LTE Downlink Carrier Aggregation RF Measurements with the R&S[®]CMW500 according to 3GPP TS 36.521-1

Application Note

Products:

| R&S®CMW500

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

This application note describes how to use the LTE Frequency Division Duplex (FDD) and Time Division Duplex (TDD) measurement functionality associated with the Downlink Carrier Aggregation feature of the R&S[®]CMW500 wideband radio communication tester to perform LTE R10 receiver measurements according to this test specification.

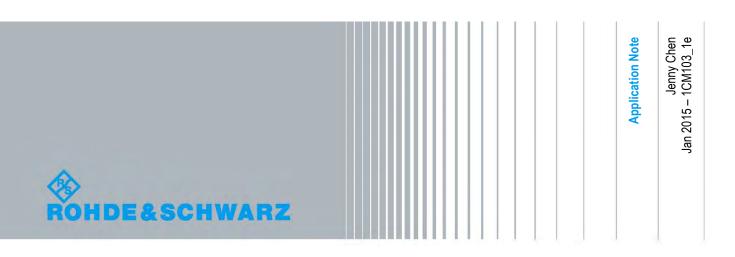


Table of Contents

1	Introduction	3
1.1	Understanding Test Case Suffixes	4
1.2	Understanding Bandwidth Class	4
1.3	Setting Up Downlink Carrier Aggregation (DL CA) Mode	4
1.4	Generic Setup for DL CA	8
1.5	Throughput Measurement	10
2	Receiver Characteristics	12
2.1	Generic Test Description for Receive Tests	12
2.2	Reference Sensitivity Level for CA (TS 36.521-1, 7.3A. <i>x</i>)	14
2.3	Maximum Input Level for CA (TS 36.521-1, 7.4A)	16
2.4	Adjacent Channel Selectivity for CA (TS 36.521-1, 7.5A)	19
2.5	In-Band Blocking for CA (TS 36.521-1, 7.6.1A)	21
2.6	Narrowband Blocking for CA (TS 36.521-1, 7.6.3A)	23
2.7	Wideband Intermodulation (TS 36.521-1, 7.8.1)	25
3	Using CMWRun	29
3.1	General Configurations	31
3.2	User-Defined Band Channel Configurations	31
4	Literature	33
5	Additional Information	33
6	Ordering Information	34

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 Downlink Carrier Aggregation (DL CA). This document provides a step-by-step guide to performing Release-10 DL CA measurements with the R&S®CMW500 LTE callbox according to **3GPP TS 36.521-1 V12.2**, Clause 7. No transmitter test cases are defined for DL CA in V12.2 without UL CA device testing. This description refers to the functionality provided with **Version 3.2.80 of the R&S®CMW500 firmware**. This document will be updated to specify relevant changes resulting from new firmware releases.

This application note (AN) shall function as an extension of application note 1CM94 *"LTE RF Measurements with the R&S®CMW500 according to 3GPP TS 36.521-1"* for R10 Downlink Carrier Aggregation (DL CA) without Uplink Carrier Aggregation (UL CA). It is recommended to read 1CM94 before this AN to gain a basic understanding of *the R&S®CMW500* concept of operation.

The tests described here are limited to those without a requirement for 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 other tests that can be performed with such additional equipment, please refer to the latest R&S®CMW500 capability list found on the CMW customer web:

https://extranet.rohde-schwarz.com

1.1 Understanding Test Case Suffixes

According to **3GPP TS 36.521-1**, DL CA test case numbers must be followed by the suffix 'A' (compare to R8). In addition to this suffix, an extension is used to identify various requirements for different kinds of CA. The extensions in **3GPP TS 36.521-1 V12.2** differ from those used in V11.2 and are listed below:

- '.1' Intra-band contiguous DL CA and UL CA
- '.2' Intra-band contiguous DL CA without UL CA
- '.3' Inter-band DL CA without UL CA
- '.4' Intra-band non-contiguous DL CA without UL CA

As the test procedure applies equally to all of the above, these digital number suffixes are replaced with '.*x*' in this AN, and the different requirements for each type of DL CA are highlighted.

1.2 Understanding Bandwidth Class

The aggregated transmission bandwidth configuration (ATBC) consists of a number of aggregated physical resource blocks (PRB).

CA bandwidth class indicates a combination of maximum ATBC and a maximum number of component carriers (CC).

Three classes are defined in R10 and R11:

Class A: ATBC \leq 100, maximum number of CC = 1 Class B: ATBC \leq 100, maximum number of CC = 2 Class C: 100 < ATBC \leq 200, maximum number of CC = 2

Test requirements may vary according to bandwidth class, especially for intra-band DL CA.

1.3 Setting Up Downlink Carrier Aggregation (DL CA) Mode

Two signalling unit widebands (B300B) and the KS502 (FDD) / KS552 (TDD) and KS512 software options are required to support 2DL CA testing. Two B510F fading boards and the KE100, KE500 and KS520 software options are needed to test Chapters 8 and 9. Testing of 3 DL CA requires three signalling unit widebands (B300B).

1.3.1 CA Scenario Selection

To activate DL CA, click on the *Scenario* dropdown button on the Signalling *Config* page. The diagram below shows all of the choices available with a CMW outfitted with two signalling unit widebands, four TRx boards and two fading boards. Some options may not appear in the dropdown menu depending on the hardware and software options installed.

PCC	+ SCC1	
Path: Scenario		
Duplex Mode		FDD 💌
Scenario		2CC CA - 4 RF Out
		1 Cell - 2 RF Out 1 Cell - 4 RF Out 1 Cell - IQ Out, RF In 1 Cell - Fading - 1 RF Out 1 Cell - Fading - 2 RF Out 1 Cell - Fading - MIMO4x2 - 2 RF Out 2CC CA - 2 RF Out
		2CC CA - 4 RF Out 2CC CA - Fading - 2 RF Out 2CC CA - Fading - 4 RF Out ▼

Fig. 1: CA scenario selection.

- 2CC CA 2 RF Out: both component carriers (CC) can transmit in SISO (TM1) or single layer beamforming (TM7) mode; only two RF channels are required.
- 2CC CA 4 RF Out: both CCs can transmit in SIMO (TM1), transmit diversity (TM2), 2x2 MIMO (TM3, TM4), single layer or dual layer beamforming (TM7, TM8) mode; four RF channels are required.
- 2CC CA Fading 2 RF Out: fading profiles can be activated for 2CC CA 2 RF Out scenarios. Fading board is required. KE500 is required to activate internal fading profile.
- 2CC CA Fading 4 RF Out: fading profiles can be activated for 2CC CA 4 RF Out scenarios. Fading board is required. KE500 is required to activate internal fading profile.

The SCC1 tab is activated following CA scenario selection.

Click on the SCC1 tab to view all the secondary CC1 (SCC1) settings. It is similar to Primary CC (PCC) configuration page.

The Scenario option can only be selected in Cell ON or Cell OFF. This setting will be greyed out once the mobile phone has been registered with the CMW.

It is recommended to use a CMW with 4 configured RF channels. If the CMW has only 2 RF channels, an external splitter will be needed to feed the signal to all of the receiving antennas. The External Attenuation setting should include the attenuation caused by the external splitter.

1.3.2 RF port selection

With the Advanced RF frontend, the PCC and SCC signals can be transmitted from the same RF *Connector* port using different RF *Converters*. The *External Attenuation* value can be set separately.

For 2CC CA – 2 RF Out scenarios, the default setting uses the RF1COM for both PCC and SCC.

For 2CC CA – 4 RF Out scenarios, the default setting uses RF1COM and RF2COM for PCC and RF3COM and RF4COM for SCC.

The RF port setting below is recommended for DUTs that support a combined PCC/SCC antenna. RF1COM should be connected to the mobile's Tx/Rx antenna, while RF3COM is linked to the phone's Rx antenna.

h: RF Settings/RF Output (TX)/External At	tenuation		Path: RF Settings/RF Output (TX)/External At		
Duplex Mode	FDD -		Duplex Mode	FDD /	
Scenario	2CC CA - 4 RF Out	-	Scenario	2CC CA - 4 RF Out	-
Enable Speech Codec	Γ		+ SCC Activation Mode	Auto 💌	
RF Settings			-Enable Speech Codec		
⊨♦RF Output (TX)	Out 1	Out 2			
Connector	RF1COM 🝷	RF3COM 🔻	➡ ◆ RF Output (TX)	Out 1	Out 2
Converter	RFTX1 -	RFTX2 🔻	Connector	RF1COM •	RF3COM
			Converter	RFTX3 🔻	RFTX4 🔻
External Attenuation	1.00 dB	0.00 dB	External Attenuation	2.00 dB	0.00 dB
External Delay Compensation			External Delay Compensation	0 ns	
i⊟RF Input (RX)	In		– RF Input (RX)	In	
Connector	RF1COM -		Connector	RF1COM -	
Converter	RFRX1 🔻		Converter	RFRX1 -	
	0.00 dB		External Attenuation	0.00 dB	
External Delay Compensation	0 ns		External Delay Compensation		
: PCC RF port config	uration		b: SCC RF por	t configuration	I



c: Connecting the CMW500 to a CA DUT with a dual-antenna design

Fig. 2: RF settings for PCC and SCC and the connection setup between CMW500 and DUT.

This AN describe DL CA testing only. If the mobile phone under test also supports UL CA, *the RF Input (Rx)* for SCC1 should be configured to a different RF *Converter*.

1.3.3 SCC Settings

For the R&S CMW500 LTE firmware V3.2.80, there are no limitations on PCC SCC band combinations as long the same Duplex is used. The SCC band, channel, bandwidth and connection type are all configurable via the SCC tab.

On the SCC1 Configuration page, set the SCC Activation Mode to 'Auto' or 'Manual'. The default value is 'Auto.'

If '*Manual*' is selected, the procedure for turning on / off SCC, SCC add / delete RRC and SCC activate / deactivate MAC needs to be done manually. Fig. 4 and Fig. 5 show the buttons to press and sequence for this. '*Auto*' is the recommended setting for all purposes except troubleshooting.

SCC Activation Mode can only be changed in Cell ON or Cell OFF. This setting will be greyed out once the mobile phone has been registered with the CMW.

The SCC State should be "MAC Activated" before starting a throughput test.

Fig. 3 shows the LTE signaling screen when SCC is connected.

🚯 LTE Signaling 1 - V3.2.80 - Base V 3.2.40									
Connection Status		PCC	sco	C1					
Cell 🕎		Operating Band	d E	Band 5		•	FDD		
Packet Switched 🚬 Attached			D	ownlink			Uplink		
RRC State Connected SCC1 State MAC Activated		Channel		2525	Ch		20525	Ch	
Event Log	,	Frequency		881.5	MHz		836.5	MHz	
06:10:08 (SCC1 State 'SCC MAC Activated'		Cell Bandwidth	1	10.0 MHz		•	10.0 MHz		
06:10:08 SCC1 State 'SCC RRC Added'		RS EPRE		-85.0	dBm/15kHz				
06:10:08 (SCC1 State 'SCC On' 06:10:08 (State 'Attached'		Full Cell BW P	ow.	-57.2	dBm				
06:10:07 🕧 EPS Default Bearer Established, ld 5		PUSCH Open L	Loop	Nom.Powe	r		-20	dBm	
06:10:07 () RRC Connection Established 06:01:56 () State 'Cell On'		PUSCH Closed Loop Target Power -20.0 dBm							
06:01:36 A Signaling Unit Startun	•								
UE Info 🗸		Connection S Sched. RMC	Setup)					
		Sched. RINC		-	<u> </u>				
IMEI 356432052226698 IMSI 450050123456063			г	Downlink		Lle	link		
	V6 prefix	#RB		Jowinink	50 🔻	Op	IIIIR	50	Ŧ
Left Left Left Left Left Left Left Left		RB Pos./Start	no	low	• 0	Ŀ	low -	00	0
Dedicated Bearer TFT Port Range	e		RU	10.44	_	Ŀ			
		Modulation			QPSK 🔻			OPSK	
	Þ	TBS Idx / Valu	е	5	4392		6 -	51	
		Throughput		3.9	53 Mbit/s		5.160	Mbit/s	
Detach Connect Off				Send SMS	G Inter/ RAT		ra- Conf	ig	

Fig. 3: SCC activated.



Fig. 4: SCC manual activation process.



Fig. 5: SCC manual deactivation process.

1.4 Generic Setup for DL CA

1.4.1 Physical Cell ID

According to 36.521, section 7.1 for CA tests, Cell ID = 0 applies to P-Cell, and Cell ID = 1 is used for S-Cell. This setting is located under *Physical Cell Setup*. The default value in LTE Firmware V3.2.80 is determined by specification.

⊟Physical Cell Setup	
DL Cell Bandwidth	10.0 MHz 🔻 #RB Max: 50
Physical Cell ID	1
Cyclic Prefix	Normal 🔻
-Sounding RS (SRS)	
te⊢SRS	
tDD	
⊡ • PRACH	

Fig. 6: Physical Cell ID setting.

1.4.2 OCNG

OCNG should be activated during all tests required for DL CA. It can be found under *Downlink Power Levels* and should be activated for both PCC and SCC.

RS EPRE	-85.0 dBm/15kHz Full Cell BW Power: -57.2 dBm
PSS Power Offset	0.0 dB
SSS Power Offset	0.0 dB
PBCH Power Offset	0.0 dB
PCFICH Power Offset	0.0 dB
	0.0 dB
PDCCH Power Offset	0.0 dB
- OCNG	
	RS EPRE PSS Power Offset SSS Power Offset PBCH Power Offset PCFICH Power Offset PHICH Power Offset PDCCH Power Offset

Fig. 7: OCNG activation.

1.4.3 MIMO Settings

The *MIMO Settings* are located in the *Connection* category. Prior to testing, the correct *Transmission Mode* and *DCI Format* must be set.

Receiver characteristics testing, (TM1) is used for all of chapter 7. For chapter 8 and 9, this setting varies according to test case and is specified in each.

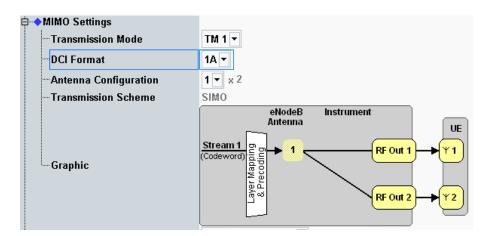


Fig. 8: MIMO settings.

Only *TM1* and *TM8* can be supported if the '2CC CA - 2 RF Out' scenario is selected. Once the mobile phone has been registered with the CMW, possibilities for changing the *Transmission Mode* and *DCI Format* are limited depending on the *Duplex* and *Scenario* settings. It is therefore recommended to properly set the *Duplex* and Scenario prior to switching on the phone.

🚸 CMW	r																			
🚸 LTE 9	Signaling '	1 - V3.2	.80 - Ba	ase V 3.	.2.40 - 1	RX Mea	sureme	ent												LTE
_	ended B			.C Thr	oughp	out														Extended BLER
Overa	all PC	х)	(SCC1																RDY
◆ ₿ ×	Off	fy:				Q x:		Off	y:			◆₿ >	c	C	Off y:					<u> </u>
Mbit/s 6	Throughp																			
4	 Overa Overa 	II PCC																		<u></u>
2	🔶 Overa 🔶 Max. F	all SCC Possible																		
-																		S	ubframes	
	-950	-900	-850	-800	-750	-700	-650	-600	-550	-500	-450	-400	-350	-300	-250	-200	-150	-100	-50	
						ver Al						er All I						er All		Routing
				Rela		/	Absolut				lative		Absol				ative		Absolute	ļ
ACK				100.0			216			100.0			10	080		100.0			1080	
NACK DTX				0.0				0			DO % DO %			0			10 % 10 %		0	Display
BLER				0.0				U			00 % 00 %			U			10 % 10 %		U	L
	ighput	1.1		Relat			Mb	it/e		Rela			M	bit/s		Relat			Mbit/s	
	erage			100.00				.91		100.0				3.95		100.00			3.95	Marker
	nimum				.			.91						3.95			· · ·		3.95	L
- Ma	aximum						7.	.91					:	3.95					3.95	Signaling
Subfrar	mes			Sched	uled:		Median	i CQI	PCC	N	/ledian	CQI S	CC1							Parameters
	2 40	0 / 120	10		21	60	Stream	1		S	Stream	1		-						<u> </u>
(7)	PS: »		ched State	: 60		s. 🔀 1200	SCC St	tate:	MAC A	ctivate	d									LTE Signaling ON
Repeti	ition	Stop Conc	lition]	Subfra	ames .												Сог	ıfig	

1.5 Throughput Measurement

Fig. 9: Extended BLER (throughput) measurement result.

The CA throughput measurement display is similar to that for R8 measurement and features additional tabs with detailed Overall, PCC and SCC results. Click on each tab to view these details.

1.5.1 BLER Error Ratio Calculation

1.5.1.1 Error Ratio Calculation for Receiver Characteristics

According to TS 36.521-1 Annex G.2. Annex G.2A for CA, (NACK + DTX) / (NACK+ DTX + ACK) is the error ratio (ER) for receiver characteristics testing, and it is based on the standard concept defined in G.2.

The error ratio formula in the CMW500 can be selected under *LTE RX Meas. Page > Extended BLER > Config* page as shown in the figure below. The default setting is "(*NACK* + *DTX*) / (*NACK* + *DTX* + *ACK*)".

No early pass or early fail should be implemented for receiver characteristics testing. The *Stop Condition* should be '*None*' (default value).

🚸 LTE BLER Configuration				
Path: Extended BLER/Error Ratio Calculation				
⊨-Extended BLER				
	SingleShot 🔻			
	None 🔻			
-No. of Subframes	1200		Stop Condition	
Error Ratio Calculation	(NACK+DTX)/(ACK+NACK+DTX) 🔻	ĪN	one	- hed
E-Confidence BLER	(NACK+DTX)/(ACK+NACK+DTX)	Ŀ		ected
	DTX/(ACK+NACK+DTX) NACK/(ACK+NACK+DTX) NACK/(ACK+NACK)		Stop Condition	Subframes

Fig. 10: Error ratio calculation formula.

2 Receiver Characteristics

2.1 Generic Test Description for Receive Tests

The receiver test items listed in Table 1 are described in this application note. The CMW500 supports the rest of the test items according to the specification. They are not listed, however, in this application note, as they require external filters or spectrum analyzers and describing the relevant procedures would exceed the scope of this short application note. Users are encouraged to contact their local sales representative regarding the pre-conformance / conformance test system provided by Rohde-Schwarz for those tests.

	TS 36.521-1 Section	Test case	Additional generator required
1	7.3A	Reference sensitivity level for CA	No
2	7.4A	Maximum input level for CA	No
3	7.5A	Adjacent channel selectivity for CA	Yes/ LTE Signal(4TRx required)
4	7.6.1A	In-band blocking for CA	Yes/LTE Signal(4TRx required)
5	7.6.3A	Narrowband blocking for CA	Yes/ CW Signal(4TRx required)
6	7.8.1A	Wideband intermodulation for CA	Yes/CW & LTE Signal (4TRx required)

Table 1: Receiver test cases described in this application note.

The example measurement screenshots in this chapter were taken based on a device supporting CA_3A-5A (10M + 10M) with a combined PCC/SCC antenna.

2.1.1 Interference Description

Extra interference that coexists with the LTE communication signal is required to perform test cases 7.5A, 7.6.1A, 7.6.3A and 7.8.1A, and there are many ways of generating the necessary interference signal. It is possible, for instance, to use an external generator such as an R&S[®]SMU/SMW/SMBV to create the interference signal. Alternatively, it is possible to generate the interference signal with the third RF channel of the R&S[®]CMW500 so as to avoid the need for an external instrument.

With the internal generator method, only the '2CC CA - 2 RF Out' scenario should be selected. This leaves the third and the fourth RF channels for interference signal generation. In this case, the user needs a combiner to merge the useful signal and interference signal as well as a power splitter to distribute the combined signal to both receiving antennas. Proper RF attenuation needs to be set in CMW500 to ensure the signal received at the DUT receiver antenna port has the correct power according to the specification. An example of this setup is shown in Fig. 11, but it is not applicable if the DUT's PCC and SCC antennas are separated.



Fig. 11: Setup for testing with an internal interference generator.

Detailed interference settings are described in the separate test steps for the test cases. Please note that the R&S[®]CMW500 should use the GPRF generator (ARB mode) to create the interference signal in test cases 7.5A and 7.6.1A. This means that a number of ARB files are required. Additionally, users are encouraged to pay close attention to the cable-loss calibration in this setup, as it varies depending on the type of combiner used.

Two interference signals are required for 7.8.1. One is a CW signal, and the other is an ARB signal, meaning a total of four 4 RF signals must be generated, including the LTE signal. Only CMWs equipped with four TRx channels can perform this test.

Interference signal frequency setting details for each CA configuration are available in the CMWRun report both in Demo mode and real execution cases.

2.1.2 Uplink Power Settings

A typical note for CA receiver test cases is "The transmitter shall be set to 4dB below P_{CMAX_L} or P_{CMAX_L} ca as defined in Clause 6.2.5A". P_{CMAX_L} applies to DUTs supporting DL CA only, and P_{CMAX_L} ca applies to DUTs supporting DL CA and UL CA.

For DL CA-only DUTs, the formula for calculating the uplink power for UE transmission is the same as the R8 requirements. As for all bands, the uplink RB number specified in TS 36.521-1 receiver tests for CA satisfies the 1 dB maximum power reduction defined in TS 36.521-1, Table 6.2.3.3-1. The P_{CMAX_L} is 22 dBm or 30 dBm for HPUE if there is no applicable additional maximum power reduction. Notes 2,5,6 in TS 36.521-1, Table 6.2.2.3-1 do not apply.

For DUTs that also supporting UL CA, the power reduction should be referred to TS 36.521-1, Table 6.2.3A.x.3-1 (where *x* refers to a different DL CA as mentioned in section 1.1).

A similar concept for the CMW500 close loop power setting is referred to in 1CM94 for DL CAonly DUTs. This close loop power setting should be ($P_{CMAX_L} - 4 - 1.7$) if the carrier frequency is f ≤ 3.0 GHz or ($P_{CMAX_L} - 4 - 2$) if the carrier frequency is 3.0GHz < f ≤ 4.2 GHz.

2.1.3 Filter Coefficient Setting

The filter coefficient should be set as 'fc8' for all receiver tests. It can be modified in a connected state.

ģ (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. 12: Filter coefficient setting.

2.1.4 Uplink Resource Block Allocation

If the DUT does not support UL CA, the uplink resource block configuration follows TS 36.521-1, Table 7.3.5-2.

If the DUT supports UL CA, the uplink resource block configuration follows the test specific Test Configuration Table defined in the relevant test cases.

2.2 Reference Sensitivity Level for CA (TS 36.521-1, 7.3A.x)

The purpose of this test is to verify the CA-supported UE's ability to receive data at a given average throughput for a specified reference measurement channel under conditions involving a low signal level, ideal propagation and no added noise.

An UE that is unable to meet the throughput requirement under these conditions will decrease the effective coverage area of an e-NodeB.

2.2.1 Test Description

The purpose of the test is to verify the sensitivity level with QPSK modulation and full RB allocation in the downlink.

The minimum conformance requirement for all the CA band class combinations is defined in TS 36.521-1, Chapter 7.3A.1.3. The minimum number of samples defined is found in TS 36.521-1, Annex G.2A (1003 per CC).

Generally speaking, the cell full bandwidth (BW) power should follow the formula below. Exceptions are permitted for certain CA configurations. The exception conditions are defined in TS 36.521-1, Tables 7.3A.1.3-0a and 7.3A.1.3-0b. New versions may include more exception definitions.

 $P_{REFSENS_{CA}} = P_{REFSENS_{R8}} - \Delta RIB, c$ ------ Equation 1

Where

- $P_{refsen_{R8}}$ refers to 3GPP TS 36.521-1, Table 7.3.5-1. - Δ RIB, *c* refers to 3GPP TS 36.521-1, Tables 7.3A.1.3-0 and 7.3A.1.3-2. The value should be 0 if the CA configuration is not listed in the table. A network signalling value must be applied for certain CA configurations (summarized in the table below). This network signaling value should be applied only when the PCC is the *Uplink Band* listed in the table. In all other cases, it should be *NS_01* e.g., for CA_4A-12A, the *PCC Network Signaling* value should be "*NS_06*" only when the PCC is band 12 and the SCC is band 4. The *PCC Network Signaling* value should be "*NS_01*".when the PCC is band 4 and the SCC is band 12.

UL resource allocation is defined in *Test Description* for each CA configuration (TS 36.521-1 TC7.3A.x.4). It generally follows Table 7.3.3-2 for definitions not provided in the specification.

Table 2: Summary of network signalling (NS) settings for	for specified CA configuration.
--	---------------------------------

E-UTRA CA Configuration	Uplink Band	Network Signalling value		
CA_4A-12A	12	NS_06		
CA_4A-17A	17	NS_06		
CA_2A-29A	2	NS_03		

2.2.2 Test Procedure

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

- Step 1. Preset the instrument.
- Step 2. Set Duplex mode.
- Step 3. If the DUT has combined antennas for the PCC and SCC, connect the DUT to the CMW500 as shown in Fig. 2 and set the Scenario to "2CC CA 4 RF Out" or "2CC CA 2 RF Out". as depicted in Fig. 11. If the DUT has separate PCC and SCC antennas, connect each RF port to the corresponding DUT antenna port and select the appropriate scenario for the connection.
- **Step 4.** Set the *RF Output Connector/Converter* and *RF Input Connector/Converter* accordingly.
- Step 5. Set the correct *External Attenuation* for each port and cell.
- Step 6. Set the Transmission Mode to 'TM1' and the DCI Format to '1A'.
- **Step 7.** Set the *PCC network signalling values* to match those specified in Table 2. Use *"NS_01"* for bands not listed in this table (e.g. CA_3A-5A).
- **Step 8.** Enable the LTE cell. Power on the LTE UE so that it attaches to the network and press *Connect* to establish the connection.
- **Step 9.** Set the testing *Cell Bandwidth, DL Channel, Downlink and Uplink #RB, Modulation* and *RB Pos./Start RB* for both the PCC and SCC (defined in TS 36.521-1 7.3A.x.4.1 *Initial conditions where x* represents the number used for various types of CA configurations).
- Step 10. Set Active TPC Setup to Max Power to ensure that the UE power reaches its maximum.
- Step 11. Enable *OCNG*. This can be done before powering on the DUT.
- **Step 12.** Go to the *LTE RX Meas.* pPage and set *Subframes* >= *1200* (1200 is the next smallest number greater than 1003) in accordance with the specification.
- **Step 13.** Set the DL EPRE to Resource Element power based on the calculated $P_{REFSENS_CA}$, from $P_{REFSENS_CA} = P_{REFSENS_RB} \Delta RIB, c$ ------ Equation 1 for both the PCC and SCC. Please be aware that $P_{REFSENS_CA}$ is the total cell power for the corresponding PCC or SCC. This has a fixed relationship with the *RS EPRE* (reference signal energy per resource element) used in the R&S[®]CMW500, which is:
 - P_{REFSENS_CA} = RS EPRE + 10 * log10(N_RE)

N_RE is the number of resource elements (12 *[number of RBs]) and the number of RBs depends on the DL PCC / SCC cell bandwidth.

Consequently, a Band 3 10 MHz-bandwidth RS EPRE needs to be set to $-121.1 \ dBm$ to achieve P_{REFSENS} = -93.3 dBm. (-93.3 dBm - 10*log10(600) = - 121.1 dBm)

Measure the throughput achieved under these conditions. In this example, the throughput is *7.91 Mbps*, which represents 100 % of the scheduled throughput according to the *RMC* settings and can be seen directly on the measurement screen.

🚸 CMW																			
🚸 LTE S	Signaling 1 - V	3.2.80 - 1	Base V 3	.2.40 - R	X Meas	surem	ent												LTE
	ended BLER	F	RLC Thr	oughp	ut														Extended BLER
Overa			(SCC1)																RDY
◆ ₿ ×:	Off y:			•	🛛 🛛		Off	y:			\	c	0	ff y:					
Mbit/s 6 ~	Throughput : Overall Overall PCC																		
4 -	 Overall SCO Max. Possil 																		
L																		ubframes	Ļ
	-950 -90	0 -850) -800		-700 /er All	-650	-600	-550	-500	-450	-400 er All F	-350	-300	-250	-200		-100 r All	-50	Routing
L			Rela	ative		bsolu	ite		Re	lative		Absol	ute		Re	ative		Absolute	Routing
ACK			100.0	0 %		21	60		100.0	0 %		10	80		100.0	0 %		1080	<u>}</u>
NACK			0.0	0%			0		0.0	00 %			0		0.0	0%		0	Display
DTX				0%			0)0 %			0			0%		0	
BLER				0%						00 %						0%			
Throug	· ·		Rela				bit/s		Rela				bit/s		Relat			Mbit/s	Marker
Ave	erage nimum		100.0	U%			7.91 7.91		100.0	U%_			3.95 3.95		100.00	۱%		3.95 3.95	
	nimum aximum						7.91						3.95					3.95	
Subfram		200	Sched	uled: 216			n CQI	_		1edian Stream	CQI S 1							3.55	Signaling Parameters
()	PS: »L Att	tached RC Stat	e: C	-					ctivate	_									LTE Signaling ON
Repetit	tion Sto	op nditior	n	Subfra	mes	•			Í		ľ						Cor	nfig]

Fig. 13: Measurement screen of the block error rate (BLER) test for reference sensitivity testing.

2.2.3 Test Requirements

The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Table 7.3A.x.5-1.

2.3 Maximum Input Level for CA (TS 36.521-1, 7.4A)

The maximum input level test evaluates the CA-supported 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.

An UE that is unable to meet the throughput requirement under these conditions will decrease the coverage area near an e-NodeB.

2.3.1 Test Description

This test is carried out with 64 QAM modulation and full RB allocation in the downlink for both PCC and SCC. The values to be selected for the bandwidth, frequency and RMC, along with details on the UL RB allocations, are defined in TS 36.521-1, Table 7.4A.x.4.1-1.

For carrier aggregation, UE maximum input level is defined as the mean power received at the UE antenna port over the aggregated channel bandwidth, at which the specified relative throughput shall meet or exceed the minimum requirements for the specified reference measurement channel over each component carrier. In summary, the total aggregated DL transmitting cell power with all CCs for bandwidth class A and C UEs should be -22.7dBm. For inter-band DL CA, the DL transmitting power should be -25.7dBm per CC. For bandwidth class B UEs, the aggregated DL Cell power with all CCs should be -25.7dBm.

The UE transmitter power should be set to 4dB below P_{CMAX_L} or P_{CMAX_L} as defined in Clause 6.2.5A. The CMW500 close loop power setting is explained in section 2.1.2.

2.3.2 Test Procedure

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

- Step 1. Preset the instrument.
- Step 2. Set *Duplex* Mode.
- Step 3. If the DUT has combined antennas for the PCC and SCC, connect the DUT to the CMW500 as shown in Fig. 2 and set the Scenario to "2CC CA 4 RF Out" or "2CC CA 2 RF Out" as shown in as Fig. 11. If the DUT has separate antennas for PCC and SCC, connect each RF port to the corresponding DUT antenna port and select the appropriate scenario for the connection.
- Step 4. Set the RF Output Connector/Converter and RF Input Connector/Converter accordingly.
- Step 5. Set the correct External Attenuation for each port and cell.
- Step 6. Set the Transmission Mode to 'TM1' and the DCI Format to '1A'.
- **Step 7.** Enable the LTE cell. Power on the LTE UE so that it attaches to the network and press *Connect* to establish the connection.
- **Step 8.** Set the testing *Cell Bandwidth, DL Channel, Downlink and Uplink #RB, Modulation* and *RB Pos./Start RB* for both the PCC and SCC (defined in TS 36.521-1 7.4A.x.4.1 *Initial conditions* where *x* represents the number used for various types of CA configurations).
- **Step 9.** Set *Active TPC Setup* to *Close Loop* and *Closed Loop Target Power*, *16.3dBm* (calculated according to Section 2.1.2) to ensure that the UE power reaches its required range.
- Step 10. Enable OCNG. This can be done before powering on the DUT.
- **Step 11.** Go to the *LTE RX Meas.* page and set *Subframes* >= *1200* (1200 is the next smallest number greater than 1003) in accordance with the specification.
- **Step 12.** Adjust the DL *RS EPRE* so that the *Full Cell BW Pow.* indicates -25.7dBm (*RS EPRE* = 50.5dBm/15kHz for 10M BW) for both the PCC and SCC.

Measure the throughput achieved under these conditions. In this example, the throughput is *54.59 Mbps*, which represents 100% of the scheduled throughput according to the *RMC* settings. The *Throughput* rate can be found directly on the measurement screen.

if y: put: all	1			_													
all				0 x:		Off	y:	-		♦ ₽ ×	c	c	off y:				
all PCC all SCC Possible																	
															1	1	ubframes
-900	-850	-800				-600	-550	-500				-300	-250	-200			-50
													_				
																	Absolut
					216						10						108
						-						-					
		0.0) %			0		0.0	0%			0		0.	00 %		
		0.0)%					0.0	0%					0.	00 %		
		Relat	ive		Mł	bit/s		Rela	tive		M	bit/s		Rela	tive		Mbit
		100.0)%		54	.59		100.0	0%		27	7.29		100.0	0%		27.2
					54	.59					27	7.29					27.2
					54	.59					27	7.29					27.2
	S	Schedu	ed:	1	vledian	CQI F	PCC	Me	dian C	al sc	C1						
/ 1200			216	0 8	Stream	1		Sti	ream 1								
	-900	-900 -850	-900 -850 -800 Rela 100.00 0.00 0.00 Relat 100.00 Schedul 7 1200	-900 -850 -800 -750 Relative 100.00 % 0.00 % 0.00 % Relative 100.00 % Scheduled: 2/1200 216	-300 -850 -800 -750 -700 Relative 100.00 % 0.00 % 0.00 % Relative 100.00 % Scheduled: N 2/1200 2160 5	-300 -850 -800 -750 -700 -650 Over All Relative Absolu 100.00 % 211 0.00 % 0.00 % 0.00 % Relative Mil 100.00 % 54 54 54 54	-900 -850 -800 -750 -700 -650 -600 Over All Relative Absolute 100.00 % 2160 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % Relative Mbit/s 100.00 % 54.59 54.59 54.59 54.59	-900 -850 -800 -750 -700 -650 -600 -550 Over All Relative Absolute 100.00 % 2160 0.00 % 0 0.00 % 0 Relative Mbit/s 100.00 % 54.59 54.59 54.59 54.59 54.59 54.59	-900 -850 -800 -750 -700 -650 -600 -550 -500 Ver All Relative Absolute Rel 100.00 % 2160 100.0 0.00 % 0 0.0 0.00 % 0.00 % 0.0 0.00 % 0.00 % 0.00 % 0.00 %				-900 -850 -800 -750 -700 -650 -500 -500 -400 -350 -300 -900 -850 -800 -750 -700 -650 -600 -550 -500 -450 -400 -350 -300 -900 -850 -800 -750 -700 -650 -600 -550 -500 -450 -300 -900 <	-900 -850 -800 -750 -700 -650 -600 -550 -500 -400 -300 -300 -250 Over All Over All PCC Relative Absolute Relative Absolute 100.00 % 2160 100.00 % 1080 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 Relative Mbit/s Relative Mbit/s 100.00 % 54.59 100.00 % 27.29 54.59 27.29 27.29 27.29 Scheduled: Median CQI PCC Median CQI SCC1 1/1200 2160 Stream 1			-300 -850 -800 -750 -700 -650 -500 -450 -300 -300 -250 -200 -150 -100 Over All Over All PCC Over All Over All PCC Over All Su 100.00 % 2160 100.00 % 1080 100.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0 0.00 % 0.00 % 0 0.00 % 0 0.00 % 0.00 % 0 0.00 % 0 0.00 % 0.00 % 0 0.00 % 0 0.00 % 0.00 % 0 0.00 % 0 0.00 % 100.00 % 54.59 100.00 27.29 100.00 %

a. Full screen view for throughput

⊖ Extended B		C Through	put						
PCC	SCC1]							,
		Rela	ntive	Absolute	Operating Band	Band 3	•	FDD	~
ACK		100.0		1080	-	Downlink		Uplink	
NACK DTX			0 %						
BLER)0 %)0 %	(Channel	1845	Ch	19845	Ch
Throughput		Relativ		Mbit/	Frequency	1869.5	MHz	1774.5	MHz
Average			-).00 %	27.29		10.0 MHz	•	10.0 MH	Iz 🔽
Minimum				27.29	RS EPRE	-50.5	dBm/15kHz		
^l Maximum				27.29	Full Cell BW Pow.	-22.7	dBm		
Subframes	1 200	/ 1200 S	cheduled:	108	PUSCH Open Loo	p Nom.Pow	er	-20	dBm
					PUSCH Closed Lo	op Target P	ower	-20.0	dBm
					Connection Set	գլ			
					Sched. RMC		•		
						Downlink	Uţ	olink	
					#RB		50 💌		50 🕶
					RB Pos./Start RB	low 🔻	0	low 🕶	0
					Modulation	6	4-QAM 👻	Q	PSK 🔻
					TBS ldx / Value	24	30576	6 -	5160
					Throughput	27.294	Mbit/s	5.160 N	/lbit/s

b. Full screen view for BLER

Fig. 14: Measurement screen of the block error rate (BLER) test for maximum input level testing.

2.3.3 Test Requirements

The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Table 7.4A.x.5-1.

2.4 Adjacent Channel Selectivity for CA (TS 36.521-1, 7.5A)

Adjacent channel selectivity (ACS) for CA tests the UE's ability to receive data at a given average throughput for a specified reference measurement channel. This occurs 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.

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

2.4.1 Test Description

This test is carried out with QPSK modulation and full RB allocation in the downlink for both PCC and SCC. The values to be selected for bandwidth, frequency and RMC, as well as UL RB allocation details are defined in TS 36.521-1, Table 7.5A.x.4.1-1. The interference signal is a modulated LTE signal.

For inter-band CA, the interference signal setting is relative to the SCC as specified in TS 36.521-1, Section 7.5A.3.5. For Case 1, the Interferer power should be $P_{\text{REFSENS}_CA_SCC} + 45.5$, where $P_{\text{REFSENS}_CA_SCC}$ is calculated according to $P_{\text{REFSENS}_CA} = P_{\text{REFSENS}_R8} - \Delta RIB, c$ ------Equation 1. Interferer frequency setting details are defined in TS 36.521-1, Tables 7.5A.3.5-2 and 7.5A.3.5-3.

For intra-band Contiguous CA, the interferer signal frequency is an adjacent channel on either side of the aggregated downlink signal. It has a specified frequency offset and its power is relative to the total aggregated power for Case 1. The power level should be Aggregated Power + 22.5 dB for Case 1. The frequency offset is dependent of the adjacent CC calculated in Table 3.

Rx Parameter	Units			Channel B	andwidth						
		(SCC fo	or inter-band	CA or adjacent	CC for intra-k	band contigue	ous CA)				
		1.4 MHz	1.4 MHz 3 MHz 5 MHz 10 MHz 15 MHz 20 Mł								
BWInterferer	MHz	1.4	3	5	5	5	5				
FInterferer (offset	MHz	1.4+0.0025	3+0.0075	5+0.0025	7.5+0.0075	10+0.0125	12.5+0.002				
from SCC for		1	1	1	1	1	5				
inter-band CA		-1.4-	-3-0.0075	-5-0.0025	-7.5-	-10-0.0125	1				
or adjacent CC		0.0025			0.0075		-12.5-				
for intra-band							0.0025				
contiguous											
CA)											

Table 3: Interference frequency settings.

The interference frequency details are yet to be defined for intra-band noncontiguous CA.

For Case 1, the UE transmitter power should be set to 4dB below P_{CMAX_L} or P_{CMAX_L_CA} as defined in Clause 6.2.5A. The CMW500 close loop power setting is explained in section 2.1.2.

For case 2, the UE transmitter power should be set to 24dB below P_{CMAX_L} or $P_{CMAX_L_CA}$ as defined in Clause 6.2.5A.

The interference signal offset is understood as specified in the 1CM94 TC7.5 Test Description.

Section 2.1.1 describes procedures for connecting the DUT to the CMW500.

For Case 1, the DL cell power for each CC should be $P_{REFSENS_CA}+14$, where $P_{REFSENS_CA}$ is the calculated CC cell power according to $P_{REFSENS_CA} = P_{REFSENS_RB} - \Delta RIB$, c ------ Equation 1.

2.4.2 Test Procedure

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

For details on setting up the interference signal, please refer to Section 2.1.1 of this application note. The detailed interference signal settings are as shown in Fig. 15.

Upon completion of instrument Preset,

- 1. Prepare the interferer signal:
 - a. Activate General Purpose RF Generator 1
 - b. Set the appropriate routing and attenuation
 - c. Load the waveform: Set the *Baseband Mode* to *ARB*.

Load the interferer waveform according the bandwidth. The same three free interferer waveforms are used for R8 receiver testing cases, which are downloadable with application note 1CM94.

I_	_B014_	free.wv	- Bandwidth	= 1.4 MHz
----	--------	---------	-------------	-----------

h: Routing		
Scenario	StandAlone 💌	
Routing	Connector: RF30UT Converter: RFTX2	├───
-Ext. Att. (Output)	0.00 dB	
Frequency	1200.0000000 MHz 💌	
Level (RMS)	-12.00 dBm Peak Envelope Power:	<u> </u>
-Digital Gain	0.00 dB	ARB
- List Mode	Off -	
Baseband Mode	ARB 🔹	ſ
Baseband Configuration		List Confi
🗄 Dual Tone		Ļ
	LB050_free.wv Listmode: Off Total Result Count: 1	
"List Configuration	Listifute. On Total Result Count. T	
		}
		<u>}</u>
		L
		GPRF
		Generato
		OFF

I_B030_free.wv - Bandwidth = 3 MHz I_B050_free.wv - Bandwidth = 5 MHz

- Fig. 15: Interference signal settings.
- 2. Set up the LTE signalling and start the test:
- Step 1. Set *Duplex* Mode.
- **Step 2.** If the DUT has combined antennas for the PCC and SCC, connect the DUT to the CMW500 as shown in Fig. 11 and set the Scenario to "2CC CA 2 RF Out".
- **Step 3.** Set the *RF Output Connector/Converter* and *RF Input Connector/Converter* accordingly.

- **Step 4.** Set the correct *External Attenuation* for each port and cell.
- Step 5. Set the Transmission Mode to 'TM1' and the DCI Format to '1A'.
- **Step 6.** Enable the LTE cell. Power on the LTE UE so that it attaches to the network and press *Connect* to establish the connection.
- **Step 7.** Set the testing *Cell Bandwidth, DL Channel, Downlink and Uplink #RB, Modulation* and *RB Pos./Start RB* for both the PCC and SCC (TS 36.521-1 7.5A.x.4.1 *Initial conditions* where *x* represents the number used for various types of CA configurations).
- **Step 8.** Set *Active TPC Setup* to *Close Loop* and *Closed Loop Target Power*, *16.3dBm* (calculated according to Section *2.1.2*) to ensure that the UE power reaches its required range.
- **Step 9.** Enable *OCNG*. This can be done before powering on the DUT.
- **Step 10.** Go to the *LTE RX Meas.* page and set *Subframes* >= *1200* (1200 is the next smallest number greater than 1003) in accordance with the specification.
- Step 11. Go to GPRF Sig. 1, set the correct Frequency and Level(RMS) and turn on the signal.
- **Step 12.** Adjust the DL *RS EPRE* so that the *Full Cell BW Pow.* indicates (PREFSENS_CA + 14 dB) for both the PCC and SCC.
- **Step 13.** Measure the throughput achieved under these conditions. For a measurement window display example, refer to Fig. 14.
- **Step 14.** Change the *GPRF Sig. 1 Frequency* and carry out the measurement again. This concludes Test Case 1.
- **Step 15.** Change the *GPRF Sig. 1 Level* to *-25dBm* and the LTE DL *RS EPRE* so that the *Full Cell BW Pow.* indicates the required cell power (-56.5dBm for Inter-band CA) for both the PCC and SCC.
- **Step 16.** Measure the throughput achieved under these conditions. For measurement window display example, refer to Fig. 14.
- **Step 17.** Change the *GPRF Sig. 1 Frequency* and carry out the measurement again. This concludes Test Case 2.

2.4.3 Test Requirements

The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Tables 7.5A.x.5-2 and 7.5A.x.5-3.

2.5 In-Band Blocking for CA (TS 36.521-1, 7.6.1A)

In-band blocking is defined for unwanted interference signals within a range extending 15 MHz above and below the UE receive band. Within this range, the relative throughput must meet or exceed the requirements for the specified measurement channels.

The absence of in-band blocking capabilities decreases the coverage area when other e-NodeB transmitters are present (except in adjacent channels and for spurious response).

2.5.1 Test Description

This test is carried out with QPSK modulation and full RB allocation in the downlink for both the PCC and SCC. The values to be selected for bandwidth, frequency and RMC as well as UL RB allocation details are defined in TS 36.521-1, Table 7.6.1A.x.4.1-1.

The interference in this test is an LTE signal with the interference settings specified in TS 36.521-1, Tables 7.6.1A.x.5-1 and 7.6.1A.x.5-2. The interference frequency should be set at multiple test points within +/– 15 MHz of the UE receive band following the same testing concept as TC7.6.1 for R8. The frequency gap between the test points should equal the bandwidth of the interferer. Although their descriptions differ slightly, the principle behind interferer signal frequency offsets for inter-band CA and intra-band contiguous CA is the same.

The UE transmitter power should be set to 4dB below P_{CMAX_L} or P_{CMAX_L_CA} as defined in Clause 6.2.5A. The CMW500 close loop power setting is explained in section 2.1.2.

The DL cell power for each CC should be $P_{REFSENS_CA}$ plus the channel bandwidth specific value defined in TS 36.521-1, Table 7.6.1A.x.5-1, where $P_{REFSENS_CA}$ is the calculated CC cell power derived from $P_{REFSENS_CA} = P_{REFSENS_RB} - \Delta RIB, c$ ------- Equation 1.

Table 4: In-band blocking parameters for intra-band contiguous CA (source: TS 36.521-1, Table 7.6.1A.1.5-1, Table 7.6.1A.1.5-2).

Rx Parameter	Units	CA Bandwidth Class								
		В	С	D	E	F				
Power per CC in		RE	EFSENS + CA Ba	andwidth Class S	pecific Value Bel	ow				
aggregated transmission bandwidth configuration	dBm		12							
BWInterferer	MHz		5							
Floffset, case 1	MHz		7.5							
Floffset, case 2	MHz		12.5							

CA Co	onfiguration	Parameter	Unit	Case 1	Case 2						
		PInterferer	dBm	-56	-44						
		FInterferer	MHz	=-F _{offset} - F _{loffset,case 1} & =+F _{offset} + F _{loffset,case 1}	≤-F _{offset} – F _{loffset,case 2} & ≥+F _{offset} + F _{loffset,case 2}						
Ċ	1C, CA_7C, CA_38C, CA_40C,CA_41 C	F _{Interferer} (Range)	MHz	F _{DL_low} – 15 to F _{DL_high} + 15							
Note 1:	For certain bands, the unwanted modulated interfering signal may not fall inside the UE receive bandwithin the 15 MHz below or above the UE receive band.										
Note 2:	a. Carrier freque	frequency, the re ency -Foffset - Floffs ency +Foffset + Flof	et, case 1	is valid for two frequencies:							
Note 3:	Foffset offset fron bandwidth.	n the frequency of	of the adjac	ent CC being tested to the ed	ge of aggregated channel						
Note 4:	The F _{interferer} (offset) is relative to the frequency of the adjacent CC being tested should be further adjusted to $[F_{interferer}/0.015 + 0.5]0.015 + 0.0075$ MHz to be offset from the sub-carrier raster for										
	interferer signal above the wanted signal and adjusted to $[F_{interferer}/0.015 + 0.5]0.015 - 0.0075$ MHz to										
	be offset from th	be offset from the sub-carrier raster for interferer signal below the wanted signal.									

Table 5: In-band blocking parameters for inter-band CA (source: TS 36.521-1, Table 7.6.1A.3.5-1, Table 7.6.1A.3.5-2).

Rx Parameter	Units	Channel Bandwidth								
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz			
Power in			REFSENS + Channel Bandwidth Specific Value Below							
transmission bandwidth configuration for each CC	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+0.012	12.5+0.002	12.5+0.007
					5	5	5

E-UTRA SCC	Parameter	Unit	Case 1	Case 2	Case 3	Case 4				
Band	PInterferer	dBm	-56	-44	-30	[-30]				
	F _{Interferer} (offset from SCC)	MHz	=-BW/2 - F _{loffset,case 1} & =+BW/2 + F _{loffset,case} 1	≤-BW/2 – Floffset,case 2 & ≥+BW/2 + Floffset,case 2	-BW/2 – 15 & -BW/2 – 9	-BW/2 – 10				
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 18, 19, 20, 21, 22, 23, 25, 26, 33, 34, 35, 36, 37, 38, 39, 40, 41	FInterferer	MHz	(Note 2)	F _{DL_low} – 15 to F _{DL_high} + 15						
12	FInterferer	MHz	(Note 2)	F _{DL_low} – 10 to F _{DL_high} + 15		F _{DL_low} – 10				
17FInterfererMHz(Note 2)FDL_low - 9 toFDL_low - 15 and										
Note 1: For certain bands, the unwanted modulated interfering signal may not fall inside the UE receive band. Note 2: For each carrier frequency the requirement is valid for two frequencies: a. Carrier frequency -BW/2 - Floffset, case 1 b. Carrier frequency +BW/2 + Floffset, case 1 Fort 3: Finterferer range values for unwanted modulated interfering signal are interferer center frequencies										

Note 4: Case 3 and Case 4 only apply to assigned UE channel bandwidth of 5 MHz

2.5.2 Test Procedure

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

For details on setting up the interference signal, please refer to Section 2.1.1 of this application note. The detailed interference signal settings are the same as shown in Fig. 15.

The test steps, including interferer signal settings, are the same as for Test Case 7.5A.

2.5.3 Test Requirements

The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Tables 7.6.1A.x.3.5-1 and 7.6.1A.x.3.5-1.

2.6 Narrowband Blocking for CA (TS 36.521-1, 7.6.3A)

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

The lack of narrowband blocking capabilities decreases the coverage area when other e-NodeB transmitters are present.

2.6.1 Test Description

This test is carried out with QPSK modulation and full RB allocation in the downlink for both the PCC and SCC. The values to be selected for the bandwidth, frequency and RMC as well as UL RB allocation details are defined in TS 36.521-1, Table 7.6.3A.x.4.1-1.

The interference in this test is a continuous wave (CW) signal with the interference settings specified in TS 36.521-1, Table 7.6.3A.x.5-1. The interference signal level is -55dBm for all BWs.

Although their descriptions differ slightly, the principle behind the interferer signal frequency offsets for inter-band CA and intra-band contiguous CA is the same.

The UE transmitter power should be set to 4dB below P_{CMAX_L} or P_{CMAX_L_CA} as defined in Clause 6.2.5A. The CMW500 close loop power setting is explained in Section 2.1.2.

The DL cell power for each CC should be $P_{REFSENS_CA}$ plus the channel bandwidth specific value defined in TS 36.521-1, Table 7.6.3A.x.5-1, where $P_{REFSENS_CA}$ is the calculated CC cell power derived from $P_{REFSENS_CA} = P_{REFSENS_RB} - \Delta RIB, c$ ------- Equation 1.

Table 6: Narrowband blocking parameters: interference power setting and frequency offset for intra-band contiguous CA and inter-band CA.

Parameter	Unit	SCC for Inter-Band CA and Adjacent CC for Intra-Band Contiguous CA							
		1.4 MHz 3 MHz 5 MHz 10 MHz 15 MHz 20 MHz							
P _{uw} (CW)	dBm	-55	-55	-55	-55	-55	-55		
F _{uw} (Offset from the SCC for inter-band CA or the adjacent CC for intra-band contiguous CA)	MHz	0.9075	1.7025	2.7075	5.2125	7.7025	10.2075		

2.6.2 Test Procedure

For general test conditions and settings, please refer to Section 2.1 of this application note. The values to be selected for bandwidth, frequency and RMC as well s RB allocation details are defined in TS 36.521-1, Table 7.6.3A.x. 4.1-1.

For details on setting up the interference signal, please refer to Section 2.1.1 of this application note. The detailed interference signal settings are to be configured as shown in Fig. 16.

🚯 General Purpose RF Generator 1 - V3.2.21 - Base V 3.2.60								
Path: Level (RMS)								
Scenario	StandAlone 🔻							
Routing	Connector: RF3OUT 💌 Converter: RFTX2 💌							
Ext. Att. (Output)	U.UU dB							
Frequency	1200.0000000 MHz 🔻 Baseband Offset:							
Level (RMS)	-55.00 dBm Peak Envelope Power:							
Digital Gain	U.UU dB							
List Mode	Off -							
-Baseband Mode	CW 💌							
⊕-Baseband Configuration ⊞-List Configuration	Listmode: Off List Count: 1							

Fig. 16: Interference signal settings for the narrowband blocking test.

Upon completion of instrument *Preset*, Prepare the interferer signal:

- a. Activate General Purpose RF Generator 1
- b. Set the proper routing as shown in Fig. 16.
- c. Ensure the *Baseband Mode* is set to *CW*.
- d. Set the correct *Ext. Att (Output)*

The test steps are the same as for Test Case 7.5A. Only the interference signal setting is different.

2.6.3 Test Requirements

The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Tables 7.6.1A.x.3.5-1 and 7.6.3A.x.3.5-1.

2.7 Wideband Intermodulation (TS 36.521-1, 7.8.1)

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

2.7.1 Test Description

This test is carried out with QPSK modulation and full RB allocation in the downlink for both the PCC and SCC. The values to be selected for bandwidth, frequency and RMC as well as RB allocation details are defined in TS 36.521-1, Table 7.8.1A.x.4.1-1.

In this test, two interference signals must be generated: one CW signal (interferer 1) and one LTE signal (interferer 2). The interference settings are specified in TS 36.521-1, Table 7.8.1A.x.5-1.

Table 7: Wideband intermodulation parameters: interference power setting and frequency offset for intra-band contiguous CA and inter-band CA.

Rx Parameter	Units	SCC for Inter-Band CA or Adjacent CC for Intra-Band Contiguous CA								
		1.4 MHz	1.4 MHz 3 MHz 5 MHz 10 MHz 15 MHz 20 MHz							
P _{Interferer 1} (CW)	dBm			-	-46					
P _{Interferer 2} (Modulated)	dBm	-46								
BW Interferer 2		1.4	3		5					
F _{Interferer 1} (Offset from SCC)	MHz	+/- 2.7MHz	+/- 6MHz	+/- 10MHz	+/- 12.5MHz	+/- 15MHz	+/- 17.5MHz			
FInterferer 2	MHz	2*Finterferer 1								
(Offset from SCC)		+/- 5.4MHz	+/- 12MHz	+/- 20MHz	+/- 25MHz	+/- 30MHz	+/- 35MHz			

Although their descriptions differ slightly, the principle behind the interferer signal frequency offsets for inter-band CA and intra-band contiguous CA is the same.

The UE transmitter power should be set to 4dB below P_{CMAX_L} or P_{CMAX_L} as defined in Clause 6.2.5A. The CMW500 close loop power setting is explained in Section 2.1.2.

The DL cell power for each CC should be $P_{REFSENS_CA}$ plus the channel bandwidth specific value defined in TS 36.521-1, Table 7.6.1A.x.5-1, where $P_{REFSENS_CA}$ is the calculated CC cell power derived from $P_{REFSENS_CA} = P_{REFSENS_RB} - \Delta RIB, c$ ------- Equation 1.

2.7.2 Test Procedure

A CMW500 with 4 RF channels is required for this test, as it involves an LTE signal, two interference signals, a CW signal and an ARB signal. Only one B110 is required. Please refer to Section 2.4.2 (7.5A Test Procedure) for information on loading the ARB waveform.

🚯 General Purpose RF Generator 1 - V3.2.	40 - Base V 3.2.50	X	GPRF Gen
Path: Level (RMS)			
Scenario	StandAlone -	•	
- Routing	Connector: RF30UT Converter: RFTX2		<u>}</u>
ΕΧΤ. Απ. (Ουτρυή	U.UU aB		
Frequency	2097.5000000 MHz 🔻 Baseband Offset: 0.0000000 MHz		
Level (RMS)	-46.00 αBm Peak Envelope Power: -34.59 dBm		
Digital Cain	0.00 48		ARB
-List Mode	Off -		
Daseballu moue			
F Baseband Configuration			List Config.
⊕ Dual Tone			
d⊷ARB			
	0.0000000 MHz 💌		
Repetition	Continuous 🔻		
	D:\Rohde-Schwarz\CMW\Data\waveform\3GPPTest\1_B050_free.wv		
Date	2011-10-13;14:18:04		
Version			<u> </u>
-Required Options	None		
	15360.000 kHz		
Samples	153600 Range: Full Range 💌		<u> </u>
Level Offset (PAR)	11.41 dB		GPRF
Peak Offset	0.06 dB		Generator
CBC Brotostion	Yan		

🚯 CMW		
🚯 General Purpose RF Generator 2 - V3.2.	40 - Base V 3.2.50 📃 🔀	GPRF Gen
Path: Level (RMS)		
Scenario	StandAlone -	
Routing	Connector: RF3OUT Converter: RFTX4	
ΕΧΙ. ΑΠ. (Ουτραι)	U.UU 0D	
Frequency	2115.0000000 MHz 🔻 Baseband Offset:	
Level (RMS)	-46.00 dBm Peak Envelope Power: -46.00 dBm	
Digital Cain	9.69 JB	
List Mode	Off •	Ļ
Dasevanu Nove	CW .	List Config.
⊡…Dual Tone		
	Listmode: Off List Count: 1	
		<u>}</u>
		GPRE
		Generator ON

Fig. 17: General purpose RF generator 1 & 2 settings.

Upon completion of instrument Preset,

- 1. Prepare the interferer signal:
 - a. Activate General Purpose RF Generator 1
 - b. Set the proper routing and attenuation
 - c. Load the waveform:

Set the *Baseband Mode* to *ARB*.

Load the interferer waveform according the bandwidth. Three free interferer waveforms are included in this application note package, and they should be saved to the R&S[®]CMW500:

I_B014_free.wv - Bandwidth = 1.4 MHz I_B030_free.wv - Bandwidth = 3 MHz I_B050_free.wv - Bandwidth = 5 MHz

- d. Activate General Purpose RF Generator II
- e. Set the proper routing and attenuation
- 2. Setup the LTE signalling and start the test:
- Step 1. Set Duplex Mode.
- **Step 2.** If the DUT has combined antennas for the PCC and SCC, connect the DUT to the CMW500 as shown in Fig. 11 and set the Scenario to "2CC CA 2 RF Out".
- **Step 3.** Set the *RF Output Connector/Converter* and *RF Input Connector/Converter* accordingly.
- Step 4. Set the correct *External Attenuation* for each port and cell.
- Step 5. Set the Transmission Mode to 'TM1' and the DCI Format to '1A'.
- **Step 6.** Enable the LTE cell. Power on the LTE UE so that it attaches to the network and press *Connect* to establish the connection.
- **Step 7.** Set the testing *Cell Bandwidth, DL Channel, Downlink and Uplink #RB, Modulation* and *RB Pos./Start RB* for both the PCC and SCC (defined in TS 36.521-1 7.8.1A.x.4.1 *Initial conditions*, where *x* represents the number used for various types of CA configurations).

- **Step 8.** Set *Active TPC Setup* to *Close Loop* and *Closed Loop Target Power*, *16.3dBm* (calculated according to Section *2.1.2*) to ensure that the UE power reaches its required range.
- Step 9. Enable OCNG. This can be done before powering on the DUT.
- **Step 10.** Go to the *LTE RX Meas.* page and set *Subframes* >= *1200* (1200 is the next smallest number greater than 1003) in accordance with the specification.
- **Step 11.** Go to *GPRF Sig. 1* and set the correct *Frequency* and *Level(RMS), -46dBm.* Turn on the signal.
- **Step 12.** Go to *GPRF Sig. II* and set the correct *Frequency* and *Level(RMS)*, -46dBm. Turn on the signal.
- **Step 13.** Adjust the DL *RS EPRE* so that the *Full Cell BW Pow*. indicates (P_{REFSENS_CA} + channel bandwidth specific value, according to Table 7.8.1A.x.5-1) for both the PCC and SCC.
- **Step 14.** Measure the throughput achieved under these conditions. For the measurement window display, please refer to Fig. 14.
- **Step 15.** Change the *GPRF Sig. 1 Frequency* and *GPRF Sig. 2 Frequency* and carry out the measurement again.

2.7.3 Test Requirements

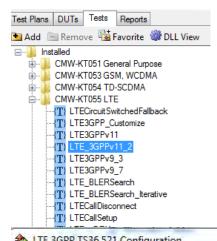
The throughput must be \geq 95 % of the maximum throughput specified for the reference measurement channels under the parameters provided in TS 36.521-1, Table 7.8.1A.x.5-3.

3 Using CMWRun

LTE3GPPv11.2 is available for CMWRun Version 1.8.0. The limits and configurations are based on TS 36.521-1 V11.2. The table below provides a list of supported test cases for TS 36.521-1. The list will be updated, and it is recommended to execute it with CMW500 LTE firmware version 3.2.82.

Chapter	6	7	8	9
Release				
	6.2.2 / 6.2.2_1	7.3	8.2.1.1.1	9.2.1.1
	6.2.3 / 6.2.3_1	7.4	8.2.1.1.1_1	9.2.2.1
R8 / R9	6.2.4 / 6.2.4_1	7.5	8.2.1.2.1	9.3.2.1.1 / 9.3.2.1_1
	6.2.5 / 6.2.5_1	7.6.1	8.2.1.2.1_1	9.2.1.2
	6.3.2	7.6.3	8.2.1.3.1	9.2.2.2
	6.3.4.1	7.8.1	8.2.2.1.1	9.3.1.2
	6.3.4.2		8.2.2.1.1_1	
	6.3.5.1 / 6.3.5_1.1		8.2.1.1.1	
	6.3.5.2 / 6.3.5_1.2		8.2.1.1.1_1	
	6.3.5.3 / 6.3.5_1.3		8.2.2.3.1	
	6.5.1			
	6.5.2.1			
	6.5.2.1A			
	6.5.2.2			
	6.5.2.3			
	6.5.2.4			
	6.6.1			
	6.6.2.1			
	6.6.2.3			
	6.6.3.1			
	6.2.5A.2 (required	7.3A.2/3		
R10	by 36.521 V10.2)	7.4A.2/3		
		7.5A.2/3		
		7.6.1A.2/3		
		7.6.3A.2/3		
		7.8.1A.2/3		

Fig. 18 shows the LTE 3GPP TS36.521 configuration window. The user can select the Duplex, UE Category, Power Class, test cases, Non-CA bands, CA bands and channels to be tested. Various automatic power cycling methods are also enabled to handle call-drop contingencies. The sections below provide the details of the configurations. Details on DUT power cycle automation can be found in *application note 1CM94* "LTE RF Measurements with the R&S®CMW500 according to 3GPP TS 36.521-1", Section 7.4.



ettings Duplex FDD JE Category 3 Von CA Intra Band	• P	_classm		*		Jser Con	Standard iguration Graphics	~	Testitem	8.2.2.3.1 T 9 Reporting of 9.2.1.1 FD 9.2.2.1 FD	DD PDSCH Oper Channel State Inf D CQI Reporting D CQI Reporting 3.3.2.1.1 1 FDD C	oma Unde Unde
Band	Test	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	*	—	9.2.1.2 TD 9.2.2.2 TD 9.3.2.1.2 T 9.3.2.1.2 T	D CQI Reporting D CQI Reporting DD CQI Reporting	Undi Undi
2			Ba	nd B	andw	idth C	ell			6 Transmitter C	Characteristics onfigured UE tran	smitt
3		-						E	÷.	7 Receiver Ch	aracteristics	
4				\setminus /	-	_	-				erence sensitivity	
5		1.11		V	1.11						erence sensitivity ximum input level f	
6											ximum input level i ximum input level i	
7											acent Channel Se	
8	Tel					-					acent Channel Se	
9				-							n-barid blocking fo n-band blocking fo	
10	E										arrow band block	
11	F			-						i hand to be the second second	larrow band block	-
							-				Videband intermod	
12							-			·····[[]] 7.8.1A.3 V	Videband intermod	ulati
13			-	-						m		*
14				-				*	Interfe	rer Setup for TC7	5, TC7.6.1, TC7.6	5.3
User Defined Ba	nd					1	lear Tab	le	1	DUT Powe	r Cycles	

Fig. 18: CMWRun LTE 3GPP TS36.521 V11.2 configuration.

3.1 General Configurations

- *Duplex* Select FDD or TDD. Configuring for both FDD and TDD is NOT currently supported. Users should sequence two LTE_3GPPv11_2 into their test plan (one for TDD and one for FDD).
- UE Category The UL configuration for certain tests will differ for various UE categories. This value must be configured accordingly. For UE categories above 5, please select '5', as the UL configuration is the same for categories 5 and above.
- *P_classmax* Set the maximum UE output power. This value is used to differentiate normal DUTs from high output power DUTs.
- *3GPP Standard* If selected, only the channels and bandwidths required for the selected bands will be tested.
- *User Configuration* If selected, all channels and bandwidths listed in the configuration table will be tested. This is the only mode, in which the user can define the channels to be tested. Double clicking on any Band_Bandwdith cell brings up a separate window. Placing the cursor over a particular Band Bandwidth cell displays the full channel configuration.
- Include Graphics If selected, all the graphics are displayed. In not selected, only the Relative Power Control graphic result is displayed.

3.2 User-Defined Band Channel Configurations

The listed non-CA bands and CA bands listed are those defined in TS36.521-1 V11.2. The "*User Defined Band*" button provides definitions for non-3GPP defined CA band combinations and BW combinations. "*User Configuration*" must be selected in order to activate "*User Defined Band*".

Non-CA: user-defined band that allows users to test non-3GPP defined bandwidths.

Intra-band contiguous CA: user-defined band, which enables users to define non-3GPP defined contiguous DLCA bands.

Inter-band CA: user-defined band that makes it possible to define non-3GPP defined DL interband CA combinations. It is designed not to swap the PCC and SCC automatically in user defined cases. The user needs to manually configure the swapped PCC and SCC bands, i.e., both USER_3A_28A and USER 28A_3A have to be added in order to test all band 3 and band 28 combinations.

User Defined Band Configuration	User Defined Band Co	onfiguration	User Defined Band Configuration	
FDD Non CA Bands USER_6 PCC Band	C Band USER_5C	iguous CA Bands PCC Band Band5 🗸	FDD InterBand CA Bands USER_28A-3A	PCC Band Band28 SCC Band Band3
Remove All Remove	Add Remove All	Remove	Remove All Remove	Add
	Save	Save	Note: User Defined PCC/SCC Ban not switched automatically.	are Save

Fig. 19: Addition of a user-defined band for testing.

Double clicking on any non-greyed Band_Bandwidth cell brings up a window for test channel configuration.

Fig. 20 shows how to configure user-defined testing channels for CA Band28_3A. Band 28 supports 5M BW and band 3 supports 20M BW.

- Step1: Double click on the 5MHz cell to bring up the configuration window for the 5MHz BW.
- Step2: Select Band28 and configure the channels to be tested.
- Step3: Select Band3 and ensure that the channel list is empty.
- Step4: Click Save to save the 5MHz configurations.
- Step5: Double click on the 20MHz cell to bring up the configuration window for the 20MHz BW.
- Step6: Select Band28 and ensure that the channel list is empty.
- Step7: Select Band3 and configure the channels to be tested.
- Step8: Click Save to save the configurations.

The full channel configuration can be viewed by placing the cursor over the 5MHz or 20MHz cell. Channel separation between the two bands is indicated by a colon (':'). If an empty string is displayed before this character, it means that no channel has been configured for the PCC of that particular BW. If an empty string comes after a colon, it signifies that no channel has been configured for the SCC of that particular BW. The channels configured for the PCC and SCC with different/same BW are automatically combined in corresponding sequence. This means that the number of channels must be the same for the PCC and SCC.

Band	Test	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz			
USER_28A-3A	V	:	:	273	:	:	:193			
dit Frequency Channels	-		6	×	Edit Fi	equency Cha	nnels		4	
UL Channel for Band28, 5 MHz (2 (TS36.508[7] - subclause 4,3.1 2							and3, 20 MHz (19200 bclause 4.3.1: 1930			
27385 🚖		Channel Loo Channel Channel Channel	Start 27385 Stop 27635		¢	annel 1930	0	Channel Loop Channel Start Channel Stop Channel Stop	19850	
Add V Channel List Testing Frequency Channels (sep	ersted by "1		Add I V		2	annel List	Add V cy Channels (seperate	Adu 1 V	i	
27385,27510,27635	cided by ./					300,19575,19		u by .,		
Clear Channel List Use	Default Char	nnels				Clear Channe	I List Use Defa	ult Channels		
USER_28A-3A Band	28 👻			Save	-	USER_28A	3A Band3	•		Save

Fig. 20: Inter-band CA channel configuration

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: <u>Jenny.Chen@rohde-schwarz.com</u> or <u>Guenter.Pfeifer@rohde-schwarz.com</u>

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

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									
Name	Description	Order number							
R&S [®] CMW500	Wideband Radio Communication Tester	1201.0002K50							
R&S [®] CMW-PS503	R&S [®] CMW500 Basic Assembly	1208.7154.02							
R&S [®] CMW-S100A	Baseband Measurement Unit	1202.4701.02							
R&S [®] CMW-S570B	RF Converter (TRX)	1202.5008.03							
R&S [®] CMW-S550B	Baseband Interconnection Board (Flexible Link)	1202.4801.03							
R&S [®] CMW-B570B	Extra RF Converter (TRX)	1202.8659.03							
R&S [®] CMW-B570B	Extra RF Converter (TRX)	1202.8659.03							
R&S [®] CMW-B570B	Extra RF Converter (TRX)	1202.8659.03							
R&S [®] CMW-S590D	RF Front-End Module Advanced	1202.5108.03							
R&S [®] CMW-B590D	Extra RF Front-End Module Advanced	1202.8707.03							
R&S [®] CMW-S600B	Front Panel with Display/Keypad	1201.0102.03							
R&S [®] CMW-B620A	Digital Video Interface (DVI) Module	1202.5808.02							
R&S [®] CMW-B300B	Signalling Unit Wideband (SUW+)	1202.6304.03							
R&S [®] CMW-B300B	Signalling Unit Wideband (SUW+)	1202.6304.03							
R&S [®] CMW-KS500	LTE FDD Release 8, SISO, signalling/network emulation, basic functionality	1203.6108.02							
R&S [®] CMW-KM500	LTE FDD Release 8, TX measurement, uplink	1203.5501.02							
R&S [®] CMW-KS550	LTE TDD (TD-LTE) Release 8, signalling/network emulation, basic functionality	1204.8904.02							
R&S [®] CMW-KM550	LTE TDD (TD-LTE) Release 8, TX measurement, uplink	1203.8952.02							
R&S [®] CMW-KS510	LTE Release 8, SISO, signalling/network emulation, advanced functionality	1203.9859.02							
R&S [®] CMW-KS502	LTE FDD Release 10, CA, signalling/network emulation, basic functionality	1208.6029.02							
R&S [®] CMW-KS512	LTE Release 10, CA, signalling/network emulation, advanced functionality	1208.6041.02							
R&S [®] CMW-KT055	LTE, CMWRun sequencer software tool	1207.2107.02							
R&S [®] CMW-Z05	Nano UICC Test Card, supporting 3GPP SIM/USIM/ISIM/CSIM applications	1208.5651.02							