Testing LTE-A Releases 11 and 12 Application Note

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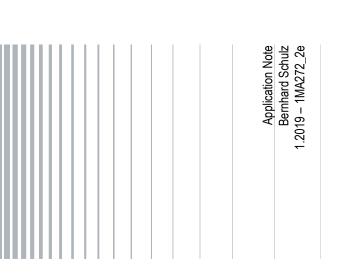
LTE is under continuous development. Release 10 (LTE-Advanced) introduced carrier aggregation (CA) as the primary enhancement. Releases 11 and 12 add several new components to LTE. Some are enhancements to existing features (such as improvements to CA), while others are completely new concepts, such as coordinated multipoint (CoMP).

This application note summarizes the Rohde & Schwarz test solutions for LTE-Advanced according to Releases 11 and 12 using vector signal generators, signal and spectrum analyzers and the wideband radio communication tester.

Note:

The most current version of this document is available on our homepage: http://www.rohde-schwarz.com/appnote/1MA272.





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The following abbreviations are used in this application note for Rohde & Schwarz test equipment:

- The R&S[®]SMW200A vector signal generator is referred to as the SMW.
- The R&S[®]FSW signal and spectrum analyzer is referred to as the FSW.
- The R&S[®]FSV3000 spectrum analyzer is referred to as the FSV.
- The R&S[®]FSVA3000 spectrum analyzer is referred to as the FSA.
- The R&S[®]FPS spectrum analyzer is referred to as the FPS.
- The FSW, FSV3000, FSVA3000 and FPS are referred to as the FSx.
- The R&S[®]CMW500 wideband radio communication tester is referred to as the CMW500.
- The R&S®TS8980 LTE RF Test System is referred to as the TS8980.

1 Introduction

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Since end 2009, LTE mobile communication systems according to Releases 8 and 9 are commercially deployed. LTE Release 10 added major features (e.g. carrier aggregation (CA)). Especially CA has been integrated in commercial networks.

LTE is under continuous development. Releases 11 and 12 add several new components to LTE. Some are enhancements to existing features (such as improvements to CA), while others are completely new concepts, such as coordinated multipoint (CoMP). Releases 11 and 12 are still called LTE-Advanced.

You can find a complete basic set of White Papers and Application Notes regarding LTE Releases 8 to 12:

I.	Release 8	
	White Paper:	UMTS Long Term Evolution (LTE) Technology Introduction
I	Release 9	
	White Paper:	LTE Release 9 Technology Introduction
	Application Note:	Testing LTE Release 9 Features
I.	Release 10	
	White Paper:	LTE-Advanced Technology Introduction
	Application Note:	Testing LTE-Advanced
I.	Release 11	
	White Paper:	LTE- Advanced (3GPP Rel.11) Technology Introduction
I.	Release 12	
	White Paper:	LTE- Advanced (3GPP Rel.12) Technology Introduction

The different LTE-Advanced technology components are illustrated in Fig. 1-1. They naturally have different market requirements and also require different testing strategies.

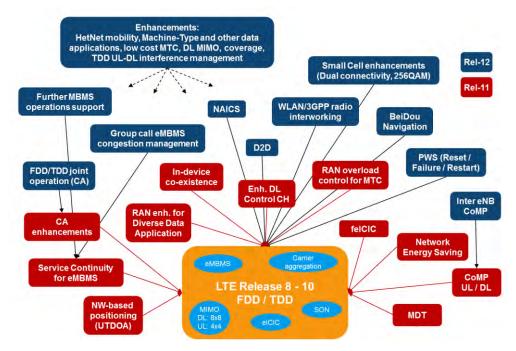


Fig. 1-1: LTE technology component dependencies: red Release 11 and blue Release 12.

Section 2 explains briefly the single features; section 3 of this application note discusses the testing aspects of each technology component in LTE-Advanced and describes available test solutions in the Rohde & Schwarz product portfolio.

2 LTE-A Features in Rel. 11 and 12

Releases 11 and 12 introduced a number of new features. This chapter summarizes the features that are relevant for Rohde & Schwarz instruments. For more information, refer to the white papers [2] and [3] mentioned in Chapter 1.

2.1 UE Categories

The following tables summarize the UE categories in Release 12. Up through Rel. 11, the category defined both downlink and uplink characteristics; Release 12 specifies more flexible downlink categories that correspond to various uplink characteristics.

Category 0 was newly added. It supports cost-efficient configuration in half-duplex mode for machine type communication (MTC). Fig. 2-1 shows the logical relationships between the various categories. The number of component carriers (CC) in the tables indicates the minimum required number of CC's to achieve the maximum data rate.

UE	categorie	s in Releas	e 811			
Rel	Category	DL max data	UL max data	Number of CC's	MIMO layer	Highest modulation scheme
						DL - UL
	1	10	5	1	1	64 QAM – 16 QAM
	2	50	25	1	2	64 QAM – 16 QAM
8	3	100	50	1	2	64 QAM – 16 QAM
	4	150	50	1	2	64 QAM – 16 QAM
	5	300	75	1	4	64 QAM – 64 QAM
	6	300	50	1 or 2	2 or 4	64 QAM – 16 QAM
10	7	300	100	1 or 2	2 or 4	64 QAM – 16 QAM
	8	3000	1500	5	8	64 QAM – 64 QAM
	9	450	50	2 or 3	2 or 4	64 QAM – 16 QAM
	10	450	100	2 or 3	2 or 4	64 QAM – 16 QAM
11	11	600	50	2, 3 or 4	2 or 4	64 QAM – 16 QAM
	12	600	100	2, 3 or 4	2 or 4	Rel 12: 256 QAM – 16 QAM

Table 2-1: UE categories in Release 8...11.

UE dow	nlink catego	ories Relea	ase 12			
Downlink Category	DL max data		UL max data	Number of CC's	MIMO layer	Highest modulation scheme DL - UL
0	1	0	1	1	1	64 QAM – 16 QAM
6/7	300	5,13	75,150	1 or 2	2 or 4	64 QAM – 64 QAM
9/10	450	5,13	75,150	2 or 3	2 or 4	64 QAM – 64 QAM
11/12	600	5,13	75,150	2, 3 or 4	2 or 4	256 QAM – 64 QAM
13	400	3,5,7,13	50,75,100,150	1 or 2	2 or 4	256 QAM – 16 / 64 QAM
14	4000	8	1500	5	8	256 QAM – 64 QAM
15	750800	3,5,7,13	50,75,100,150	2 or 4	2 or 4	256 QAM – 16 / 64 QAM
16	10001050	3,5,7,13	50,75,100,150	2 or 5	2 or 4	256 QAM – 16 / 64 QAM

Table 2-2: UE downlink categories in Release 12.

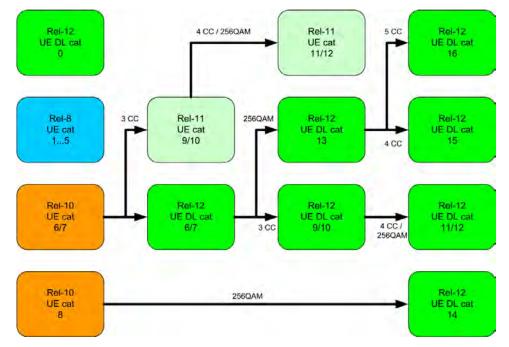


Fig. 2-1: UE categories - Logical dependencies.

2.2 Release 11 features

2.2.1 Carrier aggregation enhancements

Carrier aggregation (CA) was first introduced in Release 10. Release 11 included several enhancements.

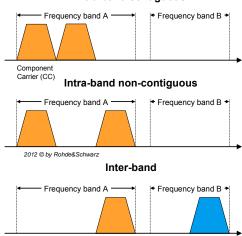
2.2.1.1 Multiple Timing Advances (TAs) for Uplink Carrier Aggregation

If a UE sends two carriers in the uplink to two physically separate receivers (e.g. one eNB and one remote radio head (RRH)), they will be received at different times. To

compensate this, the base stations can send different timing advance commands to the UE for the different uplink carriers. The eNodeB thus instructs the UE to transmit the two carriers at different times.

2.2.1.2 Non-contiguous intra-band carrier aggregation

A gap between the carriers (or between the subblocks) is now possible for the first time. This is represented by W_{Gap} .



Intra-band contiguous

Fig. 2-2: CA scenarios.

I.

This has consequences for the following tests:

- Base station tests
 - Timing error
 - ACLR and a new cumulative ACLR (CACLR) within the GAP
- Different UE tests

2.2.1.3 TDD: Additional Special Subframe Configuration and different UL/DL configurations

Effective with Release 11, two TDD carriers can use differing UL/DL configurations (from the set of known configurations 0...6).

In addition, two new special subframe configurations are available:

- Special Subframe Configuration 9, normal cyclic prefix
- Special Subframe Configuration 7, extended cyclic prefix

The additions allow a balanced use of DwPTS and GP, i.e. enhance the system flexibility while maintaining the compatibility with TD-SCDMA.

2.2.2 Coordinated Multi-Point Operation (CoMP)

CoMP is one of the most important new features in Release 11. Like all other features, the purpose of CoMP is to reduce or prevent interference. The basic idea behind

CoMP is that two cells (eNodeB) or one cell and an RRH coordinate how to supply a UE. This involves the coordinated use of multiple physically separate antennas. CoMP in Rel 11 requires an ideal connection between the transmission points (TP) or receiving points (RP), i.e. fiber-optic connections.

Downlink

The downlink includes the following schemas:

- Joint Processing (data available at all TPs)
 - Dynamic Point Selection (DPS) This is the most important function within CoMP because it is the most effective. In this case, only one TP transmits, although the transmitting TP can change with every subframe.
 - Joint Transmission (JT)
 In this case, the data is transmitted by all TPs, either at the same time (e.g. multipath propagation) or separately (SU-MIMO). It is also possible to transmit both coherently (all TPs precode jointly, e.g. 4x2 MIMO) or non-coherently (all TPs precode individually, e.g. each 2x2 MIMO).
- Coordinated Scheduling / Beamforming (data available at only one TP)
 - Scheduling (CS) In this case, a TP can reduce the transmit power in order to improve the communication of another TP to another UE.
 - Beamforming (CB) In this schema, the TPs coordinate the beamforming so that the UEs have good coverage and interfere as little as possible with the other communications.

Uplink

Joint Reception

The data (PUSCH) is received by all RPs.

Coordinated Scheduling / Beamforming

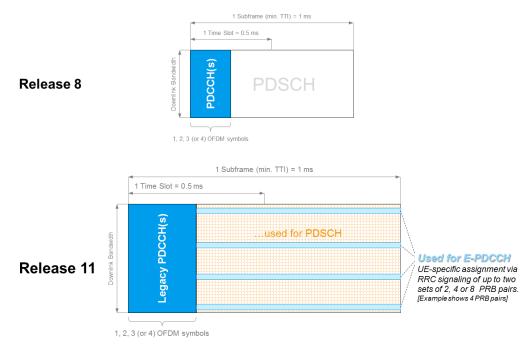
In this case, the RPs coordinate the scheduling and precoding, but the PUSCH is received by only one RP.

In general, TPs and RPs are decoupled in the uplink, i.e. the TP does not necessarily also have to be the RP any longer. Virtual cell IDs (VCID) have been introduced for this purpose.

In order to support CoMP, the transmission mode TM10 was introduced. It is similar to TM9 and supports up to 8-layer PDSCH. The main difference is the new DCI format 2D.

2.2.3 Enhanced PDCCH (E-PDCCH)

New functions in Release 11 such as CoMP require additional capacity on the control channel. This is why the E-PDCCH was newly introduced. It is based on the PDCCH and is backward compatible. In order to provide additional capacity, resource blocks from the PDSCH are used. Either two, four or eight blocks can be allocated within the system bandwidth. The information can also be continuously transmitted across the



complete subframe. The information is UE specific and beamforming of the E-PDCCH is also possible.

Fig. 2-3: E-PDCCH structure compared to PDCCH.

2.2.4 Further enhanced non CA-based ICIC (feICIC)

Generally inter-cell interference coordination (ICIC) has the task to manage radio resources such that inter-cell interference is kept under control. Up to Release 10 the ICIC mechanism includes a frequency and time domain component. The frequency domain ICIC manages radio resource, notably the radio resource blocks, such that multiple cells coordinate use of frequency domain resources. For the time domain ICIC, subframe utilization across different cells are coordinated in time through so called Almost Blank Subframe (ABS) patterns.

The main enhancement in Release 11 was to provide the UE with Cell specific Reference Symbol (CRS) assistance information of the aggressor cells in order to aid the UE to mitigate this interference. Thus, it was necessary to define signaling support indicating which neighbor cells have ABS configured.

The information element RadioResourceConfigDedicated may optionally (from Rel. 11 on) include a neighCellsCRSInfo field, which includes the following information of the aggressor cell(s):

- Physical Cell ID.
- Number of used antenna ports (1, 2, 4).
- MBMS subframe configuration.

Furthermore in case of strong interference the UE may not be able to decode important system information transmitted. From Release 11 System Information Block Type 1 (SIB1) information may be optionally included in the RRCConnectionReconfiguration

message. If the UE receives the SIB1 via dedicated RRC signaling, it needs to perform the same actions as upon SIB1 reception via broadcast.

2.3 Release 12 features

2.3.1 Small cell enhancements

2.3.1.1 Higher Order Modulation (256QAM)

Up to Release 10 the LTE technology applies QPSK, 16QAM and 64QAM (optional in uplink) modulation. For small cells in addition 256QAM modulation is available in the downlink, because high signal to noise/interference is potentially available at the UE.

2.3.1.2 Dual Connectivity

Dual Connectivity (DC) is a feature to avoid handovers between two basestations (eNodeB). Especially in heterogeneous networks with many pico cells, a travelling UE may cause many handovers. In DC instead of handovers, the UE stays connected to both eNodeB's. DC assumes different carrier frequencies in macro and pico cell and that the UE runs two MAC entities. Each cell acts either as a Master eNB (MeNB) or as a Secondary eNB (SeNB). Both cells cooperate via a non-ideal backhaul. For more information, see [4].

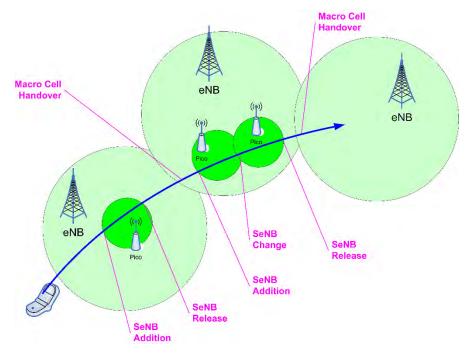


Fig. 2-4: Dual Connectivity: a travelling UE in a heterogeneous network

2.3.2 D2D communication

Up to now, Critical Communication (or Public Safety) uses its own networks like TETRA or APCO. Features for Public Safety communication are:

- Reliability and Resilience. Functioning satisfactorily over periods and under adverse circumstances
- Direct Communication between terminals
- Group Communication
- Off network communication
- Mission Critical Push-To-Talk (MCPTT) including group call communication with low call setup time

LTE Release 12 allows direct communication between UE's. The new feature set is called Device to Device (D2D) Communication. In Release 13 the functionality will be further enhanced.

Following scenarios are identified:

	Within network coverage (Intra-/Inter-cell)	Outside network coverage	Partial network coverage
Non-public safety use case	Discovery	-	-
Public safety use case	Discovery, Communication	Communication	Communication
	eNode B UE #1 UE #2	UE #1	eNode B UE #1 Partial coverage

Table 2-3: LTE Device-to-Device scenarios.

Discovery

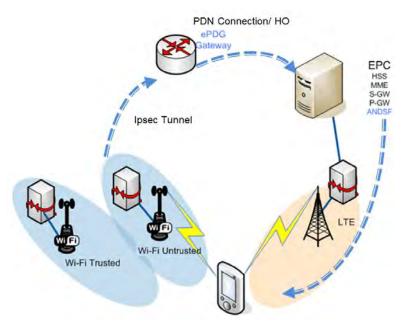
This feature identifies that two UEs are in proximity of each other. For two UEs in cellular coverage it may also be used for commercial purposes.

Direct Communication

Direct Communication between two UEs. LTE resources from cellular traffic are reserved and used for this type of communication. This is only applicable for the public safety use case.

2.3.3 WLAN/3GPP Radio Interworking

Today's cellular phones also support WLAN. WLAN offloading in LTE makes it possible to handle some data traffic via WLAN in order to reduce the LTE load. If a UE with an LTE connection detects usable WLAN access points (APs), it must determine which data to transmit via which AP. Up through Release 11, the UE configuration was



specific to the network operator. Starting with Release 12, an additional RAN-assisted solution is available. This transmits a list of preferred APs to the UE.

Fig. 2-5: WLAN offloading.

2.3.4 TDD-FDD joint operation in different bands

Starting with Release 12, the component carrier in carrier aggregation can use different duplexing methods, i.e. a carrier FDD in band 19 and the second carrier TDD in band 42.

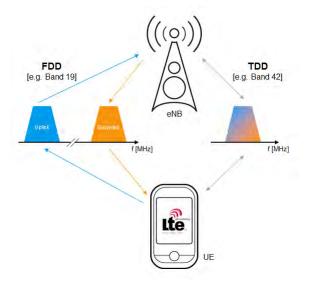


Fig. 2-6: Carrier aggregation with FDD and TDD.

2.3.5 Enhanced Interference Mitigation & Traffic Adaption (eIMTA)

eIMTA is an improvement to the LTE TDD mode. It allows a dynamic reconfiguration of UL/DL time slots within the LTE frame structure. Table 2-4 recalls the seven possible frame configurations. The TDD frame configuration in each cell is signaled in SIB1. eIMTA allows to reconfigure UL-DL in a more flexible way. The network sends a L1 signaling to the UE on PCell PDCCH to indicate which uplink-downlink configuration is used for one or more serving cell(s). This uplink-downlink configuration provided by the L1 signaling applies for a RRC-configured number of radio frames. The signaling is done via DCI Format 1C.

UL/DL	Subfr	ame n	umber							
Configuration	0	1	2	3	4	5	6	7	8	9
0	D	S	U	U	U	D	S	U	U	U
1	D	S	U	U	D	D	S	U	U	D
2	D	S	U	D	D	D	S	U	D	D
3	D	S	U	U	U	D	D	D	D	D
4	D	S	U	U	D	D	D	D	D	D
5	D	S	U	D	D	D	D	D	D	D
6	D	S	U	U	U	D	S	U	U	D

Table 2-4: LTE TDD frame configuration.

2.3.6 Further downlink MIMO enhancements

To achieve a better throughput Release 12 introduces an enhanced **4Tx** codebook as further DL MIMO enhancements. The enhanced codebook is supported for all aperiodic reporting modes that are valid for transmission modes (TM) 8, 9, 10 only. For more information (e.g. the precoding tables) see [4].

2.3.7 Coverage Enhancements

The bottleneck in coverage in LTE networks are uplink medium data rate PUSCH and VoIP. Thus the introduction of **Enhanced TTI Bundling** improves the coverage by extending the cell range for low data rates.

The main differences compared to legacy TTI bundling are:

- Enhanced HARQ pattern for FDD
- HARQ RTT reduced from 16 ms to 12 ms
- More than 3 PRBs per subframe can be allocated (FDD and TDD)

The UE signals the eNodeB the support of the enhanced TTI bundling.

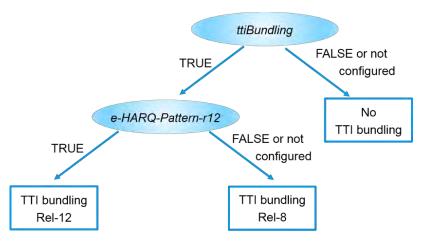


Fig. 2-7: Decision tree for TTI bundling.

3 Testing of LTE-A Releases 11 und 12

3.1 Baseband and RF signal generation



R&S signal generators offer many features that are particularly helpful when generating signals with multiple component carriers and MIMO according to LTE-Advanced requirements. This is especially true for the multi-channel concept of the SMW signal generator (Fig. 3-1) which combines up to four signal sources in one single instrument. The SMW includes up to two RF paths in the main instrument. In addition, the SMW can handle up to eight RF paths with additional RF sources like the SGS or SGT.

Fig. 3-1: SMW Vector Signal generator.

The multi-path concept of the SMW allows configuration of each baseband according to individual testing needs (see Fig. 3-2, example generating a LTE and UMTS signal) or different MIMO modes. With the option SMW-K75 higher order MIMO modes like 8x4, 4x8 and 4x4 for 2 component carriers (CC) are possible. As an option in addition fading is available.

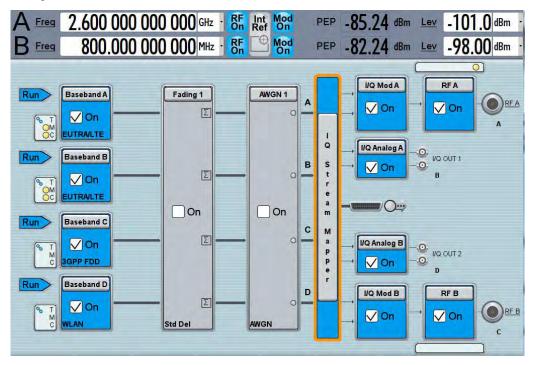


Fig. 3-2: SMW example with four different signals.

The options SMW-K112 and K113 allow testing of LTE-Advanced physical layer features in line with the 3GPP Release 11 and Release 12 standard. It covers downlink and uplink signal generation. SMW-K112 and SMW-K113 require the basic LTE functionality being installed on the equipment (SMW-K55 LTE option).

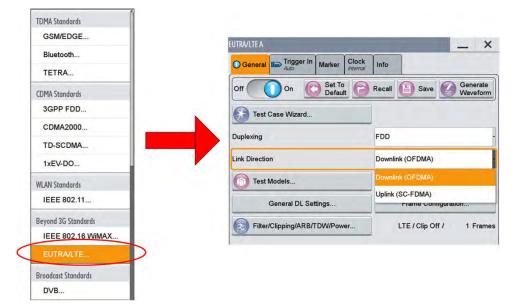


Fig. 3-3: Start of the LTE standard and Link Direction.

3.1.1 Carrier aggregation enhancements (Rel 11)

3.1.1.1 Multiple Timing Advances (TAs) for uplink carrier aggregation

The SMW supports two methods of transmitting two carriers at different times in carrier aggregation:

1. Static methods in the CA menu: An individual delay can be set here for each of the five CC's.

C	CA	Physic 10 MHz	al Cell	Signals	PRACI	H PUS	CH PUCC	н				
Ac	tivate	Carrier A	ggregati	on							Off	0
	Cell Index	Phys. Cell ID	Band- width	Δf /MHz	Duple- xing	UL/DL Config		n(1)_DMRS	SRS SF Config	SRS BW C_SRS	Delay /ns	State
0	0	0	10 MHz	0.000 000	FDD			0	15	0	0	On
1	1	1	10 MHz	0.000 000	FDD	-	4	0	15	0	5	On
2	2	2	10 MHz	0.000 000	FDD	-	÷	0	15	0	10 000	On
3	3	3	10 MHz	0.000 000	FDD	-	(÷	0	15	0	0	Off
4	4	4	10 MHz	0.000 000	FDD	-	+	0	15	0	0	Off

Fig. 3-4: Static delay of the individual uplink carriers in carrier aggregation.

 As part of the SMW-K69 Realtime Feedback software option, two uplinks can be individually controlled with different commands. The baseband selector is required for multiplexing serial commands for different basebands to one feedback line. The baseband unit listens only to serial commands containing the set selector (e.g. 0 stands for Baseband A).

UTRA/LTE A: Us	er Equipment Con	ifiguration ((UE1)					_ ×		
O Common	Realtime Feedback	PUCCH	OFRC	PUSCH	DRS	OSRS	Antenna Port Mapping			
Realtime Fee	dback Mode	Seria								
Redundancy '	Version Seque	nce 0,2,3,	1							
Max. Number	of Transmissio	ins						4		
Assume ACK	Until First Rec	eived ACI	(Comma	ind				On		
Initial Timing A	Advance					O	16 T_S			
Connector		Local	6. L							
UTRA/LTE A: Us	er Equipment Con	ifiguration ((UE1)	-	_			_ ×		
O Common	Realtime Feedback	PUCCH	OFRC	PUSCH	DRS	OSRS	Antenna Port Mapping			
Connector		Local	Local -							
		0	Local C	onnector \$	Settings.					
Additional Us	er Delay					0.00 \$	Subframes			
Baseband Se	lector							C		

Fig. 3-5: Realtime feedback for carrier aggregation is possible for up to two CC's.

3.1.1.2 Non-contiguous intra-band carrier aggregation

The SMW supports non-contiguous carrier aggregation from the very first firmware version. One baseband can position up to five carrier freely in the bandwidth of the baseband.

3.1.1.3 TDD: Additional Special Subframe Configuration and different UL/DL configurations

The SMW supports the new special subframes in TDD. **TDD Special Subframe Config** can be found under **General Settings**|**Physical/TDD.** Fig. 3-6 shows an example in the downlink using configuration 9.

UTRA/LTI	A: General DL	Settings							_ ×
OCA	OMBSFN	Physical/TDD 10 MHz, UL/DL 0	Scheduling Manual	Cell	Signals	OPRS	Ocsi	Antenna Ports 1 TxAntenna	
Channel	Bandwidth		10 MHz		- Num	ber of Re	locks per Slot	50	
FFT Siz	e		1024		-				
Physica	I Resource Bl	ock Bandwidth	3	12 * 15	KHz Occ	Occupied Bandwidth			
Samplir	ng Rate		1	5.360 M	IHz Num	Number of Occupied Subcarriers			
Number	of Left Guard	I Subcarriers		2	212 Num	Number of Right Guard Subcarriers			
TDD UL	/DL Configura	tion			0 TDD	TDD Special Subframe Config			
D		U	U	U	D		- 3	U U	U

Fig. 3-6: TDD Special Subframe Configuration. Both configurations 7 and 9 are supported.

The SMW additionally allows different TDD configurations for carrier aggregation in the uplink.

C	CA Physical/TDD 10 MHz, UL/DL 0		Physical/TDD 10 MHz, UL/DL 0		Physical/TDD		Physical/TDD		Physical/TDD		Physical/TDD 10 MHz, UL/DL 0		Physical/TDD 10 MHz, UL/DL 0		hysical/TDD		Signa	Is PRACH	PUSCH	PUCCH			
Ad	ctivate	Carrier A	Aggregati	on	1						(
	Cell Index	Phys. Cell ID	Band- width	Duple- xing	UL/DL Config		n(1)_DMRS	SRS SF Config	SRS BW C_SRS	Delay /ns	State												
0	0	0	10 MHz	TDD	0	0	0	15	0	0	On												
1	1	1	3 MHz	TDD	5	9	0	15	0	0	On												
2	2	2	10 MHz	FDD	-	-	0	15	0	0	On												
3	3	3	20 MHz	FDD	-	-	0	15	0	0	On												
4	4	4	10 MHz	FDD	-	-	0	15	0	0	On												

Fig. 3-7: Different TDD configurations in the uplink.

3.1.2 CoMP (Rel 11)

The SMW supports CoMP in the downlink, which includes DCI format 2D and TM10. Different combinations of component carriers and MIMO modes are possible together with fading as well. The SMW can handle up to four CC's with 2x2 MIMO each or up to two CC's with 4x4 MIMO. For the maximum numbers the setup requires additional external generators like the SGS or the SGT.

Set in the **System Configuration** a scenario with CA and MIMO, e.g. 2 x 2 x 2.

In the **DL Frame Configuration** tab **General** click on **Tx Modes** and enter *Mode 10* for all cells (Fig. 3-8).

EUTRA/LTE A	A: DL Frame C	onfiguration			EUTRA/LTE (User 1) 🔔 🗙			
General	Time Plan	Subframe	PCFICH	PHICH		-	C User 1: TxMode Co	nfiguration
General		Sf0	Sf 0	Sf D	Sf 0	- User C	PCell	Mode 10 -
No. of Co	onfigurable S	ubframes		1	User 1	User		Mode 10 -
Re	eset All Subf	rames		State	Qn			Mode 10
		lanies	-	Activate C	CA 🗸		SCell 2(Cell Index 2)	Mode 2 👻
Behaviou	Behaviour in Unsch. REs (OCNG) DTX				10/10/-/	/-/ 2	SCell 3(Cell Index 3)	Mode 2 ·
				UL Carrie	rs Confi	g C	80-11 4/0-11 leday 4)	Mada 2
				UE Categ	ary Use	r	SCell 4(Cell Index 4)	Mode 2 -
				EPDCCH	Confi	g C		
				Antenna M	Napping Config	g C		
				Scramblin	ng Confi	g C		
				Channel (Coding			

Fig. 3-8: SMW CoMP Transmission Mode 10

Set in the tab (E)PDCCH the DCI format to 2D (Fig. 3-9).

G	eneral Time P	lan Subfra	me	O PC	FICH	PHICH	O (E)P	DCCH					
		-		4	Subfram	e	0	Prev		lext	000	ру	Paste
~							N.				1	0.000	-up
PL	OCCH Format	Varial	ole				T	Power				0.000	ав
	OCCH Format			CEs	1	920 / 240 /	26	-	Dummy C	CE >>>		0.000	Data
				CCEs Dele		920 / 240 / Down ↓	26	-		11	Res	solve Conf	Data
	mber of PDCC	H Bits / RE	Gs / C			Down ↓	26 Search Space		Dummy C	set	(E)CCE		Data

Fig. 3-9: SMW DCI format 2D

In the tab **Subframe** click **Configure Enhanced Settings** of the PDSCH ant set the **Precoding Scheme** to *Beamforming* and the **Transmission Scheme** to *Multi-Layer, CoMP (TM10) (*Fig. 3-10).

UTRA/LTE A: Enhanced Settings (F0/SF0/AL2.1) 🗙
Precoding BF	Scrambling O Channel Coding
Precoding Scheme	Beamforming (UE-spec.RS)
Transmission Scheme	Multi Layer, CoMP (TxMode 10) ᠂
Codewords	2
Number Of Layers	2
Antenna Ports	7-8
Scrambling Identity n_SCID	0
Antenna Port Mapping	Codebook

Fig. 3-10: SMW CoMP

Click on **Config Scrambling** to set the individual **DMRS Scrambling Identities (**Fig. 3-11).

	U:	ser Configura	ation ——		
	User 1	User 2	User 3	User 4	EUTRA/LTE A: Scramblnfiguration (User 1)
State	On	On	On	On	Scrambling Off On
Activate CA	V	V	V	V	
Tx Modes	10/10/-/-/	2/2/-/-/	2/2/-/-/	2/2/-/-/	PCell SCell 1
UL Carriers	Config	Config	Config	Config	Use DMRS Scrambling Identities Off
UE Category	User	User	User	User	DMRS Scrambling Identity 1 0
EPDCCH	Config	Config	Config	Config	
Antenna Mapping	Config	Config	Config	Config	DMRS Scrambling Identity 2 0
Scrambling	Config	Config	Config	Config	
Channel Coding					

Fig. 3-11: SMW Scrambling Identities

3.1.3 E-PDCCH (Rel 11)

The SMW supports the E-PDCCH in the AUTO PDSCH scheduling modes, so the SMW sets the signal automatically to the right configuration.

Scheduling Manual	OCA	OMBSFN	Physical 10 MHz	Cell	Signa		Ocsi	Antenna Ports 2 TxAntennas	
PDSCH Sch	eduling				N	Manual			
					N	Manual			
						Manual Auto/DCI			

Fig. 3-12: EPDCCH is available in the AUTO scheduling modes.

Select in the **Frame Configuration** in the tab **General** in the *User Configuration* "Config EPDCCH".

General Time Plan Subframe O PCFICH)PDCCH			
		— U	ser Configura	ation ——	
No. of Configurable Subframes	1	User 1	User 2	User 3	User 4
Reset All Subframes	State	On	On	On	On
	Activate CA	V	V	$\mathbf{\nabla}$	V
Behaviour in Unsch. REs (OCNG) DTX	- Tx Modes	2/2/-/-/	2/2/-/-/	2/2/-/-/	2/2/-/-/
	UL Carriers	Config	Config	Config	Config
	UE Category	User	User	User	User
	EPDCCH	Config	Config	Config	Config
	Antenna Mapping	Config	Config	Config	Config
	Scrambling	Config	Config	Config	Config
	Channel Coding		$\overline{\mathbf{v}}$		V

Fig. 3-13: EPDCCH in the User Configuration

Activate the EPDCCH and set the Number of PRB pairs, the Resource Block Assignment (for values see 3GPP TS36.213) and the n^EPDCCH_ID.

TRA/LTE A: EPDCCH Configuration	(User 1)	_ >	×
PCell OSCell 1			
Activate EPDCCH	Off		Dn
State	Off On	OSet 1	
Transmission Type	Localized -	OSet 2	
Number of PRB Pairs	8 .		
Resource Block Assignment	1 224		
n^EPDCCH_ID	0		
Rel. EPDCCH Power	0.00 dB +		

Fig. 3-14: Configuration of the EPDCCH

In the tab **(E)PDCCH** select *EPDCCH* set *x*, the wanted *DCI* format and the wanted *(E)PDCCH* format.

General	Time Plan	Subfra	me	O PC		PH Sf 0		O (E)PI Sf 0	оссн					
				-	Subfram	e		0	Prev		Vext) Co	ру	Past
РОССНИ	Format	Variab	le					•	Power				0.000	dB
		-	10	CEe	1	920	240/	26		Dummy C	CE >>>			Da
Number o	of PDCCH B	ts / REC	5570	OLS		5201	2407	20			10000			De
Number o Appe		nsert		Dele			own↓		Up ↑	Re	11	Res	olve Conf	
		nsert	Cell			Do	own ↓	Search			set	(E)CCE		licts

Fig. 3-15: Usage of the EPDCCH

Klick Content Config to set the wanted content to send.

EUTRA/LTE A: DCI Format Configuration (F0/SF0/0)	_ ×
Bit Data	0000 0000 0000 0000 0010 0000 0000
DCI Form	nat 0 —
PUSCH Frequency Hopping	On
Res.Block Assignment and Hop.Res.Allocation	0
Modulation and Cod. Scheme and Red.Version	0
New Data Indicator	⊘ On
TPC Command for PUSCH	0
Cyclic Shift for DMRS	0
CSI/CQI Request	0

Fig. 3-16: DCI Format Configuration

Check the settings in the **Subframe** (Fig. 3-17) allocations and in the **Time Plan** (Fig. 3-18).

		. DE Hu	me Configi				- r					5			-	>
Ge	neral	Time F	Plan Sub	ofram	e O	PCFI Sf 0	СН	PHI Sf 0	СН	O (E) Sf l	PDCCH	1				
Cel	PCel	n	-			Su	bfram	e		0	Pre	ev 🕜 Ne	xt	Сору		Past
Cyclic Prefix Normal - No. of Used Allocations																
	CW	Modu- lation	Enhanced Settings	VRB Gap	No. RB	No. Sym.	Offset RB	Offset Sym.	Auto	Phys. Bits	Data Source	DList / Pattern	ρΑ /dB	Content Type	State	Con- flict
0	1/1	QPSK	Config	-	6	4	22	7(1/0)		480	MIB	4	0.000	PBCH	On	
1	1/1	QPSK		4	50	2	0	0(0/0)		1920	PDCCH	. E	0.000	PDCCH	On	
2	-	QPSK		-	Auto	12	Auto	2(0/2)		Auto	User1		0.000	EPDCCH#1	On	
3	1/1	QPSK	Config	4.	1	12	0	2(0/2)		264	User1	-	0.000	PDSCH	On	

Fig. 3-17: Allocation with EPDCCH in the subframe

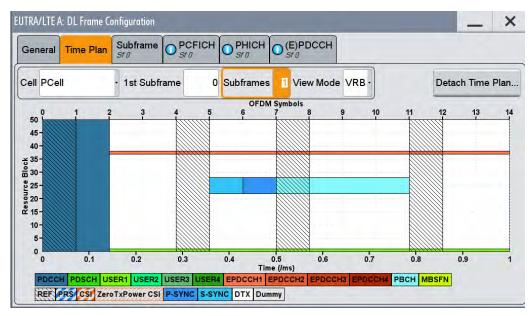


Fig. 3-18: The time plan allows easy checks at a glance. The EPDCCH is marked red.

3.1.4 UE categories (Rel 12)

The SMW supports up to 5 CC's, up to 8 MIMO layers and all modulation modes in both the downlink (up to 256 QAM) and the uplink (up to 64 QAM). This makes it possible to implement all UE downlink categories from Release 12 along with the matching uplink categories individually.

3.1.5 Small Cell Enhancements (Rel 12)

3.1.5.1 Higher Order Modulation - 256QAM (Rel 12)

Small cells may support 256QAM in the downlink. Thus for the UE receiver tests the SMW supports 256QAM.

_			Configurat		_					_		_			-	
Ge	neral	Time F	Plan Sub	ofram	e O	PCFI Sf 0	СН	PHI Sf 0	СН	O PD Sf 0	ССН					
Cel	PCe	1	J			Su	bfram	e		0	Pre	ev 💽 Nex	d 🚺 (Сору	0	Pas
Сус	lic Pre	efix			r	Vorma	I			*	No	o. of Used Allo	ocations			
	CW	Modu- lation	Enhanced Settings	VRB Gap	No. RB	No. Sym.	Offset RB	Offset Sym.	Auto	Phys. Bits	Data Source	DList / Pattern	p A /dB	Content Type	State	Con- flict
0	CW								Auto						State On	
0		lation	Settings	Gap	RB	Sym.	RB	Sym.	Auto	Bits 480	Source		ÌdB	Type PBCH	On	

Fig. 3-19: 256QAM in the downlink.

3.1.6 TDD-FDD joint operation in different bands (Rel 12)

The SMW also supports mixed duplex configurations for carrier aggregation in the uplink. Fig. 3-20 shows an example with two TDD and three FDD carriers.

C)CA		UL/DL0	Cell	Signa	Is PRACH	PUSCH	PUCCH			
Ad	ctivate		Aggregati	on		-	1 1				C
	Cell Index	Phys. Cell ID	Band- width	Duple- xing	UL/DL Config		n(1)_DMRS	SRS SF Config	SRS BW C_SRS	Delay /ns	State
0	0	0	10 MHz	TDD	0	0	0	15	0	0	On
1	1	1	3 MHz	TDD	5	9	0	15	0	0	On
2	2	2	10 MHz	FDD	-	-	0	15	0	0	On
3	3	3	20 MHz	FDD	-	-	0	15	0	0	On
4	4	4	10 MHz	FDD	-	-	0	15	0	0	On

Fig. 3-20: joint TDD-FDD operation.

3.1.7 eIMTA (Rel 12)

The bit sequence for signaling the UL/DL reconfiguration sequence is signaled on Layer 1 on the PDCCH via DCI Format 1C. First in the **Frame Configuration**, set in tab **General** the eIMTA-RNTI for the user (example User 1). Second, set in tab PDCCH the User to **User X-eIMTA**. Last, set the desired bit sequence.

General Time Plan Subframe OPCFIC		DCCH			
		L	Jser Configur	ation —	
No. of Config. DL Subframes	4	User 1	User 2	User 3	User 4
Reset All Subframes	Scrambling	V	V	$\mathbf{\nabla}$	V
	Channel Coding				
Behaviour in Unsch. REs (OCNG) DTX	UE ID	0	0	0	0
	Data Source	PN9	PN9	PN9	PN9
	DList/Pattern	1 +	1	-	-
	elMTA-RNTI	1	4	1	.1
	P_A	0 dB	0 dB	0 dB	0 dB
	SPS	Config	Config	Config	Config
	Anomalia ODC	171	1-1	177	Innut

Fig. 3-21: The eIMTA-RNTI is used for CRC scrambling of the PDCCH (example user 1).

General Time Plan	Subfram	e O PCF		PHICH						
Cell PCell	•	Si	ubframe			Prev	Next		Сору	Paste
PDCCH Format	Variable	•		-	Powe	er			0.00	0 dB
	COLCER		1 872/2	34/26		Dummy	CCE >>>	>		Da
Number of Bits / RE	557 CCES							_		
Append	Insert	Delete	•	Down ↓	Up	†	Reset		Resolve Co	nflicts
Append User		Cell CIE	DCI	Down ↓ Search Space	Contant		Number	CCE	Resolve Co No.Dummy CCEs	

Fig. 3-22: Select elMTA in the USER section in PDCCH. This sets DCI format 1C automatically.

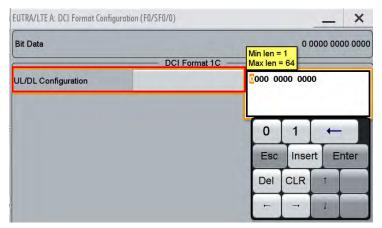


Fig. 3-23: Bit format to signal UL/DL reconfiguration in DCI Format 1C.

3.1.8 Further downlink MIMO enhancements (Rel 12)

The enhanced codebook is supported for four (4) Tx antennas in transmission modes (TM) 8, 9, 10 only.

Set in the **System Configuration** a 4 Tx antenna configuration. Klick in the **DL Frame Configuration** in the PDSCH allocation on **Config. Enhanced Settings**. Enable **Use Alternative Codebooks** (see Fig. 3-24).

UTRA/L1	FE A: Enh	anced Se	ettings (F0.	/SF0/Al	.2.1)		_	×
Preco BF	ding C)CSI-F	as 🔘	S	crambl		Channe	Coding	
Preco	ding Sch	neme		в	eamfo	rming (U	E-spec	.RS)	
Transn	nission	Schem	e	N	lulti La	yer (TxM	ode 9)		
Codev	vords								2
Numbe	er Of La	yers		[4
Antenr	na Ports			7-10 -					•
Antenr	na Port N	Mapping	9	Codebook					•
Use Al	ternative	e Code	books					3	
Codeb	ook Ind	ex							0
Codeb	ook Ind	ex 2							15
Mappir	ng Coor	dinates		C	artesia	in			•
	Cell	AP 7 Real	Imag		AP 8 Real	Imag.	AP 9 Real	Imag.	AR
BBA	PCell	0.250	+j0.00	00	-0.250	+j0.000	-0.250		-0

Fig. 3-24 enhanced 4 Tx codebook in the SMW

3.2 Signal Analysis

For measuring LTE(-A) signals, several different spectrum analyzers can be used for the tests described here:

- I FSW
- I FSV(R)
- I FSVA
- ı FPS

The **E-UTRA/LTE measurements** software option is available for each of the listed analyzers. The following are available:

- FSx-K100 E-UTRA/LTE FDD downlink measurements
- FSx-K101 E-UTRA/LTE FDD uplink measurements
- FSx-K102 E-UTRA/LTE downlink MIMO measurements
- FSx-K104 E-UTRA/LTE TDD downlink measurements
- FSx-K105 E-UTRA/LTE TDD uplink measurements
- FSx-K103 Analysis of EUTRA LTE-Advanced and MIMO Uplink Signals

Test instruments can also be controlled via the external PC software application E-UTRA/LTE and LTE-Advanced Signal Analysis. The options are named FS-K10xPC. With the software in addition to the above mentioned spectrum analyzers, the oscilloscopes of the RTO family can be used.

In principle, there are two different measurement types:

- Spectrum measurements (e.g. ACLR, SEM, ...)
- Demodulation measurements (e.g. EVM, Frequency error, ...)

RefLevel 0.00 dBm Freq Att 10 dB 193:EXT1	2.11 GHz Mode MIM	DL FDD, SI		Time 20.1 Count Lof1		e An		SGI
Capture Buffer		O1 Cirw	3 EVM vs Carr	i 1 Avg :	2 Min • 3 Max	5 Power Spe	ectrum	1 Cfrv
anni Start Officer : 12 199102 no						ViB.dEn/Ho-		
d@m)						-us denilito		
it gem			9.02			AR BUNNES		
and the local sector of the Annealter	territer (floored an entities Tree Inti-	the local sector	0 %			-sidembla-		
and the second sec	and a sub-					All diministration		-mey
Barth to Bart a best and a set of the book set of	and the particular states of the	a burdinada.				111 a de chiling della		
			I To Annual			192 am (H2-		
0 ms 2.01	ms/	20.1 ms	-3.84 MH2	768.0 kHz/	3.84 MHz	-3.84 MHz	768.0 kHz/	3.84 MH
Result Summary			-		4 Constellati	ion Diagram		
rame Results 1/1	Mean	Max	Limit	Min	Points Measure	1:41424		
VM PDSCH QPSK (%)	0,86	0.86	18.50	0.86				
VM PDSCH 16QAM (%)			13.50					
VM PDSCH 64QAM (%)			9.00					
VM PDSCH 256QAM (%)							20 A	
	bframes All, Sel		, Frame Resu					
VM AII (%)	0.85	0.91		0.82				
VM Phys Channel (%)	0.85	0.91		0,82	A			
VM Phys Signal (%)	0.81	0.87		0,74				
requency Error (Hz)	-0.00	0.83		-0,85				
Sampling Error (ppm) Q Offset (dB)	-58,42	-57.57		-59,55	T			
Q Gain Imbalance (dB)	-0.00	-0.00		-0.01				
Q Quadrature Error (°)	-0.00	0.02		-0.01				
STP (dBm)	-58,48	-58,47		-58,48				
STP (dBm)	-33.70	-33.70		-33.71				
SSI (dBm)	-33.89	-33.89		-33.94				
ower (dBm)	-33.76	-33.76		-33.82				
Crest Factor (dB)	10.39							

Fig. 3-25: LTE demodulation measurements on a single component carrier.

The FSW offers a Multi Standard Radio Analyzer (MSRA) option as well. With the MSRA mode, detailed investigations on multi-standard base stations can be done and interactions between technologies in different frequency bands can be detected. The MSRA mode is based on the analysis of I/Q data. It captures up to 200 Msamples of I/Q data at one moment in time (sufficient for 1 s over a bandwidth of 160 MHz) which can then be analyzed by different measurement applications (e.g. LTE, WCDMA and GSM). Each signal can be analyzed with the corresponding technology option (LTE and WCDMA in the example). Additionally the MSRA view displays both measurement results on a single screen. The type of measurements for each technology can be configured individually.

3.2.1 Carrier aggregation enhancements (Rel 11)

When a carrier aggregation signal comprising multiple component carriers is transmitted, each carrier needs to be tested on RF level the same way as single carrier LTE, e.g. EVM and frequency error measurements. In addition, measurements like Maximum power or ACLR have to be measured in multi-carrier configurations.

3.2.1.1 Non-contiguous intra-band carrier aggregation

ACLR

The transmitter test requirements for eNodeB for Adjacent Channel Leakage Power ratio (ACLR) applies outside the used RF bandwidth for single or multi-carrier configurations. In multi-carrier scenarios with certain gap sizes (spectrum between two wanted channels) the requirements also apply inside the unused gap. In addition, for multi-carrier special gap sizes the Cumulative Adjacent channel Leakage power ratio (CACLR) applies (see Table 3-1).

ACLR				
5	Scenario	A	CACLR	
Carrier	Gap	Inside gap	Outside RF bandwidth	
Single Carrier	-	-		×
	5 MHz ≤ Gap ≤ 15 MHz	×	_	V
Multi-Carrier / CA	15 MHz ≤ Gap < 20 MHz	Ø		V
	Gap ≥ 20 MHz	Ø		X

Table 3-1: Overview ACLR measurements.

The FSx supports the ACLR for multi-carrier including the measurements inside the gap and the CALCR. Fig. 3-26 shows an example with two carriers.

RefLevel 0.00 dBm Att 7 dB = SV	• ₩T 50 ms (~134 ms) •	RBW 30 kHz VBW 300 kHz Mode Aut	o FFT	
ACLR			2.117	o1Rm Cln
	A:LTE 5M1		ويجرب والأحصيص الكري	
dBm-	A:LIE_3MI		B:LTE_	2MT
0 dBm				
and the second se		AB:Gap1L	AB:Gap1U	Adi Upper
Alt1 Lower		ABIGADIL	AB;Gap10	Alt1 Upper
) dBm - +		* *		
) dBm-				
) dBm e				
dBm-				
dBm				
F 2.41125 GHz		2001 pts	4.89 MHz/	Span 48.9 M
Result Summary		Multi-Standard	Radio	
Channel	Bandwidth	Frequency	Power	
A:LTE_5M1 (Ref)	4.515 MHz	2.400 GHz	-33.99 dBm	
Sub Block A Total			-33.99 dBm	
Channel	Bandwidth	Frequency	Power	
B:LTE_5M1	4.515 MHz	2.422 GHz	-34.05 dBm	
Sub Block B Total			-34.05 dBm	
Adj Channels	Bandwidth	Offset	ACLR Power	
Adj Lower	4.515 MHz	5.000 MHz	-47.75 dBc -48.45 dBc	
Adj Upper	4.515 MHz	5.000 MHz 10.000 MHz	-48.45 dBc	
Alt1 Lowor	4.515 MHz		-48.47 dBc	
Alt1 Lower				
Alt1 Upper	4.515 MHz Bandwidth	10,000 MHz		CACLD Dowor
	4.515 MHz Bandwidth 3.840 MHz	0,000 MHz Offset 2,500 MHz	ACLR Power -48,42 dBc	CACLR Power -51.40 dBc

Fig. 3-26: ACLR with a measurement inside the gap. The FSW automatically measure the in-gap channels if necessary.

Timing Alignment Error

Infrastructure suppliers have to perform dedicated tests for carrier aggregation. One of them is the time alignment error measurement, short TAE. As frames of LTE signals at a base station antenna port are not perfectly aligned, they need to fulfill certain timing requirements. Table 3-2 lists the limits for various combinations. These requirements are independent of TX diversity or MIMO applied per component carrier.

Time alignment error limits	
Transmission combination	Limit
MIMO/TX diversity single carrier	90 ns
Intra-band CA with or without MIMO or TX diversity	155 ns
Intra-band non-contiguous CA with or without MIMO or TX diversity	285 ns
Inter-band CA with or without MIMO or TX diversity	285 ns

Table 3-2: Time alignment error limits; yellow marked the non-contiguous requirement [1].

	Spectru Spectru	m X	LTE				
Ref Level 0. Att	.00 dBm Freq 10 dB	2.115 GHz	Mode DL FDD, CC1 1 Tx		Capture Time 20 2 Tx / 1 Rx Frame Count 1 of	.1 ms Subframe All	SGL
1 Capture Bu				.,		- (+)	O1 Clrw
All CC 1	ITCC 2						
1.1 CC 1					1.2 CC 2		
Frame Start Offs 18 dBm	et : 9.038706 ms				Frame Start Offset : 9.038704 ms		
6 dBm					6 dBm		
=6 dBm					-6 d8m		
18, (95) 1000 100	in when particle short many	a des plan e para para	an lancar a para la parabora	A participant of the state	· · · · · · · · · · · · · · · · · · ·	des these second se	and the second second second second
1							
1 - 1 - S				1.2.2	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	A	1
المعاد والمعاد	da halt dri	har har t	dial the his	de al cola de	the she all a break a break a drive	at dat dat the	and a look of
0.0 ms		2.01 ms/		20.1 ms	-0.0 ms	2.01 ms/	20.1 ms
0.0 ms 2 Time Alignr	ment Error	2.01 ms/		20.1 ms	0.0 ms 3 Power Spectrum	2.01 ms/	20.1 ms • 1 Clrw
2 Time Alignr	ment Error itenna (CC1) :		÷ Limi	20.1 ms t : 285 ns		2.01 ms/	
2 Time Alignr	ntenna (CC1) :			-	3 Power Spectrum	2.01 ms/	
2 Time Alignr Reference An	ntenna (CC1) : Frequency Time Alignmen	Antenna 1 Error to CC:		t : 285 ns	3 Power Spectrum All CC 1 CC 2		
2 Time Alignr	ntenna (CC1) : Frequency Time Alignmen	Antenna 1 Error to CC:	1 : -6.33 Hz	t : 285 ns	3 Power Spectrum All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -55 dBm/Hz	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 Error to CC: ht Error to Ar	1 : -6.33 Hz ntenna 1 (CC1)	t : 285 ns	3 Power Spectrum All CC 1 CC 2 3.1 CC 1	3.2 CC 2 -59 dBm/Hz -55 dBm/Hz -74 dBm/Hz	
2 Time Alignr Reference An Component Carrier	ntenna (CC1) : Frequency Time Alignmen Antenna	Antenna 1 / Error to CC: nt Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	B Power Spectrum All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz 92 dBm/Hz	3.2 CC 2 -58 dBm/Hz -55 dBm/Hz -74 dBm/Hz -24 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 / Error to CC: nt Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	B Power Spectrum All CC 1 CC 2 3.1 CC 1	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz -82 dBm/Hz -90 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 / Error to CC: nt Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -56 dBm/Hz -56 dBm/Hz -58 dBm/Hz -59 dBm/Hz -90 dBm/Hz -98 dBm/Hz -98 dBm/Hz	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 / Error to CC: nt Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	3 Power Spectrum All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -58 dBm/Hz -56 dBm/Hz -58 dBm/Hz -58 dBm/Hz -90 dBm/Hz -90 dBm/Hz -58 dBm/Hz -106 dBm/Hz -58 dBm/Hz -58 dBm/Hz	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 / Error to CC: ht Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -56 dBm/Hz -56 dBm/Hz -58 dBm/Hz -59 dBm/Hz -90 dBm/Hz -98 dBm/Hz -98 dBm/Hz	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz	
2 Time Alignr Reference An Component Carrier CC2	ntenna (CC1) : Frequency Time Alignmer Antenna Antenna 1	Antenna 1 / Error to CC: ht Error to Ar Min	1 : -6.33 Hz ntenna 1 (CC1) Mean	t : 285 ns) Max	3 Power Spectrum All CC 1 CC 2 3.1 CC 1 -58 dBm/Hz -56 dBm/Hz -56 dBm/Hz -66 dBm/Hz -66 dBm/Hz -98 dBm/Hz -98 dBm/Hz -106 dBm/Hz -114 dBm/Hz -114 dBm/Hz -12 dBm/Hz	3.2 CC 2 -58 dBm/Hz -56 dBm/Hz -74 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz -106 dBm/Hz -114 dBm/Hz	

Fig. 3-27: Example for a time alignment measurement with CA

3.2.2 Small Cell Enhancements (Rel 12)

3.2.2.1 Higher Order Modulation - 256QAM

Small cells may support 256QAM modulation. As part of the eNodeB transmitter tests the FSx supports 256QAM EVM measurement as well.

Z Result Summary				
Frame Results 1/1	Mean	Мах	Limit	Min
EVM PDSCH QPSK (%)			18.50	
EVM PDSCH 16QAM (%)			13.50	
EVM PDSCH 64QAM (%)			9.00	
EVM PDSCH 256QAM (%)	0.56	0.56		0.56

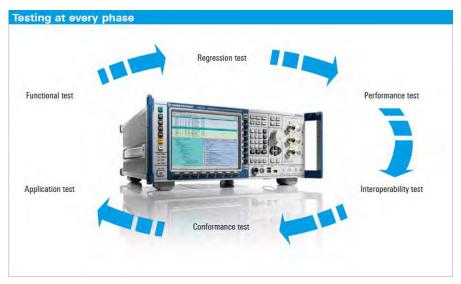
Fig. 3-28: FSW Result summary: The EVM measurement supports 256QAM modulation.

3.3 CMW500

The CMW can be used as a protocol tester (message analysis) as well as a radio communication tester (call box, RF test).

In addition to LTE-A, the CMW offers other radio communication standards, including WCDMA, GSM, CDMA2000[®], 1xEV-DO and so on. This makes it possible to test InterRAT scenarios, such as LTE handover to GSM or WCDMA.

Equipped with powerful hardware and various interfaces to wireless devices, the CMW can be used throughout all phases of LTE-A device development – from the initial module test up to the integration of software and chipset, as well as for conformance



and performance tests of the protocol stack of 3GPP standard-compliant wireless devices.

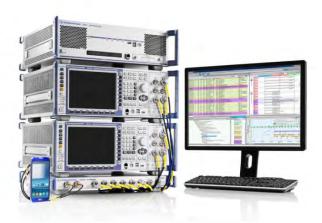
Fig. 3-29: Consistent hardware and software concept for all device development phases.

MIMO and Carrier Aggregation

The CMW (protocol tester and callbox) supports different transmission and MIMO modes like 8x2 MIMO and carrier aggregation up to five (5) component carriers (CC) and MIMO in parallel like CA with 4x4 MIMO. The CMW supports all possible frequency allocations in CA (intra-band contiguous, intra-band non- contiguous and inter-band). All CC's can be set up independently of each other.

Carrier Aggregation with CMWflexx

The CMWflexx (protocol tester and callbox) provides more than 2 CC's with MIMO each, therefore more than one CMW is used. The CMW Controller (CMWC) allows easy manual and remote control, it acts like one CMW with extended RF hardware.



3.3.1 CMW protocol tester

The device under test (a chip set or terminal) is connected to a network emulator, which simulates all required network functions and protocols. However, errors may occur in all layers (physical layer, Layer 2/3, application layer) and throughout the whole development cycle (R&D, conformance, production). Thus any test instrument needs to offer manifold analysis capabilities. Rohde & Schwarz offers the CMW500 wideband radio communication tester, which provides all necessary functions within a single test instrument.

Different bandwidths per component carrier, up to 20 MHz each, are supported. CMW500 supports all variances of carrier aggregation in one single instrument: intraband (contiguous, non-contiguous) and inter-band. Already today the instrument supports all 3GPP frequency bands that are utilized for LTE.

First of all the tester and the DUT have to run throughout a successful LTE-A channel setup. I.e. the signaling procedure from starting with a LTE Rel8 setup and adding secondary component carriers (SCC's) has to be verified on all relevant protocol layers (PHY, MAC and RRC). This is typically be done using a CMW500 in protocol test configuration. Example scenarios are available for lower layer API (LLAPI) and medium layer API (MLAPI) as well as the graphical user interface CMWcards. Fig. 3-30 shows example physical layer scenarios using different configurations for primary and secondary cells as well as different transmission modes.

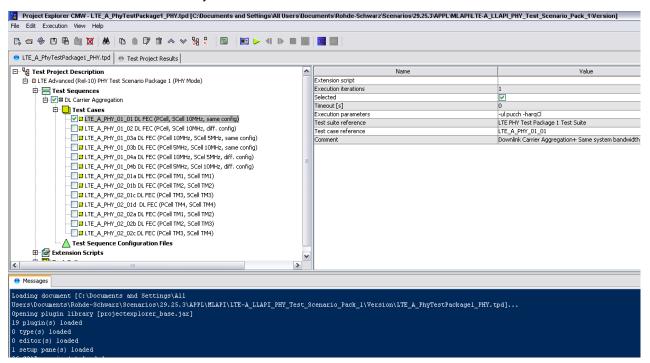


Fig. 3-30: Physical layer example scenario for carrier aggregation.

MLAPI

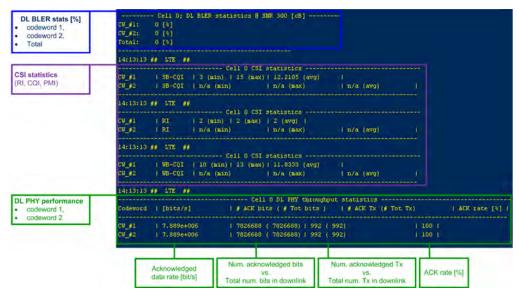
In order to verify the signaling communication on layer 2 and 3, MLAPI scenarios are available. These can be used as provided in various test scenario packages. Additionally existing scenarios may be modified according to the individual testing needs.

Following MLAPI scenarios packages with Release 11/12 features are available:

Scenario Packages Rel 11/12						
Name	Description	Remark				
CMW-KF515	LTE Rel10/11 MLAPI Scenarios eICIC and FeICIC	94 scenarios				
CMW-KF518	LTE Rel. 10/11 PHY Scenarios 3CA DL/CoMP/TM10	46 scenarios				
CMW-KF519	LTE Rel. 10/11 MLAPI Scenarios 3CA DL/CoMP/TM10	74 scenarios				
CMW-KF650	LTE Rel 12 MLAPI Scenario PACK, LTE - WLAN Offloading					
CMW-KU500	LTE Rel.12 TDD/FDD coexistance, 256QAM DL, Cat.0 and e-PDCCH MLAPI Scenarios	63 scenarios				
CMW-KU503	LTE Rel. 9-12 MTC MLAPI Scenario PACK , MTC-, IoT-, M2M-Test Scenarios to test CAT0, EAB, Extended Wait Time	35 scenarios				
CMW-KU506	LTE R12 MLAPI SCN Pack D2D DISCOVERY	24 scenarios				
CMW-KU507	LTE R12 MLAPI D2D direct communication	13 scenarios				
CMW-KU509	LTE R12 MLAPI Dual Connectivity	31 scenarios				

Table 3-3: MLAPI Scenario Packages Rel 11/12.

In addition, MLAPI scenarios also allow user extendible KPI collection (BLER and SQI).





CMWcards

CMWcards is a graphical test case creation tool for signaling and application tests on CMW500 mobile radio tester.

Create wireless signaling and application tests on the CMW500 wideband radio communication tester just by setting up a hand of cards – no programming required.

Thanks to the CMW500 tester's unrivaled multitechnology capability, CMW-KT022 CMWcards can be utilized to rapidly reproduce signaling scenarios for various wireless communications standards just like LTE, WCDMA, GSM as well as WLAN.

CMWcards includes test coverage for LTE-advanced up to Release 12 features such as LTE-WLAN offloading or LTE-FDD-TDD joint operation. Fig. 3-32 shows an example in CMWcards with LTE-WLAN Offloading.



Fig. 3-32: CMWcards Example for Release 12: LTE-WLAN Offloading.

CMWmars

Efficiently analyze recorded message logfiles. The convenient, intuitive CMWmars message analyzer user interface combined with various tools and views helps users quickly narrow down the root cause of signaling protocol and lower layer problems. The multifunctional logfile analyzer provides access to all information elements of all protocol layers for LTE, WCDMA, GSM, TD-SCDMA, CDMA2000[®] and WLAN, including the IP layer. CMWmars presents the logfile in various synchronized views that visualize the data from different perspectives, helping users to postprocess complex message logs in a very intuitive and easy way.

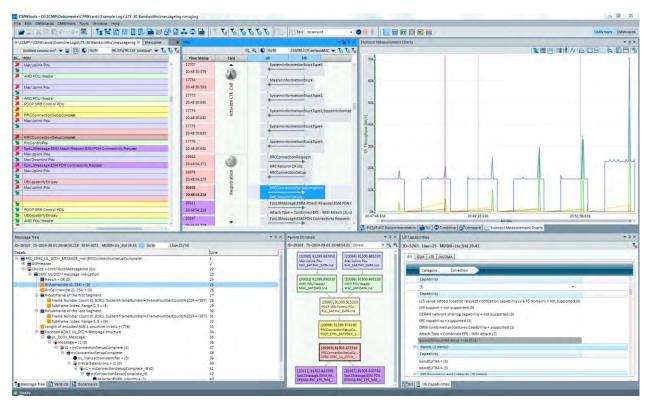


Fig. 3-33: Overview CMWmars.

Uplink – TX Measurements

Furthermore there is a need to verify the uplink signal transmitted by the device. All relevant measurements are available with the CMW500. The RF uplink measurements can be done in parallel to a MLAPI test scenario or in the RF tester environment. These measurements do not differ from LTE Release 8 uplink TX measurements if only one uplink carrier is used. The CMW also supports uplink carrier aggregation measurements and 64QAM in the uplink. For a short Tx measurement overview see next section.

3.3.2 CMW RF tester ("call box")

When used as an RF tester, the CMW provides a generator for the LTE downlink and an analyzer for the LTE uplink signal. The CMW can also emulate network operation ("signaling") under realistic conditions for RF tests. The CMW supports carrier aggregation up to five (5) component carriers (CC) and MIMO in parallel like CA with 4x4 MIMO (CMWflexx).

Transmitter tests (TX)

Measurements on the TX side of the DUT are made possible with the LTE Multi Evaluation option (see Fig. 3-34).

The overview screen provides all measured results and scalar values for the essential measurements: UE power, error vector magnitude (EVM) root mean square (RMS) power, RB allocation table and spectrum measurements. Because measurements results are based on the same set of data, the individual results relate to each other, thus facilitating troubleshooting and debugging.

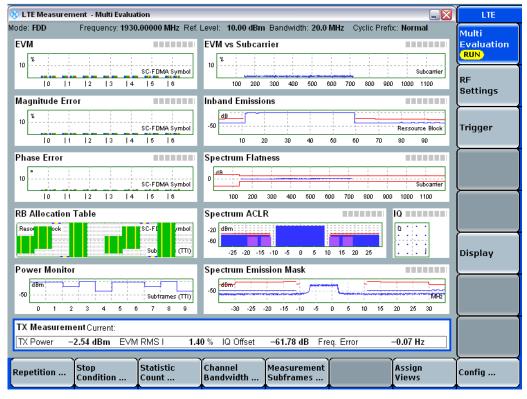


Fig. 3-34: Tx measurements of a DUT uplink signal using CMW500.

The overview display in multi-evaluation mode can be adapted to the individual testing needs. For example, it may be necessary to closely monitor only two measurement results, or just one measurement result with a comparison of maximum and average values. The overview display can be configured to meet individual needs.

These measurements do not differ from LTE Release 8 uplink TX measurements if only one uplink carrier is used. If two uplink carriers are used, the modulation measurements, e.g. EVM, can be done on each CC. Measurements like inband emission, power monitor and RB allocation table can be done at the same time. Spectrum measurements (Spectrum ACLR and Spectrum emission mask) are measured for the aggregated bandwidth for CC's together for intra-band contiguous uplink CA. 64QAM modulation in the uplink has been introduced in Rel. 8 as optional for UE's. The CMW supports the signaling and the measurement in the Tx Meas. Multi-Evaluation (see Fig. 3-35).

LTE Signaling 1 - X3.5.80.28 - Base V 3.5.120					×.						
Connection Status	PCC SCC1	SCC2 SCC3	SCCA	LTE	Multi Evaluation PRACH SRS						
Cell (M)	Operating Band	Band 7	FDD	LTE 1	FDD Free 2535.0 MHz Ref Level: -3.20 dBm BW 20.0 MHz CP Normal Meas Subfr/Slot: 0 / All						
Packet Switched Attached		Downlink	Uplink	TX Meas.	IQ Constellation						
RRC State Connected	Channel	3100 Ch	21100 Ch	LTE 1	Q Statistic Count 13						
SCC1 State MAC Activated	Frequency	2655.0 MHz		RX Meas.	1 Out of Tolerance						
	Cell Bandwidth	20.0 MHz	• 20.0 MHz								
Event Log	RS EPRE Full Cell BW Pov	-85.0 dBm w54.2 dBm		Go to	Detected Modulation						
13:38:29 SCC1 State 'SCC1 MAC Activated' 13:38:29 SCC1 State 'SCC1 RC Added'	PUSCH Open Lo		-20 dBm -20.0 dBm	Routing	64-QAM Detected Channel PUSCH						
3:38:29 € SCC1 State 'SCC1 On' 3:38:29 € State 'Attached' 3:38:29 € EPS Default Bearer Established, ld 5 3:38:28 € RRC Connection Established	Sched, RMC		-		Sched. RMC		MC				View Filter Through 100.0 %
UE Info											
IMEI 004400152020002 IMSI 001010123456063		Downlink	64-QAM Volume Galactic Galacti		and the second sec						
	^C # RB ii: RB Pos./Start R			100 • 28 low • 0	100 ×	LTE Signaling					
L-5 (cmw500.ro 192.168.48.129fc01:abab:cdcc Dedicated Bearer TFT Port Range DL / UL	Range DL / UL		Value 5 8760 QPSK								
	Throughput	7.884 Mbit/s	16-QAM 64-QAM		-1 0 1						
Scenario Routing External Att. (Output) (Output)		External Att. (Input)		Config							

Fig. 3-35: CMW Uplink 64QAM

Signaling and receiver tests (RX)

The CMW can optionally provide signaling. The "LTE signaling" firmware application (option KS5xx) allows users to emulate an E-UTRA cell and to communicate with the UE under test. The UE can synchronize to the DL signal and register

This means that RX tests, e.g. ACK/NACK measurements (BLER, throughput), can be performed in test mode on the DUT.

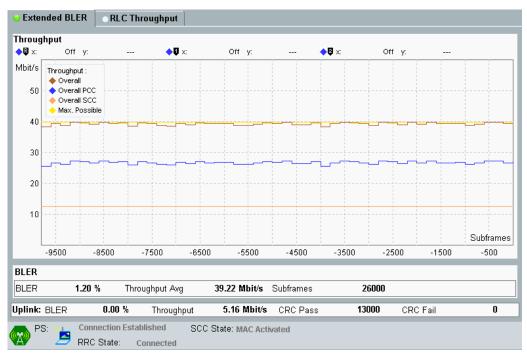


Fig. 3-36: LTE RX measurement for Carrier Aggregation. As an example, the throughput for two CC's and the overall throughput are displayed.

3.3.2.1 UE Categories (Rel 12)

LTE defines different UE categories 0...15. The CMW supports following UE categories:

- Downlink
 - 0...4
 - 6,7
 - 9...13
 - 15
- Uplink

ı

- 0...4
- 6,7
- 9...12

The UE typically reports its capabilities via signaling. UE category 0 (also called LTE MTC) requires option CMW-KS590.

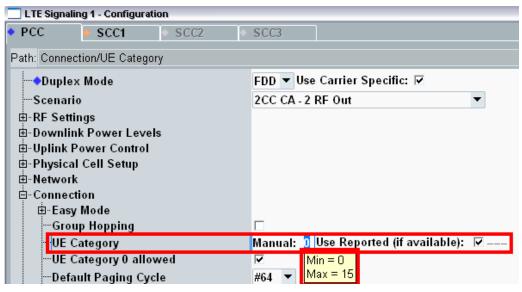


Fig. 3-37: UE categories 0...15 in the CMW.

3.3.2.2 Carrier aggregation enhancements (Rel 11)

Non-contiguous intra-band carrier aggregation

The CMW is capable of generating up to four CC's (PCC and SCC1...SCC3). In order to test non-contiguous intra-band configurations, the same band is selected for all CC's and the desired channels are set, e.g. Channel and/or Frequency. Fig. 3-38 shows an example with two CC's.

PCC SCC1	SCC2 SCC3		PCC SCC1	SCC2 SCC3	
Operating Band	Band 1 🔹	FDD 🔻	Operating Band	Band 1 🔹 🔻	FDD
	Downlink	Jplink		Downlink	
Channel	300 Ch	18300 Ch	Channel	500 Ch	
Frequency	2140.0 MHz	1950.0 MHz	Frequency	2160.0 MHz	
Cell Bandwidth	10.0 MHz 🔹	10.0 MHz 📃	Cell Bandwidth	10.0 MHz 🔹	

Fig. 3-38: Non-contiguous intra band CA. This example shows two carriers in band 1.

TDD: Additional Special Subframe Configuration and different UL/DL configurations

The CMW supports both the new special subframes and the different UL/DL settings in TDD. This is accomplished in the *TDD* section by selecting **Use Carrier Specific** for each CC. This makes it possible to set the **Uplink /Downlink Configuration** individually for each carrier. The setting for **Special Subframe** (7 and 9 are new) is also in the TDD section. Fig. 3-39 shows an example with two CC's.

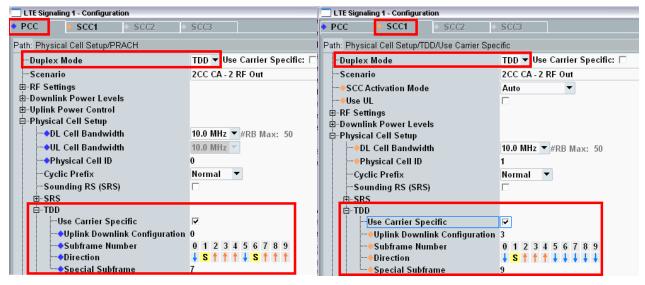


Fig. 3-39: Different UL/DL configuration und special subframe. In the example, 2 CC are configured to 0 and 3 and special subframes to 7 and 9.

3.3.2.3 Small cell enhancements (Rel 12)

Higher Order Modulation (256QAM)

As one of the main parameters, the modulation in the downlink can be already configured in the main LTE Signaling screen. 256QAM requires the Release 12 options CMW-KS504 (FDD) and – 554 (TDD).

LTE Signaling 1 - V3.5.30 - Base V 3.5.80						
Connection Status	PCC	SCC1	SCC2	SCC3		
Cell	Operating	; Band	Band 1	•	FDD	•
Packet Switched 📕 OFF			Downlink		Uplink	
RRC State Idle	Channel		300	Ch	18300	Ch
SCC1 State OFF	Frequenc	у	2140.0	MHz	1950.0	MHz
	Cell Band	lwidth	10.0 MHz	-	10.0 MHz	
	RS EPRE	E	-85.0	dBm/15kHz	:	
Event Log 🛛 🛛 🗙	Full Cell	BW Pow	-57.2	dBm		
44-40-40 2 1 TE Cimpeling 2 E 20 22	PUSCH	Open Loc	p Nom.Power		-20	dBm
11:46:10 ()LTE Signaling 3.5.30.23	PUSCH (losed Lo	oop Target Pow	ver	-20.0	dBm
	Sched.	RMC	•	🗖 🗆 Mu	lticluster UL	
UE Info 🔹 🔲						
IMEI						
IMSI			Downlink		Uplink	
Voice Domain Pr UE's Usage Setti	#RB			50 🕶		50 🔻
Default Bearer IPv4 address IPv6 prefix	RB Pos.	/Start RF	3 low	• 0	low 🔻	0
· · · · · · · · · · · · · · · · · · ·	Modulati		_	256-QAM 🔻		бк≖
Dedicated Bearer TFT Port Range DL / UL	TBS Idx			QPSK		160
/ /	Through			16-QAM	5.160 M	
	mough			64-QAM 256-QAM	5.100 10	0105

Fig. 3-40: 256QAM for small cells in the downlink.

3.3.2.4 WLAN/3GPP Radio Interworking (Rel 12)

The CMW supports WLAN offloading tests for LTE. This requires the following:

- 1 pc LTE Signaling option (advanced CMW-KS510)
- 1 pc WLAN Signaling option (advanced KS660)
- 1 pc DAU

In the DAU, the CMW-KA065 WLAN offloading untrusted option must be available. It implements the following features:

- ePDG Server
- IKE Signaling
- Multiple PDN offload support

The following important settings are made in the DAU:

- I The IMS server must be started
- In the DNS server, the correct addresses must be set. These differ depending on provider and must match the settings on the SIM card.
- Authentication parameters and certificates

)verview 🎰 IP Config	j 🕒 DNS 💽 FTP (🔾 HTTP 💛 IMS 💛 e	PDG	
omain Name System				
DNS Server Info for th	e mobile			
Primary DNS Server: Ir	nternal	Secondary DNS Serve	r: No DNS	
Current IPv4 Address:13	72.22.1.201	Current IPv4 Address:	n/a	
Current IPv6 Address:fc	01:cafe:0:0:0:0:0:1	Current IPv6 Address:	n/a	
Local DNS entries —				
Domain		IP	,	
www.dau.dau		172	2.22.1.201	
www.dau.dau		fc0	1:cafe::1	
ss.epdg.epc.mnc260.m	cc310.pub.3gppnetwork	c.org 192	2.168.1.201	
ss.epdg.epc.mnc260.m	cc310.pub.3gppnetwork	c.org fc0	1::1	
Application services				
Application	Domain	Protocol		Port
pcscf	dau.dau	UDP		5060

Fig. 3-41: DNS settings in the DAU. These settings differ depending on SIM card provider.

ePDG IP Configuration	
B-ePDG ID Configuration	
ġ-IKE	
Encryption	
⊕ -PRF	
⊕-Integrity	
🖻 Diffie Hellman	
□ -ESP	
Encryption	
⊞-Integrity	
P-CSCF IKEv2 Attribute	
🖻 Authentication Data	
IMSI	310260012345606
-Authentication Algorithm	XOR •
-Secret Key	0001 0203 0405 0607 0809 0A0B 0C0D 0E0F hex
RAND	5555 5555 5555 5555 5555 5555 5555 hex
AMF	0000 hex
-Кеу Туре	OPc
Authentication OPc	CD63 CB71 954A 9F4E 48A5 994E 37A0 2BAF hex
Dead Peer Detection	
E-Certificate	

Fig. 3-42: eDPG settings.

During testing, the UE is registered both in LTE and in WLAN. As a result, the downlink level of the WLAN-APS should initially be very low (e.g. –100 dBm). The UE sets ups the connection in LTE. If the WLAN level is now set high (e.g. –16 dBm), the data should be transmitted via WLAN (see Fig. 3-43 and Fig. 3-44).

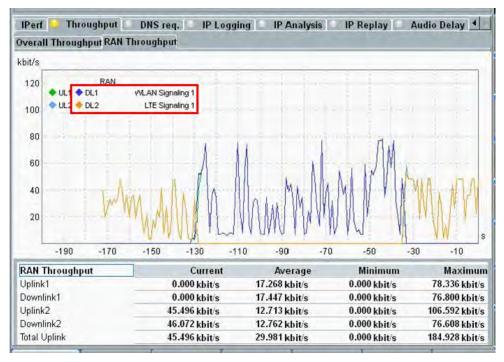


Fig. 3-43: Throughput measurement for LTE WLAN offloading. Orange shows the throughput in LTE and blue in WLAN. The points where the offloading switches are easily recognizable.

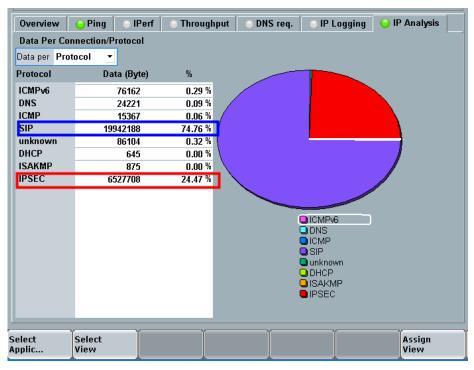


Fig. 3-44: IP analysis in LTE-WLAN offloading. WLAN traffic is via the IPSEC tunnel (red).

3.3.2.5 TDD-FDD joint operation in different bands (Rel 12)

The CMW supports different duplex modes in the individual CC's. To do this, under *Duplex Mode*, enable **Use Carrier Specific**. This makes it possible to define different settings for the individual CC's. TDD-FDD joint operation requires Release 10 options CMW-KS502 (FDD) and – 552 (TDD). Fig. 3-45 shows an example with two CC's; PCC uses FDD; SCC1 uses TDD.

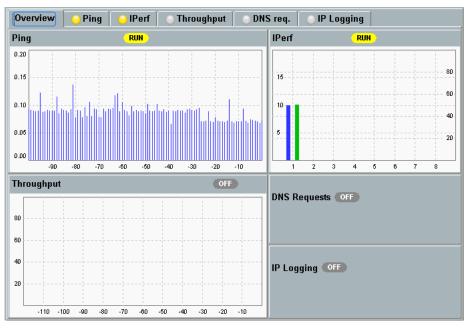
📃 LTE Signaling	g 1 - Configuratio	on			LTE Signaling 1 - Configuration									
PCC	CC SCC1 SCC2 SCC3		♦ F	РСС	SCC1	SCC3								
Path: Scenario	Path: Scenario						Path: Duplex Mode							
>Duplex	→Duplex Mode FDD ▼ Use Carrier Specific: 🔽						Mode		TDD 🔻 Use	Carrier Specific: 🗹				
Scenario	-Scenario 2CC CA - 2 RF Out					Scenario			2CC CA - 2 F	RF Out				
						+++++++++++++++++++++++++++++++++	tivation Mode	÷	Auto	•				

Fig. 3-45: Joint operation. In the example, CC1 uses FDD and CC2 uses TDD.

3.3.3 Data Application Unit (DAU) for CMW

The "Data Application Unit" (option B450x) makes it possible to test data transfer via TCP/IP or UDP/IP. It allows users to run Internet Protocol (IP) services on the CMW, such as file transfer and Web browsing. The DAU provides a common and consistent data testing solution on the CMW for all supported radio access technologies.

The DAU is required when testing End-to-End (E2E) IP data transfer as well as when using the instrument for protocol testing (U-plane tests). Together with the DAU, IP-based measurement (option KM050) applications allow users to test and measure the properties of the IP connection, such as network latency or performance. The



measurements support Internet protocols IPv4 (option KA100) and IPv6 (option KA150 on top of KA100).

Fig. 3-46: Overview of the tests in the data application unit. PING, IPerf and Throughput at a glance.

3.3.4 Channel Simulation - fading

In order to simulate a channel for UE receiver tests, the CMW provides internal fading with predefined profiles as an option:

- Delay profiles (3GPP TS 36.101, Annex B.2.)
 - For 2x2 MIMO all with low, mid and high correlation:
 - EPA 5 Hz
 - EVA 5 Hz
 - EVA 70 Hz
 - ETU 30 Hz
 - ETU 70 Hz
 - ETU 300 Hz
- High speed train profile (HST) (3GPP TS 36.101, Annex B.3.)
- Multi-path profile for CQI tests (3GPP TS 36.521-1, section 9.3.)

Various options permit a variety of MIMO configurations; see the Ordering Information (4.3).

In addition, the CMW can be connected to the SMW via optional digital IQ interfaces. The SMW provides the MIMO matrix channels (e.g. 4x2), adds AWGN and fades all matrix channels. The MIMO cross components can be faded independently of one another (e.g. for CA with 2x2 MIMO). The SMW has predefined fading profiles for LTE in accordance to specification. In addition the fading parameters can be changed separately.

3.4 RF conformance Tests System TS8980

UEs have to pass various test phases during their development. In the early phase of R&D, the different components of the UE like baseband and RF part are tested independently from each other.

During this time radio communication testers, signal generators (SG) and signal analyzers (SA) are used typically in non-signaling test environments in order to investigate RF receiver and transmitter characteristics of the UE. Pure baseband tests can be done by using simulation and verification using the IQ-interface of the UE which is connected to the IQ-interface of channel emulators, SA and SG. As soon as a logical and physical call setup can be established, further tests on UE prototypes can be performed with the help of a signaling unit (SU) fitted to a radio communication tester like CMW.

Chipset and UE manufacturers will apply differing test specifications. There are internally defined specs which are based on knowledge and prior experience. This is a main part of the test area. Other tests are derived from i.e. the 3GPP test specifications like [TS 36.521]. As maturity of a UE design increases, more testing conditions are added. "House" test specifications as well as [TS 36.521] contain LTE test scenarios with fading and interference conditions. Additionally, extreme test conditions with varying environmental factors like supply voltage, humidity and temperature are defined for a UE.

Automated test systems like TS8980 with onboard components of SU, SG and SA are able to provide the widest range of such testing conditions. In a pre-conformance context, the user friendly flexibility to change testing parameters like effects of fading and interference as well as tools to find the real design limits in an automated and hence repeatable way are essential. After all, no flaw should pass unnoticed before entering the final stage to market: UE RF certification.

The type approval or certification of UEs according to GCF, PTCRB or a given set of Network Operator test plans is the next phase. GCF and PTCRB requirements typically consist of a subset of otherwise unchanged tests from the 3GPP test specifications.

Network Operator RF test plans usually consist of two types of tests

- those based on 3GPP with extensions and/or tighter limits, based on an operator's own experience
- completely new tests as defined
 - to protect other services (like Digital TV, ATC Radar, Geolocation services)
 - ensure UE performance is not unduly compromised in the vicinity of such other services.

Reproducible and precise measurements are crucial for type approval test systems like the TS8980FTA. Apart from basic accuracy, built-in functions for user-guidance on and/or full automation of calibration is a pre-requisite for a test system to function as an arbiter of UE performance.



Fig. 3-47: The test system TS8980FTA-2.

The TS8980 family of test systems offers the most complete coverage in the industry for applications in GSM, WCDMA and LTE test. TS8980 is used by all leading test houses, first-rate chipset and UE manufacturers, and major network operators.

UTRA and E-UTRA Conformance test in line with GCF and PTCRB as used by labs accredited for certification of mobile devices are complemented by a very broad range of acceptance test packages as defined by many of the leading Network Operators.

The highly user friendly CONTEST graphical user interface gives control over test case execution, automation of DUT, Climatic chamber, DC supply and other external devices. The GUI also comes with a brace of functions for DUT management and standard-compliant result reporting as well as internal and external data base control for result handling, documentation and storage. It allows to perform the CA test cases according to the 3GPP test specification or to set the bandwidths and frequencies individually.

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EFDD	6.3.2E	4.20.0	Mnimum Outpu		CA_3A-5A															
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FDD	6.3.4.2.1	4.20.0	PRACH time mi		CA.34-8A															
FDD	5.3.4.2.2	4.20.0	SRS time mask																	
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Fig. 3-48: Contest testplan editor

Filters	ers 🕜 Operating Bands 😳				Advanced Parametrization									
Specification	3GPP *	Type to search		PR	CA_2/	A-28A								
		Available 92/92	Selected	474	СС	Band	PCC	Bandwid	th in MHz	Test Freq	uency IE	ĸ		
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		CA_2A-28A	CA_2C				-				_			
		CA_2A-30A	FDD 1		CC 2	FDD 28	1	5	20	Low	Mid	High		
		CA_2C	FDD 3					-	and the second s	-		-		
		CA:3A-5A												
		CA_3A-7A												
		CA_3A-8A												
		CA_3A-19A												

Fig. 3-49: CA band combinations in Contest

Margin Search routines and Performance Evaluation modes allow to evaluate the headroom a DUT has vs certification-level PASS criteria or vs user-specified minimum values.

RF test for LTE and WCDMA may be combined with RRM conformance for LTE / WCDMA.

Test Case Packages

Available validated test case packages for LTE according to Releases 11 and 12 are

- Release 11
 - Further enhanced non CA-based ICIC (feICIC)
 - Improved Minimum Performance Interference Rejection
 - Coordinated Multi-Point Operation (CoMP)
 - E-PDCCH
 - Non-contiguous intra-band carrier aggregation
- Release 12
 - Small cell enhancements (up to 3 CC)
 - 64 QAM UL
 - 256 QAM DL
 - TDD-FDD joint operation in different bands

4 Appendix

4.1 Literature

- [1] Rohde & Schwarz LTE Release 9 Technology Introducation [White Paper, 1MA191].
- [2] **Rohde & Schwarz** LTE Transmission Modes and Beamforming [Application Note, 1MA186]. 2015.
- [3] Rohde & Schwarz LTE-Advanced (3GPP Rel.11) [White Paper, 1MA232]. 2013.
- [4] Rohde & Schwarz LTE-Advanced (3GPP Rel.12) [White Paper, 1MA252]. 2014.
- [5] Rohde & Schwarz Testing LTE Release 9 Features [Application Note, 1MA210].
- [6] Rohde & Schwarz Testing LTE-Advanced [Application Note, 1MA166]. 2014.
- [7] Rohde & Schwarz UMTS Long Term Evolution (LTE) Technology Introduction [White Paper, 1MA111].

4.2 Additional Information

Please send your comments and suggestions regarding this application note to

TM-Applications@rohde-schwarz.com

4.3 Ordering information

Please visit the Rohde & Schwarz product websites at www.rohde-schwarz.com for ordering information on the following Rohde & Schwarz products or contact your local Rohde & Schwarz sales office for further assistance.

Vector Signal Generators

SMW200A vector signal generator SGS100A vector signal generator SGT100A vector signal generator

Signal and Spectrum Analyzer

FSW signal and spectrum analyzer FSV3000 signal and spectrum analyzer FSVA3000 signal and spectrum analyzer

- Radio Communication Tester
 CMW wideband radiocommunication tester
- Test Systems
 TS8980 Conformance test system