the LTE uplink/downlink signal.



Test setup with interferer: one RF Frontend (Advanced)

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

a. Houling		a.a.
Scenario	StandAlone *	
Routing	Connector: RF30UT + Converter: RFTX2 +	
Ext. Art. (Output) Frinquency Level (RINS) Digital Gain List Mede	0.06 48 1200.000000 MHz • -12.00 dBm Pask Envelope Pervect 0.00 dB Off •	ARB
Baseband Mode	ARE -	Sector Sector
Baseband Configuration		List Confi
G- ARB	Listmatic Off Testal Basels County 1	22
		GPRF

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<sup>®</sup>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<sup>®</sup>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<sup>®</sup>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.

Throu	ghput										
<b>♦</b> ₿ ×:	Of	fy:		<b>♦</b> Q :	x:	Off y:	<u></u> )	<b>♦</b> ₿ :	c	Off y:	<u></u>
MBit/s									s - 10	10 S	
100	🔷 Over	rall									
80											·
60											
40			4								
20			1							1	1
	-							-			Subframes
	-9500	-8500	.76	00 07	00 550	0 45	00	0500			
	0000	-0500		00 -651	-550	0 -40	00	-3500	-2500	-1500	-500
		-0500	Over /		00 -550	0 -40	00	-3500	-2500	-1500	-500
		Relati	Over A ive	Absolute	00 -550	0 -40	00	-3500	-2500	-1500	-500
ACK		Relati 99	Over A ive .82 %	All -650 All Absolute 8984	00 -550	0 -40	00	-3500	-2500	∂-1500	-500
ACK NACK		Relati 99.	Over / ive .82 % .03 %	All Absolute 8984 3	00 -550	-43	00	-3500	-2500	-1500	-500
ACK NACK DTX		Relati 99. 0.	Over <i>A</i> ive .82 % .03 % .14 %	Absolute 8984 3 13	00 -330	0 -43	00	-3500	-2500	-1500	-500
ACK NACK DTX BLER	-	Relati 99. 0. 0.	Over 4 ive .82 % .03 % .14 % .18 %	Absolute 8984 3 13	00 -330	-43	00	-3500	-2500	-1500	-500
ACK NACK DTX BLER Throu	ghput	Relati 99. 0. 0. 0. Rela	Over A ive .82 % .03 % .14 % .18 %	All Absolute 8984 3 13 kBit/s		-43		-3500	-2500	-1500	-500
ACK NACK DTX BLER Throu	ghput	Relati 99. 0. 0. 0. Rela 99.8	Over <i>A</i> ive .82 % .03 % .14 % .18 % itive .2 %	Absolute 8984 3 13 kBit/s 7869.98	00 -330	-43		-3500	-2500	-1500	-500
ACK NACK DTX BLER Throu —Av	ghput erage nimum	Relati 99. 0. 0. 0. Rela 99.8	Over A ive .82 % .03 % .14 % .18 % .18 % .tive .2 %	Absolute 8984 3 13 kBit/s 7869.98 7402.20		-43	00	-3500	-2500	-1500	-500
ACK NACK DTX BLER Throu —Av —Mi —Mi	ghput erage nimum axim	Relati 99. 0. 0. 0. Rela 99.8	Over A ive .82 % .03 % .14 % .18 % tive .2 %	Ali Absolute 8984 3 13 kBit/s 7869.98 7402.20 7884.00		-43		-3500	-2500	-1500	-500
ACK NACK DTX BLER Throu - Av - Mi Subfrar	ghput erage nimum axim	Relati 99. 0. 0. 0. Rela 99.8	Over A ive .82 % .03 % .14 % .18 % .18 % .ttive .2 %  heduled	All Absolute 8984 3 13 kBit/s 7869.98 7402.20 7884.00				-3200	-2500	-1500	-500

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

### 3.4.3 Test Requirements

The throughput  $R_{av}$  shall be  $\geq$  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	Units			Channel b	oandwidth					
parameter		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz			
Power in			REFSENS + Channel bandwidth specific value below							
transmission bandwidth configuration	dBm	6	6	6	6	7	9			
BWInterferer	MHz	1.4	3	5	5	5	5			
Floffset, 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			
Floffset, 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 t	ransmitte	r shall be set t	o 4 dB below	PCMAX_L at the	minimum uplir	nk configuration	n specified in			
TSC	36.521-1,	Table 7.3.3-2	with PCMAX_L a	as defined in cl	lause 6.2.5.					
NOTE 2: The in	nterferer	consists of the	reference me	asurement cha	annel specified	d in Annex A.3.	2 with one-			
side	d dynam	ic OCNG Patte	ern OP.1 FDD	/TDD as descr	ibed in TS 36.	521-1, Annex				
A.5.	1.1/A.5.2	.1 and set-up	according to A	nnex 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
		PInterferer	dBm	-56	-44	-30
		FInterferer	MHz	=-BW/2 -	$\leq -BW/2 -$	-BW/2 - 9
		(Offset)		Floffset, case 1	Floffset, case 2	MHz
				&	&	&
				=+BW/2 +	≥ +BW/2 +	–BW/2 – 15
				Floffset, case 1	Floffset, case 2	MHz
1, 2, 3, 4	4, 5, 6, 7, 8, 9, 10,	FInterferer	MHz		F <sub>DL_low</sub> –15	
	11,12, 13,			(Note 2)	to	
18	8, 19, 20, 21,				F <sub>DL_high</sub> +15	
33,34,35,	,36,37,38,39,40, 41					
	17	FInterferer	MHz		F <sub>DL_low</sub> -9.0	$F_{DL_{low}} - 15$
					to	and
				(Note 2)	F <sub>DL_high</sub> +15	F <sub>DL_low</sub> –9.0
						(Note 3)
Note 1:	For certain bands,	the unwanted m	nodulated i	nterfering signa	I may not fall ins	side the UE
	receive band, but w	vithin the first 18	5 MHz belo	ow or above the	UE receive ban	d.
Note 2:	For each carrier fre	equency, the rec	quirement i	s valid for two fi	requencies:	
	the carrier frequence	cy – BW/2 – Flo	offset, Case	e 1, and the car	rier frequency +	BW/2 +
	Floffset, case 1.					
Note 3:	Finterferer range value	es for unwanted	I modulate	d interfering sigi	nal are interfere	r center
	frequencies.					
Note 4:	Case 3 only applies	s to an assigned	d UE chan	nel bandwidth o	f 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.

th Routing		-
Scenario	StandAlone •	
Routing	Connector: RF30UT  Converter: RFTX2  +	<u></u>
Ext. Att. (Output) Frequency	9.00 dB 1200.000000 MHz +	
- Level (RMS) - Digital Gain - Lint Mode	-12.00 d8m Peak Envelope Power: 0.00 d8 Off •	ARB
Baseband Mode	ARB -	Hermony
Baseband Configuration Dual Tone		List Config
B-ARE	1.0050_free.wv	(C)
		GPRF Generator
lect ID File	User Defined Marker	

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 # -	Interferer	Interferer	Interferer	RS	UL power	DL RB # /
Testpoint	frequency	bandwidth	power	EPRE	(closed	UL RB #
	(MHz)	(MHz)	(dBm)	(dBm)	loop) (dBm)	
1 - 1	2127.5025	5	-56	<b>-</b> 118.1	16.3	50 / 50
1 - 2	2102.4975	5	-56	<b>-</b> 118.1	16.3	50 / 50
2 – 1	2097.4875	5	<b>-</b> 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	<b>-</b> 44	<b>-</b> 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	<b>-</b> 44	-118.1	16.3	50 / 50
2 – 8	2162.5125	5	-44	-118.1	16.3	50 / 50
2 – 9	2167.5125	5	<b>-</b> 44	<b>–</b> 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  $\geq$  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 middlerange 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.

General Purpose RF Generator 2	? - Generator	
Path: Routing		
Scenario	StandAlone -	
Routing	Connector: RF3COM 👻 Converter: RFTX2 💌	
Ext. Att. (Output) Frequency Level (RMS) Digital Gain List Mode Baseband Mode B-Baseband Configuration B-Dual Tone B-ARB B-List Configuration	3.00 dB 2665.2075000 MHz -55.00 dB 0.00 dB Off CW Listmode: Off Total Result Count: 1	

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<sup>®</sup>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<sup>®</sup>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.

🚯 LTE BLER						LTE
Results			Cell Setup			Extended
Over All	Relative	Absolute	Operating Band	Band 7	FDD 🦻	BLER
ACK	99.83 %	8985		Downlink	Uplink	RDY
NACK	0.00 %	0	Channel	3100 Ch	21100 Ch	
DTX -	0.17 %	15	Frequency	2655.0 MHz	2535.0 MHz	
BLER	0.17 %	LDS	0.0 P	200010 11112	200010 11112	
Inroughput	Relative	7970.9C	Cell Bandwidth	20.0 MHz	20.0 MHz	
	99.05 %	7402.20	RS EPRE	-106.1 dBm/15kHz		
Maximum	2	7884.00	Full Cell BW Pow.	-75.3 dBm		
		1004.00	PUSCH Open Loo	p Nom.Power	-20 dBm	
Subtrames 10	000 / 10000 Schedule	d: 9000	PLISCH Closed Lo	on Target Power	-10 dBm	
			,	op (algor) eller	no ubii	
			Connection Setu	ip		
			Scheduling Type	RMC	-	Display
			6	Downlink	Unlink	<u></u>
			#RB	100 -	75 -	
			RB Pos./Start RB	low 🕶 0	low - 0	
			Modulation	QPSK 🔻	QPSK 🕶	
			TBS ldx / Value	5 8760	3 4392	
			Throughput	7.884 MBit/s	4.392 MBit/s	
			DL Error Insertion	0 %		LTE 1 Signaling
	Í	Tab Dia	le View gram View	Ĩ		Config

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  $\geq$  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.

-
ARB
List Config.
<u> </u>
-
GPRF Generator

CMW		
S General Purpose RF Generator 2 -	V3.2.40 - Base V 3.2.50	GPRF Gen
Path: Level (RMS)		
Scenario Routing Ext. Att. (Output) Frequency Level (RMS) Digital Gain List Mode Baseband Mode Baseband Configuration B-Dual Tone E-List Configuration	StandAlone • Connector: RF3OUT • Converter: RFTX4 • 0.00 dB 2115.0000000 MHz • Beseband Offset: -46.00 dBm Peak Envolope Power: 46.00 dBm 0.00 dB Off • CW • Listmode: Off List Count: 1	List Config.

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<sup>®</sup>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<sup>®</sup>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  $\geq$  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<sup>®</sup>CMW500 web site at: <u>www.rohde-schwarz.com/product/CMW500</u>

## 6 Ordering Information

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

Ordering Information	on	
Name	Description	Order number
R&S <sup>®</sup> CMW500	Wideband Radio Communication Tester	1201.0002K50
R&S <sup>®</sup> CMW-PS503	R&S <sup>®</sup> 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 <sup>®</sup> CMW-S550B	Baseband Interconnection Board (Flexible Link)	1202.4801.03
R&S® CMW-B570B	Extra RF Converter (TRX)	1202.8659.03
R&S <sup>®</sup> CMW-S590D	RF Front-End Module Advanced	1202.5108.03
R&S <sup>®</sup> CMW-S600B	Front Panel with Display/Keypad	1201.0102.03
R&S <sup>®</sup> CMW-B620A	Digital Video Interface (DVI) Module	1202.5808.02
R&S <sup>®</sup> CMW-B300B	Signalling Unit Wideband (SUW)	1202.6304.03
R&S <sup>®</sup> CMW-KS500	LTE FDD Release 8, SISO, signalling/network emulation, basic functionality	1203.6108.02
R&S <sup>®</sup> CMW-KM500	LTE FDD Release 8, TX measurement, uplink	1203.5501.02
R&S <sup>®</sup> CMW-KS550	LTE TDD (TD-LTE) Release 8, signalling/network emulation, basic functionality	1204.8904.02
R&S <sup>®</sup> CMW-KM550	LTE TDD (TD-LTE) Release 8, TX measurement, uplink	1203.8952.02
R&S <sup>®</sup> CMW-KS510	LTE Release 8, SISO, signalling/network emulation, advanced functionality	1203.9859.02
R&S <sup>®</sup> CMW-KT055	LTE, CMWrun sequencer software tool	1207.2107.02
R&S <sup>®</sup> 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<sup>®</sup>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:

٩	LTE 3	GPP T	\$36.521 Co	onfiguratio	n					X 8
F	iettings DD 🔻	s Dup	lex 🔲 Di Category	isplay Not F	equired by	3GPP in Re nax	port 3GP User Config	P Standard ed Channel	0	Test tems            ⊕··□ 6 Transmitter Characteristics ⊕··☑ 7 Receiver Characteristics
	Band	Test	Channel 1.4 MHz	Channel 3.0 MHz	Channel 5.0 MHz	Channel 10 MHz	Channel 15 MHz	Channel 20 MHz		√ 7.3 Receiver Sensitivity Level     √ 7.4 Maximum Input Level     √ 7.5 Adjacent Channel Selectivity     √ 7.5 Adjacent Blocking
	1		Ν	Ν						·····································
	2									7.8.1 Wideband Intermodulation
	3								≡	8 Performance Requirement
	4	1	19957,	19965,	19975,	20000,	20025,	20050,		
	5						N	N		···· 🔲 8.2.1.2.1 FDD PDSCH Transmit Div ≡
	6		Ν	Ν			N	N		
	7		N	N						
	2 2						N	N		
	0		N	M						
	3		N	N					-	8.2.2.2.1_1 TDD PDSCH Transmit I
	10		N							9 Reporting of Channel State Information
	11		N	N			N	N		
	12						N	N		9.2.2.1 FDD CQI Reporting Under A
	13		Ν				N	N		9.3.2.1.1/9.3.2.1.1_1 FDD CQI Rep
	14									0.2.2.7.2 TDD CQL Reputing Under /
	15								-	۰ III +
				i	III	i		•		Interferer Setup for TC7.5, TC7.6.1, TC7.6.3
							(	Clear Tabl	e	DUT Power Cycles
										OK Cancel

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 EVMI for PUSCH	UL ModelAlice, 788	Link	MeasagerE	their	States
6.5.2.1 Error Vector Magnitude (EVM) for P05CH & Banduti	and the second	- 31553	1.	- 22/21	10000
PUSCHEVM: BULCH: 30150, BH: 20 MHz, ULPOWE 23 dBro	OPSK: 10 (HB_PosiLOW)	++ 17.50	3.21	3	Passed
PUSCHEVMOMRS: @ULCH: 39750; EW: 20 MHz; ULFower: 23 dbro	OPSK, 18 (FB_POSILOVO)	H= 17.50	3.41		Page00
PUSCHEAM BULCH: 30150: 844 20 MHz, ULPOWER 23 dBm	GPBK, 16 (RB, PECHROHO	en 17.50	2.99		Passed
PUSCH EVAN DWRS: @K/COV 30/50: 8W 20 MHz, UCFOWN: 23 JBm	GPSK, 18/RB, Psis H0H6	+= 17.93	2.97	. *	P90000
PUSCH EVAN (BULCH: 39750) BW: 20 ANIZ, ULPOWER: 23 (1970)	OPSK 100 JR9 PostLOV6	sa 17.50	3.21	*	Pacced.
PUSCH EVM DMRR: @ULCH: 39750. BW: 20 AHz, ULFower: 20 dBm	GPSK: 100 /F8_P06/L0W6	44 17 50	3,17		Passed.
PUSCH EVM: BULCH: 39750, BW: 20 MHz, ULPower: 23 dBm	Q18_18/89_PostL046	<pre>&lt;= 12.90</pre>	4,99		Passed
PUSCH EVM DMRS: 20(A)CH: 39/50, 20/ 20 MHz, 1A Power 23 dBm	Q18, 18/R9_P061,0V6	s= 12.90	333		Passed
PUSCHEVAR BULLEN 39750 SH 20 MHz ULPOWE 23 dBm	Q16, 18 (RR, P18, H0H0	+2 12.60	4.54		Passed
PHISCH EVM DMRIS: BULLOW 19750 SW 201047, ULPOWER 13 dBm	Q16, 19 (RB_Fax1404-0)	et 12.50	3.51		Pannet
PUSCHEVM: @UCCH 39/50 BW 20MHz UCPOWE 23 dBm	Q16, 106 (RS, PostLOV)	er 12.50	4.81		Patted
PHSCHEVMOMRS: @ULCOV. 30/30, BW 20104z, ULFOWN: 23 dBro	Q16, 100 (FSL Post LDW)	** 12.50	4.05		Farned.
PHSCHEVAR @ULCH/ 39150-204' 20 ABV2, ULPower -36.8 dBm	OPSIC 18 (RB_PostLOW)	++ 17.53	2.27		Passed
PUSCH EVM DMPS: (BULCOV 39750, BM 20 MHz, L/L/Ower -36.8 dBm	OPSK 10 (FB, PostLOVE)	== 17.53	2.47	1.4	Pessed.
POSCH EVAL BUCCH: 39/50 BW 20 MHz, ULPower - 36.8 dBm	GPSK, 18 (FB, PESTROPO	→ 17.50	2.42	8	Passed
PUSCHEVMOMRS: @ULCH: 30/30.5M 20 AH2. DLPower -36.8 00m	GPDK, 18 (FIB_PERTROPO	+= 17.50	2.87		Persed
PUSCHEVME (BLACH: 39730, SW 204042, ULPOWER -36.8 dBm	GP3K: 100 8FB Post_OV6	v= 17.90	2.97		Pacood
INSCREAM DWINS: BOLCOM 2015D 344: 20 MHZ ULPOWOR -36.8 (8m)	GP3K: 100-998 Posts.0Wb	e= 17.50	317		Passod
PHISCHEVAR BEACH: 30150 BW: 20 AHZ, ULPOWE: 38 8 JBM	Q16, 18 (RB PosscOWE)	** 12.50	2.31		Paccod
PUSCHEVMOMPS: BULCOR 30/50 SW 20 AHZ UCPOWE 08.8 dBm	Q16_18/RB_Post_OV6	== 12.50	2.40		Pacced
PUSCH EVML BULLCH: 39/50; BW: 20 APHZ, ULPOWER: 96.8 (80)	Q16, 18 (RB, Past+60+6	44 12 50	2.47		Passed
PUSCH EVM DMRS: BULLCH: 99/50, EW: 20 MRz, U/LFower -36.8 dBm	Q16, 18/88, PteH0H0	44 12 50	273		Passed
PUSCH EVM: @ULCH: 39350_EW: 20 MHz, ULPover -36 8 dBm	918, 100 (R9, Post, 0V6)	s= 12.50	317	16	Passed
PUSCH FUM DARS: @UX.CH/ 39/50_8W 31AH2, 1/LPower -30.8 dBm	Q15 100 (FB_Post_OV6)	42 12 50	3.24		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.

wer Cycles			Automation	AT Moders Commanda	
DUT Supports RRCRe	configuration for SIB cha	nge (LTE FW >-3.0.30)	AT Mades Country	-	
Keep RAC Connection	(LTE FW >+ 21.30)		ALC HODESI CONTRACT		
Frequency Change	Bind Hendover +	(Bind Handover and	RF OFF Command	AT+CFUN=0	
Operating Band Change	Bind Hendover +	Requercy Redirection are only supported from	Wat after OFF loal	3000	
iandWidth Change	Redrection ·	LTE Firmware 2.1.30)	the site of the	1.11	
utomation			RF ON Command	AT+CFUN+1	
Automation Ede	mail Presser Sunnale				
External Power Supply	.0.6.8.		Automation		
External Power Supply	( Defende )		Automation		
External Power Supply	< Default >		Automation Automation	Customized Test Plan	•
External Power Supply Instrument	< Default > VOLT 4.0		Automation Automation Customized Testplan	Gustomared Test Plan for Power Cycle	•
External Power Supply Instrument Votage Setup Command Current Setup Command	<default> VOLT 4.0 CURR 3.0</default>		Automation Automation Customized Testplan RF OFF Testplan	Customand Teel Plan for Power Cycle Browse	·
Estemal Power Supply Instrument	<default> VOLT 4.0 CURR 3.0 OUTP ON</default>		Automation Automation Customized Testplan RF OFF Testplan 0: DATA: CMWhar	Customed Test Plan for Power Cycle Browse	•
Etemal Power Supply Instrument	< Default > VOLT 4.0 CURR 3.0 OUTP ON OUTP OFF		Automation Automation Customized Testplan RF: OFF Testplan 0:\DATA\CMWhun	Customed Test Plan for Power Cycle Browse Filee'My Test Plans'power_off.etg	-
Etemal Power Supply buturent b	< Default > VOLT 4.0 CURR 3.0 OUTP ON OUTP OFF		Automation Automation Customized Testplan RF OFF Testplan 0:\DATA\CMWhun RF ON Testplan	Customed Test Plan for Power Cycle Browse Filee'My Test Plans'power_off.stp Browse	•

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

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