

LTE Downlink Carrier Aggregation configurations

1. DL Inter Band(2CC)

E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Bandwidth						Max Aggregated BW
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
2A-4A	(0)	Band 2	Yes	Yes	Yes	Yes	Yes	Yes	40
		Band 4			Yes	Yes	Yes	Yes	
	(1)	Band 2			Yes	Yes			20
		Band 4			Yes	Yes			
	(2)	Band 2			Yes	Yes	Yes	Yes	40
		Band 4			Yes	Yes	Yes	Yes	
2A-5A	(0)	Band 2			Yes	Yes	Yes	Yes	30
		Band 5			Yes	Yes			
2A-12A	(0)	Band 2	Yes	Yes	Yes	Yes	Yes	Yes	40
		Band 12			Yes	Yes	Yes	Yes	
	(1)	Band 2			Yes	Yes			20
		Band 12			Yes	Yes			
	(2)	Band 2			Yes	Yes	Yes	Yes	40
		Band 12			Yes	Yes			
2A-13A	(0)	Band 2			Yes	Yes	Yes	Yes	30
		Band 13			Yes	Yes			
	(1)	Band 2			Yes	Yes			20
		Band 13			Yes	Yes			
	(2)	Band 2			Yes	Yes	Yes	Yes	20
		Band 13			Yes	Yes			
2A-17A	(0)	Band 2			Yes	Yes			20
		Band 17			Yes	Yes			
2A-26A	(0)	Band 2			Yes	Yes	Yes	Yes	35
		Band 26			Yes	Yes	Yes	Yes	
2A-66A	(0)	Band 2	Yes	Yes	Yes	Yes	Yes	Yes	40
		Band 66			Yes	Yes	Yes	Yes	
	(1)	Band 2			Yes	Yes			20
		Band 66			Yes	Yes			
	(2)	Band 2			Yes	Yes	Yes	Yes	40
		Band 66			Yes	Yes	Yes	Yes	
4A-5A	(0)	Band 4			Yes	Yes			20
		Band 5			Yes	Yes			
	(1)	Band 4			Yes	Yes	Yes	Yes	30
		Band 5			Yes	Yes			
4A-12A	(0)	Band 4	Yes	Yes	Yes	Yes			20
		Band 12			Yes	Yes			
	(1)	Band 4	Yes	Yes	Yes	Yes	Yes	Yes	30
		Band 12			Yes	Yes			
	(2)	Band 4			Yes	Yes	Yes	Yes	30
		Band 12		Yes	Yes	Yes			
	(3)	Band 4			Yes	Yes			20
		Band 12			Yes	Yes			
	(4)	Band 4			Yes	Yes	Yes	Yes	30
		Band 12			Yes	Yes			
	(5)	Band 4			Yes	Yes	Yes		20
		Band 12			Yes				

2. DL Inter Band(3CC)

E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Bandwidth						Max Aggregated BW
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
2A-4A-5A	(0)	Band 2			Yes	Yes	Yes	Yes	50
		Band 4			Yes	Yes	Yes	Yes	
		Band 5			Yes	Yes			
2A-4A13A	(0)	Band 2			Yes	Yes	Yes	Yes	50
		Band 13				Yes			
2A-5A-66A	(0)	Band 2			Yes	Yes	Yes	Yes	50
		Band 5			Yes	Yes			
		Band 66			Yes	Yes	Yes	Yes	
2A-66A-66A	(0)	Band 2			Yes	Yes	Yes	Yes	60
		Band 66			66A-66A BCS 0				
4A-4A-5A	(0)	Band 4			4A-4A BCS 0				50
		Band 5			Yes	Yes			
4A-4A-12A	(0)	Band 4			4A-4A BCS 0				50
		Band 12			Yes	Yes			
5A-66A-66A	(0)	Band 5			Yes	Yes			50
		Band 66			66A-66A BCS 0				
5A-66C	(0)	Band 5			Yes	Yes			50
		Band 66			66C BCS 0				
12A-66A-66A	(0)	Band 12			Yes	Yes			50
		Band 66			66A-66A BCS 0				
26A-41C	(0)	Band 26			Yes	Yes	Yes		55
		Band 41			41C BCS 1				

3. DL Inter Band(4CC)

E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Bandwidth						Max Aggregated BW
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
2A-5A	(0)	Band 2			Yes	Yes	Yes	Yes	30
		Band 5			Yes	Yes			
		Band 5			Yes	Yes			

LTE Downlink Carrier Aggregation configurations (Continued)

1. DL Inter Band(2CC)

E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Bandwidth					Max Aggregated BW	
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz		20 MHz
4A-13A	(0)	Band 4			Yes	Yes	Yes	Yes	30
		Band 13				Yes			
4A-17A	(0)	Band 4			Yes	Yes			20
		Band 17			Yes	Yes			
5A-41A	(0)	Band 5			Yes	Yes			30
		Band 41					Yes		
5A-66A	(0)	Band 5			Yes	Yes			30
		Band 66			Yes	Yes	Yes	Yes	
12A-25A	(0)	Band 12			Yes	Yes			30
		Band 25			Yes	Yes	Yes	Yes	
12A-66A	(0)	Band 12			Yes	Yes			20
		Band 66	Yes	Yes	Yes	Yes			
	(1)	Band 12			Yes	Yes			30
		Band 66	Yes	Yes	Yes	Yes	Yes	Yes	
	(2)	Band 12		Yes	Yes	Yes			30
		Band 66			Yes	Yes	Yes	Yes	
	(3)	Band 12			Yes	Yes			20
		Band 66			Yes	Yes			
	(4)	Band 12			Yes	Yes			30
		Band 66			Yes	Yes	Yes	Yes	
Band 12				Yes	Yes				
(5)	Band 12			Yes	Yes			20	
	Band 66			Yes	Yes	Yes			
26A-41A	(0)	Band 26			Yes	Yes	Yes		35
		Band 41			Yes	Yes	Yes	Yes	

4 DL Intra Band(non-contiguous)

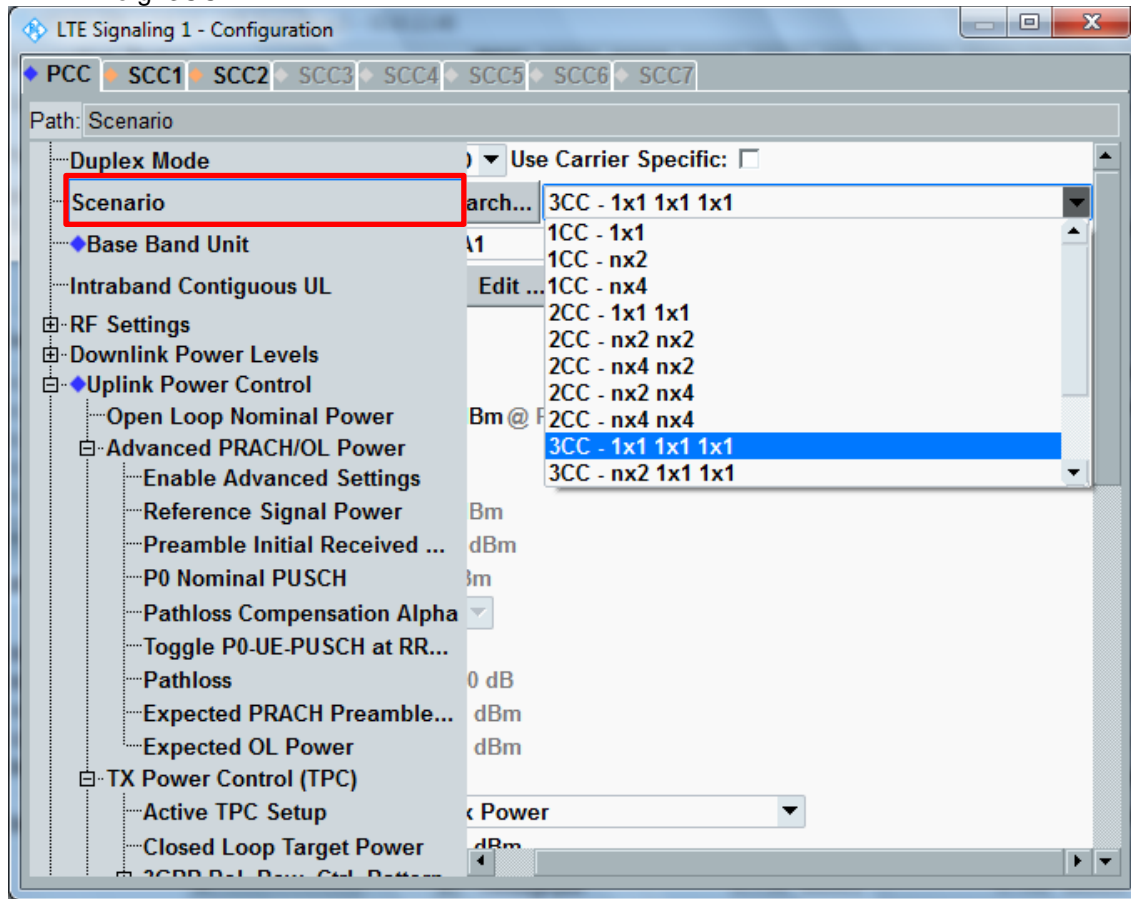
E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Allowed Channel BW Per Carrier (MHz)				max Aggregated BW
			1st Carrier	2nd Carrier	3rd Carrier	4th Carrier	
2A-2A	(0)	Band 2	5, 10, 15, 20	5, 10, 15, 20			40
4A-4A	(0)	Band 4	5, 10, 15, 20	5, 10, 15, 20			20
		Band 4	5, 10	5, 10			20
41A-41A	(0)	Band 41	10, 15, 20	10, 15, 20			40
		Band 41	5, 10, 15, 20	5, 10, 15, 20			40
66A-66A	(0)	Band 66	5, 10, 15, 20	5, 10, 15, 20			40
41A-41C	(0)	Band 41	41C BCS 1	5, 10, 15, 20			60
			41C BCS 0	5, 10, 15, 20			80
41A-41D	(0)	Band 41	41D BCS 0	5, 10, 15, 20			80
			41C BCS 0	5, 10, 15, 20			40

5. DL Intra Band(contiguous)

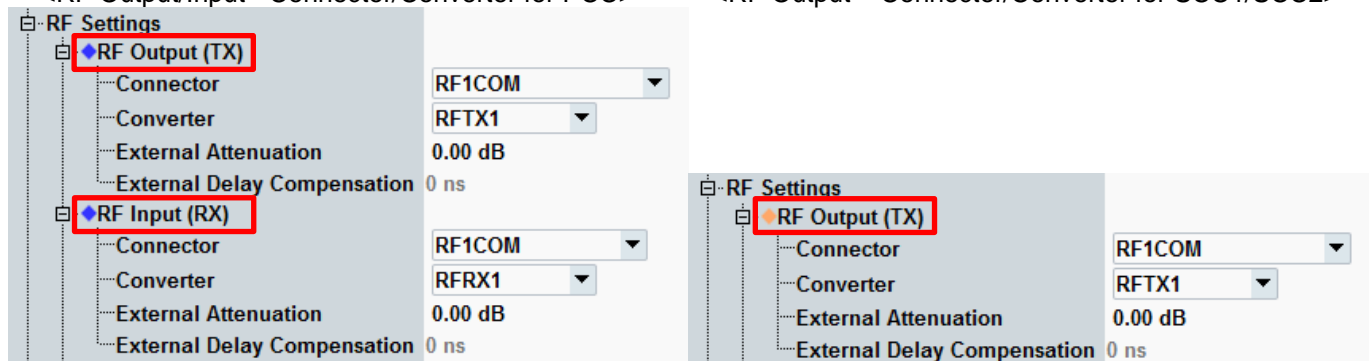
E-UTRA CA configuration	Bandwidth Combination Set	E-UTRA Band	Allowed Channel BW Per Carrier (MHz)					max Aggregated BW
			1st Carrier	2nd Carrier	3rd Carrier	4th Carrier	5th Carrier	
2C	(0)	Band 2	5	20				40
			10	15,20				
			15	10,15,20				
			20	5,10,15,20				
41C	(0)	Band 41	10	20				40
			15	15, 20				
			20	10, 15, 20				
	(1)	Band 41	5, 10	20				40
			15	15, 20				
			20	5, 10, 15, 20				
	(2)	Band 41	10	15, 20				40
			15	10, 15, 20				
			20	10, 15, 20				
	(3)	Band 41	10	20				40
20			20					
66B	(0)	Band 66	5	5, 10, 15				20
			10	5, 10				
			15	5				
66C	(0)	Band 66	5	20				40
			10	15, 20				
			15	10, 15, 20				
			20	5, 10, 15, 20				
41D	(0)	Band 41	10	20	15			60
			10	15, 20	20			
			15	20	10, 15			
			15	10, 15, 20	20			
			20	15, 20	10			
41E	(0)	Band 41	10, 15, 20	15, 20	15, 20	20		80
			15, 20	15, 20	20			

LTE Downlink Carrier Aggregation - Output Power measurement procedures

- Change the Scenario in the Configuration of LTE Signaling
e.g. 3CC – 1x1 1x1 1x1



- Set the RF Output/Input Connector and Converter for PCC/SCC1/SCC2 in each tab.
<RF Output/Input - Connector/Converter for PCC> <RF Output – Connector/Converter for SCC1/SCC2>



- Back to the LTE Signal screen, and then select the PCC tab, Set operating band, BW, channel and RB configurations for PCC

The screenshot displays the LTE Signaling 1 - X3.8.12.48 interface. At the top, the 'PCC' tab is selected and highlighted with a red box. Below the tab bar, the 'Connection Status' section shows 'Cell' with a signal strength indicator, 'Packet Switched' as 'Connection Established', 'RRC State' as 'Connected', and 'SCC1 State' and 'SCC2 State' as 'OFF'. The 'Event Log' section shows a series of events for SCC2 and SCC1. The 'UE Info' section displays IMEI, IMSI, Voice Domain Preference, and Default Bearer information. The main configuration area is divided into 'Downlink' and 'Uplink' sections. The 'Downlink' section shows 'Operating Band' as 'Band 66', 'Channel' as '67036 Ch', 'Frequency' as '2170.0 MHz', and 'Cell Bandwidth' as '20.0 MHz'. The 'Uplink' section shows 'Channel' as '132572 Ch', 'Frequency' as '1770.0 MHz', and 'Cell Bandwidth' as '20.0 MHz'. The 'Sched.' dropdown is set to 'User def. Channels'. The 'Throughput' section shows 'Downlink' as '8.734 Mbit/s' and 'Uplink' as '0.144 Mbit/s'. The 'LTE Signaling' button is highlighted in blue with 'ON' in yellow. At the bottom, there are buttons for 'Detach', 'Disconnect', 'SCC1 activate MAC', 'Multiple SCC Actions', 'Send SMS', 'Inter/Intra-RAT ...', and 'Config ...'.

- Select the SCC1/SCC2 tab, set operating band, BW, channel and RB configurations for SCC1/SCC2

CMW 500 V 3.8.12 - LTE Signaling 1 - X3.8.12.48

Connection Status

Cell: Connection Established

Packet Switch...: Connection Established

RRC State: Connected

SCC1 State: OFF

SCC2 State: OFF

Event Log

- 06:36:17 SCC2: Off
- 06:36:17 SCC2: On
- 06:36:17 SCC2: RRC Added
- 06:36:16 SCC1: Off
- 06:36:16 SCC1: On
- 06:36:16 SCC1: RRC Added
- 06:36:12 SCC2: MAC Activated

UE Info

IMEI: 355346630026654

IMSI: 001010123456063

Voice Domain ...: IMS PS Voice preferred CS

UE's Usage S...: Data centric

Default Bearer: IPv4 address IPv6 prefix 192.168.48.129

Dedicated Be...: TFT Port Range DL / UL 5005 - 5008 / 5005 - 5008

Operating Band: Co-location active with PCC FDD

Channel: 66536 Ch

Frequency: 2120.0 MHz

Cell Bandwidth: 20.0 MHz

RS EPRE: -85.0 dBm/15kHz

Full Cell BW Pow.: -54.2 dBm

PCC <-> SCC1 Swap

PCC -> SCC1 Copy

Sched.: User def. Channels

RB: 100

Start RB: 0

Mod / TBSI: QPSK 5

Code Rate / TBS: 0.330 8760

Throughput: 8.734 Mbit/s

Downlink Multicliaster

LTE Signaling ON

Buttons: Detach, Disconnect, SCC1 activate MAC, Multiple SCC Actions, Send SMS, Inter/Intra-RAT ..., Config ...

CMW 500 V 3.8.12 - LTE Signaling 1 - X3.8.12.48

Connection Status

Cell: Connection Established

Packet Switch...: Connection Established

RRC State: Connected

SCC1 State: OFF

SCC2 State: OFF

Event Log

- 06:36:17 SCC2: Off
- 06:36:17 SCC2: On
- 06:36:17 SCC2: RRC Added
- 06:36:16 SCC1: Off
- 06:36:16 SCC1: On
- 06:36:16 SCC1: RRC Added
- 06:36:12 SCC2: MAC Activated

UE Info

IMEI: 355346630026654

IMSI: 001010123456063

Voice Domain ...: IMS PS Voice preferred CS

UE's Usage S...: Data centric

Default Bearer: IPv4 address IPv6 prefix 192.168.48.129

Dedicated Be...: TFT Port Range DL / UL 5005 - 5008 / 5005 - 5008

Operating Band: Band 71 FDD

Channel: 68761 Ch

Frequency: 634.5 MHz

Cell Bandwidth: 20.0 MHz

RS EPRE: -85.0 dBm/15kHz

Full Cell BW Pow.: -54.2 dBm

PCC <-> SCC2 Swap

PCC -> SCC2 Copy

Sched.: User def. Channels

RB: 100

Start RB: 0

Mod / TBSI: QPSK 5

Code Rate / TBS: 0.330 8760

Throughput: 8.734 Mbit/s

Downlink Multicliaster

LTE Signaling ON

Buttons: Detach, Disconnect, SCC2 activate MAC, Multiple SCC Actions, Send SMS, Inter/Intra-RAT ..., Config ...

- Connect and Activate MAC for all SCCs

Multiple SCC Actions

SCC	State	Action
SCC1	OFF	activate MAC
SCC2	OFF	activate MAC

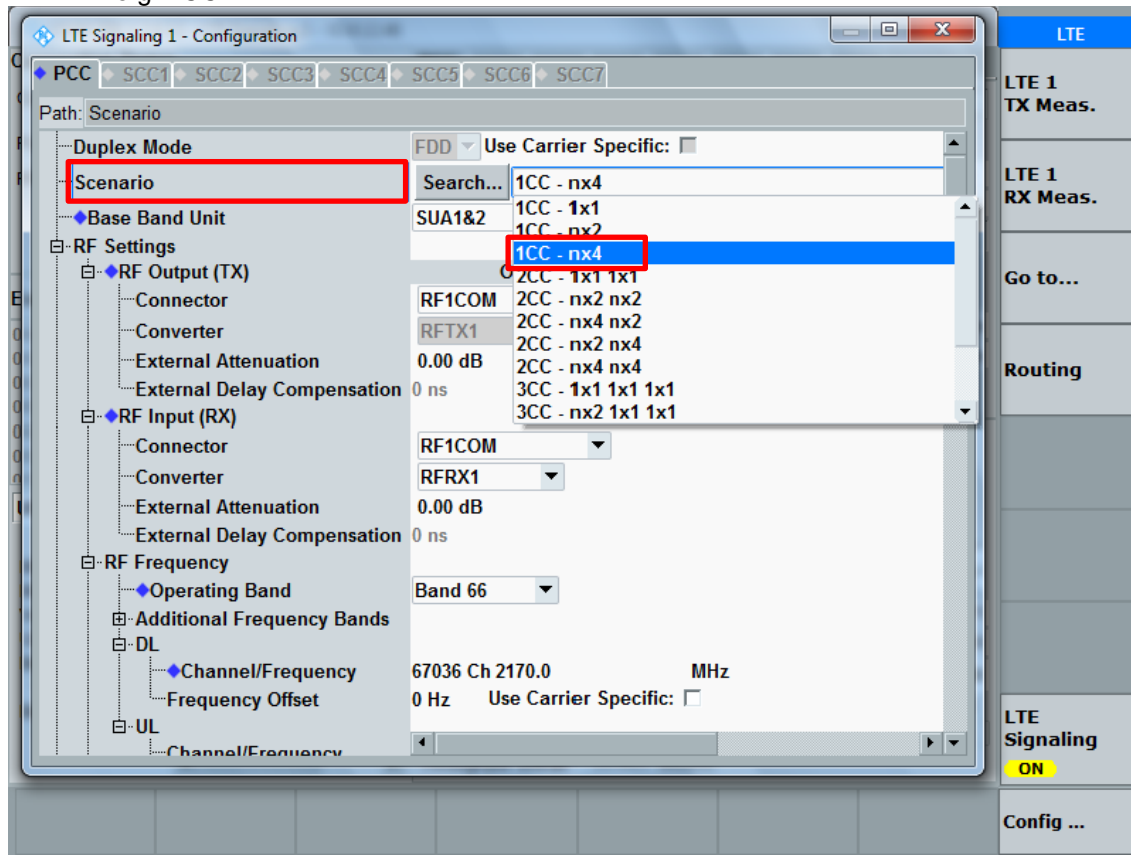
- Read the output power of DL CA in TX Measurement (LTE Tx Meas.)

TX Measurement

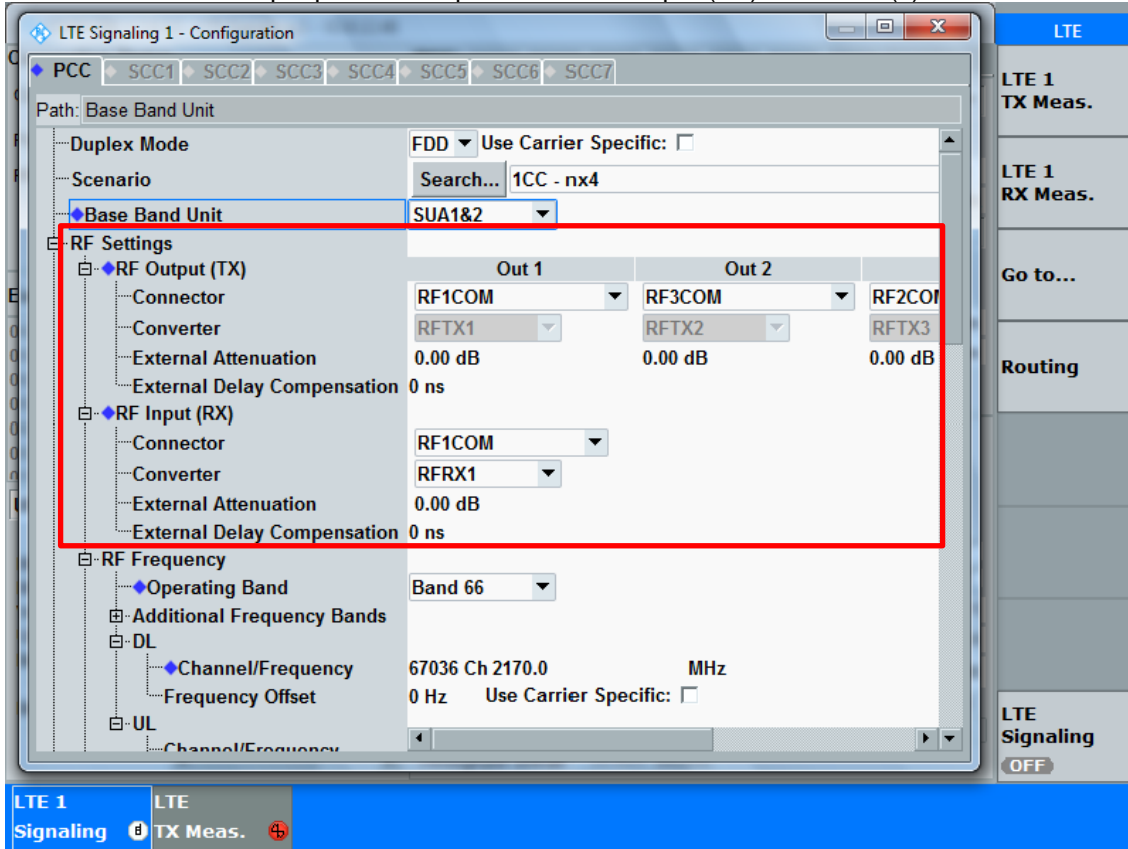
	Current	Average	Extreme	StdDev
EVM RMS [%] I/h	0.64	0.71	0.83	0.04
EVM Peak [%] I/h	1.51	2.23	3.27	0.38
EVM DMRS [%] I/h	0.61	0.60	1.02	0.10
MErr RMS [%] I/h	NCAP	NCAP	NCAP	NCAP
MErr Peak [%] I/h	NCAP	NCAP	NCAP	NCAP
MErr DMRS [%] I/h	NCAP	NCAP	NCAP	NCAP
PhErr RMS [°] I/h	NCAP	NCAP	NCAP	NCAP
PhErr Peak [°] I/h	NCAP	NCAP	NCAP	NCAP
PhErr DMRS [°] I/h	NCAP	NCAP	NCAP	NCAP
IQ Offset [dBc]	-52.22	-52.32	-49.92	0.85
IQ Gain Imbalance [dB]	NCAP	NCAP	NCAP	NCAP
IQ Quadrature Error [°]	NCAP	NCAP	NCAP	NCAP
Freq Error [Hz]	0.51	0.09	-5.38	1.33
Timing Error [Ts]	-6.30	-5.63	-8.52	2.54
OBW [MHz]	0.27	0.27	0.32	0.02
	Current	Average	Min	Max
TX Power [dBm]	13.51	13.48	13.30	13.59
Peak Power [dBm]	18.40	18.60	17.80	19.50
RB Power [dBm]	13.48	13.46	13.37	13.50

LTE Downlink 4x4 MIMO - Output Power measurement procedures

- Change the Scenario in the Configuration of LTE Signaling
e.g. 1CC – nx4



- Set the RF Output/Input Connector and Converter for PCC.
DL MIMO output ports correspond with RF Output (TX) Connector(s).



- Back to the LTE Signal screen, set operating band, BW, channel and RB configurations for PCC

- Check the Throughput of DL 4x4 MIMO in LTE Rx Measurement.

RLC Throughput

Overall | PCC | SCC1 | SCC2 | SCC3 | SCC4

Throughput (Mbit/s) vs Subframes

	Over All		Stream 1		Stream 2	
	Relative	Absolute	Relative	Absolute	Relative	Absolute
ACK	99.99%	19598	99.99%	9799	99.99%	9799
NACK	0.01%	2	0.01%	1	0.01%	1
DTX	0.00%	0	0.00%	0	0.00%	0
BLER	0.01%		0.01%		0.01%	
Throughput	Relative	Mbit/s	Relative	Mbit/s	Relative	Mbit/s
Average	99.99%	17.47	99.99%	8.73	99.99%	8.73
Minimum		17.38				
Maximum		17.47				

Subframes: 9800 | Scheduled: 9800 | Median CQI PCC: Stream 1 ----

PS: Connection Established | RRC State: Connected

- Read the output power of DL CA in TX Measurement (LTE Tx Meas.)

TX Measurement

FDD Freq.: 1770.0 MHz Ref. Level: 41.00 dBm BW: 20.0 MHz CP: Normal Meas Subfr/Slot: 0 / All

	Current	Average	Extreme	StdDev
EVM RMS [%] I/h	0.64	0.71	0.83	0.04
EVM Peak [%] I/h	1.51	2.23	3.27	0.38
EVM DMRS [%] I/h	0.61	0.60	1.02	0.10
MErr RMS [%] I/h	NCAP	NCAP	NCAP	NCAP
MErr Peak [%] I/h	NCAP	NCAP	NCAP	NCAP
MErr DMRS [%] I/h	NCAP	NCAP	NCAP	NCAP
PhErr RMS [°] I/h	NCAP	NCAP	NCAP	NCAP
PhErr Peak [°] I/h	NCAP	NCAP	NCAP	NCAP
PhErr DMRS [°] I/h	NCAP	NCAP	NCAP	NCAP
IQ Offset [dBc]	-52.22	-52.32	-49.92	0.85
IQ Gain Imbalance [dB]	NCAP	NCAP	NCAP	NCAP
IQ Quadrature Error [°]	NCAP	NCAP	NCAP	NCAP
Freq Error [Hz]	0.51	0.09	-5.38	1.33
Timing Error [Ts]	-6.30	-5.63	-8.52	2.54
OBW [MHz]	0.27	0.27	0.32	0.02
	Current	Average	Min	Max
TX Power [dBm]	13.51	13.48	13.30	13.59
Peak Power [dBm]	18.40	18.60	17.80	19.50
RB Power [dBm]	13.48	13.46	13.37	13.50

Statistic Count: 100 / 100 | Out of Tolerance: 0.00% | Detected Modulation: QPSK | Detected Channel Type: PUSCH | View Filter Throughput: 100.0%

PS: Connection Established | RRC State: Connected

LTE Downlink Carrier Aggregation Combinations

The DL CA power measurement conditions for various CC's combinations were determined according LTE DL CA SAR Test Exclusion guidance in TCB workshop note (April 2018). Only yellow highlighted cells need power measurement. The following power measurements were performed with a single carrier uplink; CA for this particular project only supports one (1) uplink and up to four (4) downlinks.

LTE Release 10 Carrier Aggregation

Index	2CC	Restriction	Completely Covered by Measurement Superset
2CC#1	2A-2A		
2CC#2	2C		
2CC#3	2A-4A		3CC#1
2CC#4	2A-5A		3CC#1
2CC#5	2A-12A		
2CC#6	2A-13A		3CC#2
2CC#7	2A-17A		
2CC#8	2A-26A		
2CC#9	2A-66A		3CC#4
2CC#10	4A-4A		3CC#5
2CC#11	4A-5A		3CC#5
2CC#12	4A-12A		3CC#6
2CC#13	4A-13A		3CC#2
2CC#14	4A-17A	B17 SCC Only	
2CC#15	5A-41A	B41 SCC Only	
2CC#16	5A-66A		3CC#7
2CC#17	12A-25A		
2CC#18	12A-66A		3CC#9
2CC#19	26A-41A	B41 SCC Only	
2CC#20	41A-41A		
2CC#21	41C		3CC#11
2CC#22	66A-66A		3CC#9
2CC#23	66B		
2CC#24	66C		3CC#8

Index	3CC	Restriction	Completely Covered by Measurement Superset
3CC#1	2A-4A-5A		
3CC#2	2A-4A-13A		
3CC#3	2A-5A-66A		
3CC#4	2A-66A-66A		
3CC#5	4A-4A-5A		
3CC#6	4A-4A-12A		
3CC#7	5A-66A-66A		
3CC#8	5A-66C		
3CC#9	12A-66A-66A		
3CC#10	26A-41C	B41 SCC Only	
3CC#11	41A-41C		
3CC#12	41D		4CC#1

Index	4CC	Restriction	Completely Covered by Measurement Superset
4CC#1	41A-41D		
4CC#2	41C-41C		
4CC#3	41E		

Note: Only yellow highlight cells need power measurement according to LTE DL CA SAR test Exclusion in TCB workshop (April.2018).

LTE Release 10 Carrier Aggregation

Index	5CC	Restriction	Completely Coveredby Measurement Superset
5CC#1	41C-41D		

Note:

Only yellow highlight cells need power measurement according to LTE DL CA SAR test Exclusion in TCB workshop (April.2018).

LTE Release 10 Carrier Aggregation with 4x4 MIMO

Index	2CC	Restriction	Completely Covered by Measurement Superset
2CC#1	2A-[4A]		3CC#1
2CC#2	2A-[66A]		3CC#3
2CC#3	[4A]-4A		3CC#6
2CC#4	[4A]-[4A]		3CC#7
2CC#5	[4A]-5A		3CC#7
2CC#6	[4A]-12A		3CC#8
2CC#7	[4A]-13A		
2CC#8	[4A]-17A	B17 SCC Only	
2CC#9	5A-[66A]		3CC#3
2CC#10	12A-[66A]		3CC#13
2CC#11	26A-[41A]	B41 SCC Only	
2CC#12	[41A]-41A		
2CC#13	[41A]-[41A]		
2CC#14	[41C]		3CC#17
2CC#15	[66A]-66A		3CC#12
2CC#16	[66A]-[66A]		3CC#13
2CC#17	[66B]		
2CC#18	[66C]		3CC#11

Index	3CC	Restriction	Completely Covered by Measurement Superset
3CC#1	2A-[4A]-5A		
3CC#2	2A-[4A]-13A		
3CC#3	2A-5A-[66A]		
3CC#4	2A-[66A]-66A		
3CC#5	2A-[66A]-[66A]		
3CC#6	[4A]-4A-5A		
3CC#7	[4A]-[4A]-5A		
3CC#8	[4A]-4A-12A		
3CC#9	5A-[66A]-66A		
3CC#10	5A-[66A]-[66A]		
3CC#11	5A-[66C]		
3CC#12	12A-[66A]-66A		
3CC#13	12A-[66A]-[66A]		
3CC#14	26A-[41C]	B41 SCC Only	
3CC#15	[41A]-41C		
3CC#16	41A-[41C]		
3CC#17	[41A]-[41C]		
3CC#18	[41D]		4CC#3

Index	4CC	Restriction	Completely Covered by Measurement Superset
4CC#1	[41A]-41D		
4CC#2	41A-[41D]		
4CC#3	[41A]-[41D]		
4CC#4	[41C]-41C		
4CC#5	[41C]-[41C]		
4CC#6	[41E]		

Note:

Only yellow highlight cells need power measurement according to LTE DL CA SAR test Exclusion in TCB workshop (April.2018).

LTE Release 10 Carrier Aggregation with 4x4 MIMO

Index	5CC	Restriction	Completely Covered by Measurement Superset
5CC#1	[41C]-41D		
5CC#2	41C-[41D]		
5CC#3	[41C]-[41D]		

Note:

Only yellow highlight cells need power measurement according to LTE DL CA SAR test Exclusion in TCB workshop (April.2018).

Single Carrier Downlink 4x4 MIMO output power results

LTE Bands	Modulation	BW (MHz)	Channel	Freq. (MHz)	RB/Offset	LTE Rel 8 Tx. Power [dBm]	DL 4x4 MIMO Tx. Power [dBm]	Delta
4	QPSK	20	20175	1732.5	1/49	23.82	23.8	-0.02
41	QPSK	20	39750	2506	1/0	24.48	24.43	-0.05
66	QPSK	20	132072	1720	1/49	23.79	23.75	-0.04

Note:

According to LTE Test Conditions in TCB workshop (May, 2017), SAR is excluded for LTE downlink 4x4 MIMO operation when uplink output with DL MIMO does not exceed highest uplink output power configuration without DL MIMO by more than 1/4 dB. And for DL MIMO with carrier aggregation, the same SAR test exclusion procedure is considered.

