

LTE Downlink Carrier Aggregation configurations**1. DL Intra Band(contiguous)**

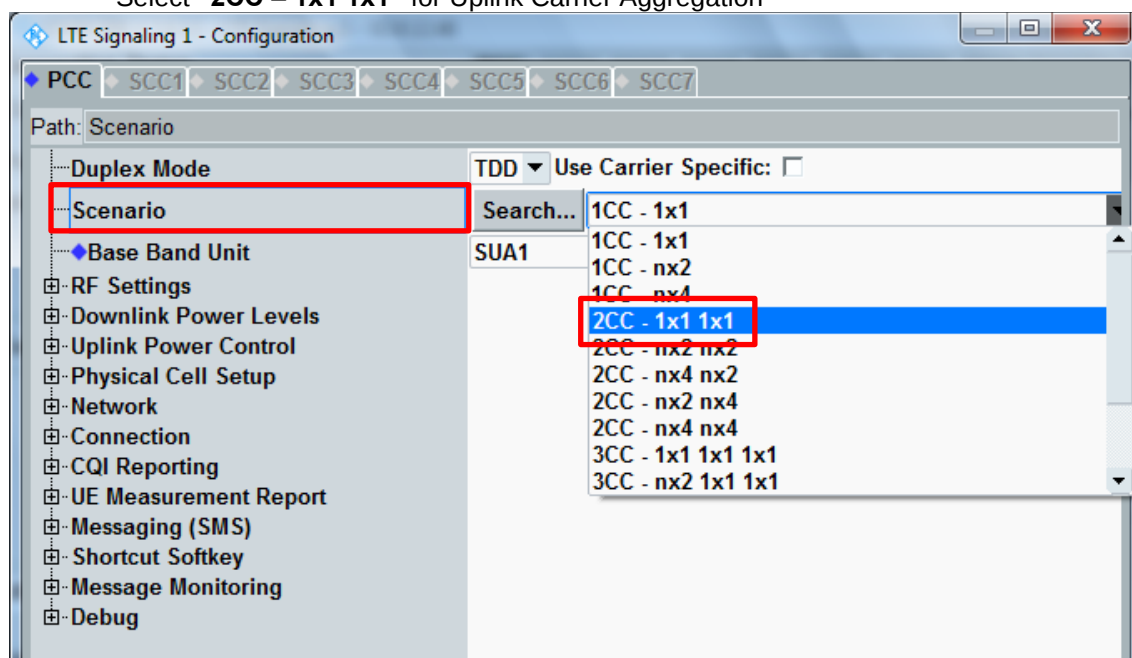
E-UTRA CA configuration	Bandwidth Combination	E-UTRA Band	Allowed Channel BW Per Carrier (MHz)					Max Aggregated BW
			1st Carrier	2nd Carrier	3rd Carrier	4th Carrier	5th Carrier	
41C	(0)	Band 41	10	20				40
			15	15, 20				
			20	10, 15, 20				
	(1)	Band 41	5, 10	20				40
			15	15, 20				
			20	5,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

Note:

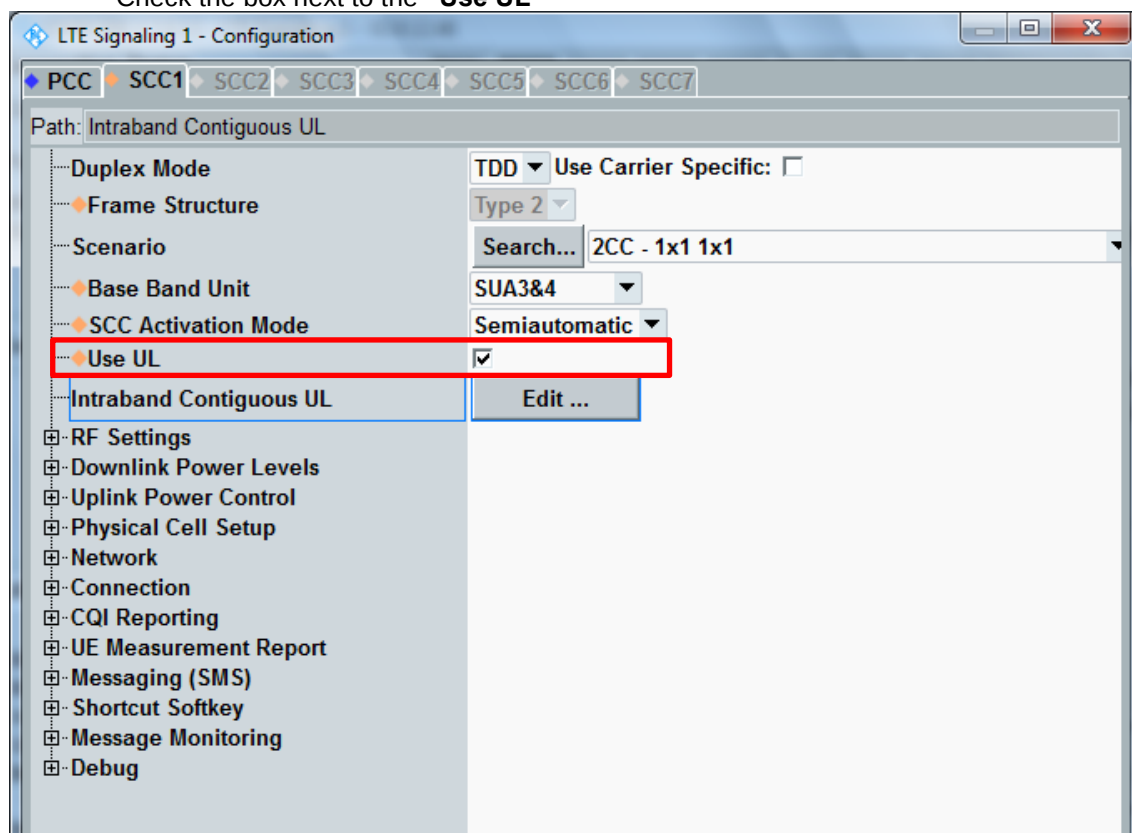
LTE CA_41C are supported in both Uplink and Downlink, other CA configurations are supported only Downlink.

LTE Uplink Carrier Aggregation – Output Power measurement procedures

- Change the Scenario in the Configuration of LTE Signaling
Select **“2CC – 1x1 1x1”** for Uplink Carrier Aggregation



- Check the box next to the **“Use UL”**



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

The screenshot shows the 'LTE Signaling 1' interface with the 'PCC' tab selected. The 'Connection Status' section on the left shows 'Cell' as 'ON', 'Packet Switched' as 'ON', 'RRC State' as 'Idle', and 'SCC1 State' as 'OFF'. The 'Event Log' shows a sequence of events from 06:13:39 to 06:13:20. The 'UE Info' section shows fields for IMEI, IMSI, Voice Domain Pr..., UE's Usage Setti..., Default Bearer, and Dedicated Bearer. The main configuration area shows the following settings:

Parameter	Value
Operating Band	Band 41
Channel	40620 Ch
Frequency	2593.0 MHz
Cell Bandwidth	20.0 MHz
RS EPRE	-85.0 dBm/15kHz
Full Cell BW Pow.	-54.2 dBm
PUSCH Open Loop Nom.Power	23 dBm
PUSCH Closed Loop Target Power	24.0 dBm
Sched.	User def. Channels
# RB	100
Start RB	0
Mod / TBSI	QPSK 5
Code Rate / TBS	0.328 8760 0.583 144
Throughput	3.478 Mbit/s 0.057 Mbit/s

The 'LTE Signaling' status is 'ON'. The 'Config ...' button is visible at the bottom right.

- Select the SCC1 tab,
Set operating band, BW, channel, and RB configurations for SCC1

The screenshot shows the 'LTE Signaling 1' interface with the 'SCC1' tab selected. The 'Connection Status' section on the left shows 'Cell' as 'ON', 'Packet Switched' as 'ON', 'RRC State' as 'Idle', and 'SCC1 State' as 'OFF'. The 'Event Log' shows a sequence of events from 06:13:39 to 06:13:20. The 'UE Info' section shows fields for IMEI, IMSI, Voice Domain ..., UE's Usage S..., Default Bearer, and Dedicated Be... The main configuration area shows the following settings:

Parameter	Value
Operating Band	Band 41
Channel	40818 Ch
Frequency	2612.8 MHz
Cell Bandwidth	20.0 MHz
RS EPRE	-85.0 dBm/15kHz
Full Cell BW Pow.	-54.2 dBm
PUSCH Open Loop Nom.Power	23 dBm
PUSCH Closed Loop Target Power	24.0 dBm
Sched.	User def. Channels
# RB	100
Start RB	0
Mod / TBSI	QPSK 5
Code Rate / TBS	0.328 8760 0.583 144
Throughput	3.478 Mbit/s 0.057 Mbit/s

The 'LTE Signaling' status is 'ON'. The 'Config ...' button is visible at the bottom right.

- Click the **“Connect”** button at the bottom of the screen, if necessary, turn the Airplane mode on/off in the DUT

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

Connection Status

Cell:  Connection Established

RRC State: Connected

SCC1 State: MAC Activated

Event Log

06:16:44 State 'Connection Established'

06:16:44 EPS Dedicated Bearer Establish

06:16:43 SCC1: MAC Activated

06:16:41 SCC1: RRC Added

06:16:41 SCC1: On

06:16:30 SCC1: Off

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

5 (cmw50... 192.168.48.129

Dedicated Be... TFT Port Range DL / UL

6 (->5, Def... 5005 - 5008 / 5005 - 5008

Operating Band Band 41 TDD

Downlink

Channel: 40818 Ch

Frequency: 2612.8 MHz

Cell Bandwidth: 20.0 MHz

RS EPRE: -85.0 dBm/15kHz

Full Cell BW Pow.: -54.2 dBm

PUSCH Open Loop Norm.Power: 23 dBm

PUSCH Closed Loop Target Power: 24.0 dBm

PCC <-> SCC1 Swap

PCC -> SCC1 Copy

Sched. User def. Channels Multicliuser UL

64/256-QAM

Downlink Multicliuser Uplink

RB: 100 1

Start RB: 0 0

Mod / TBSI: QPSK 5 QPSK 10

Code Rate / TBS: 0.328 8760 0.583 144

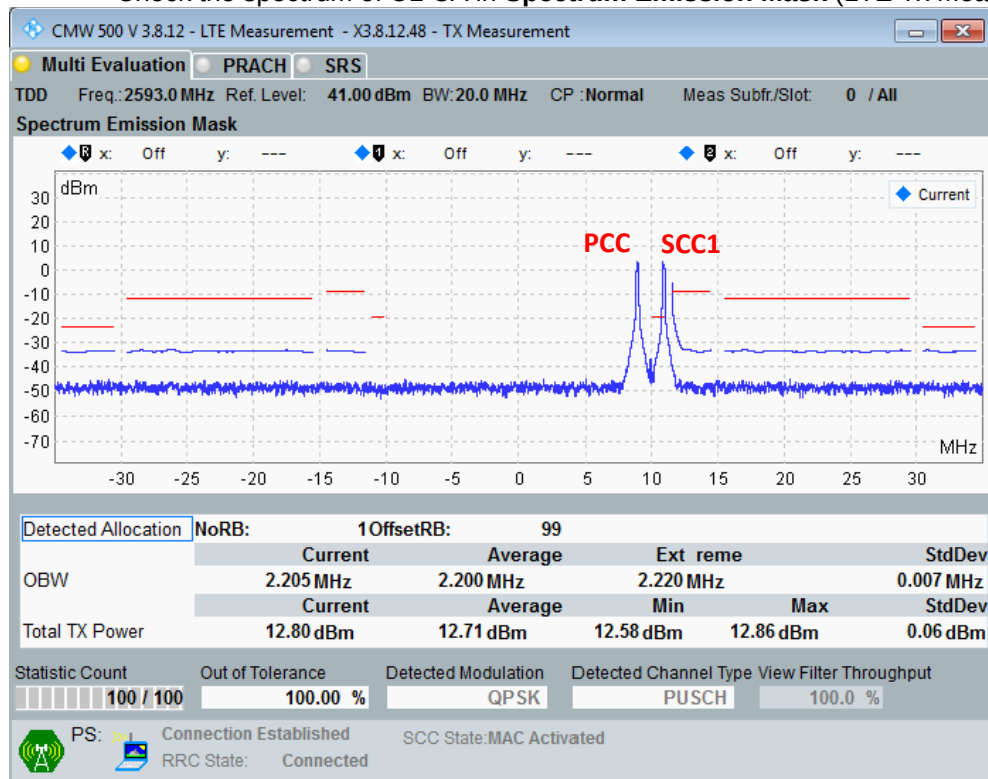
Throughput: 3.478 Mbit/s 0.057 Mbit/s

LTE Signaling ON

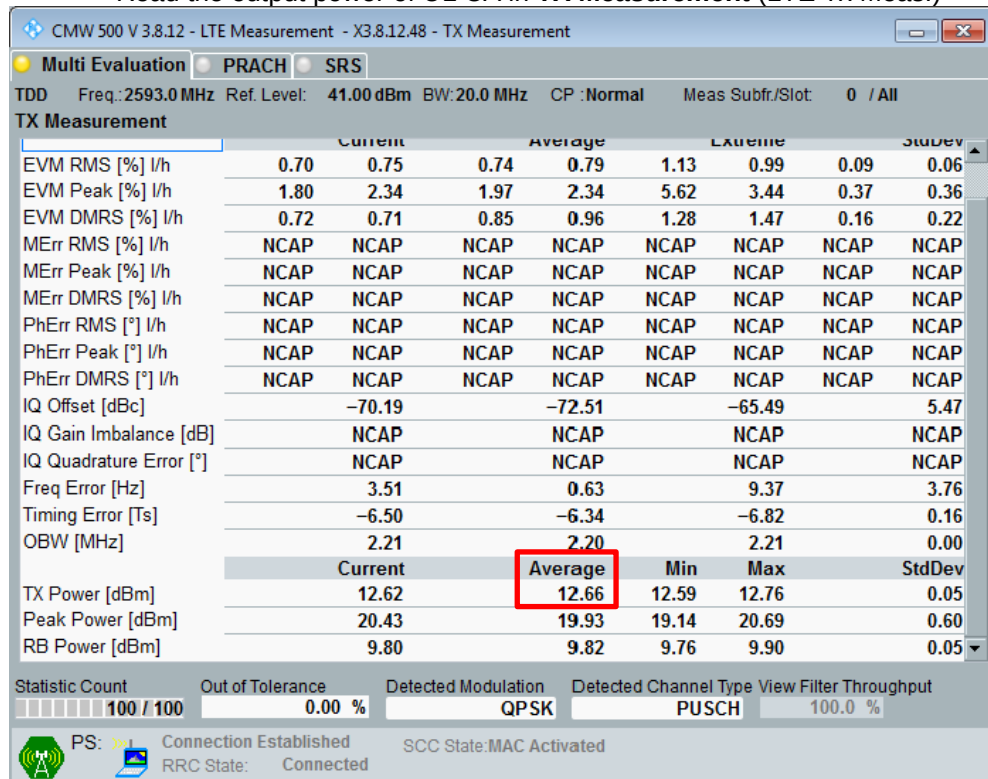
Disconnect SCC1 Off

Send SMS Inter/Intra-RAT ... Config ...

- Check the spectrum of UL CA in **Spectrum Emission Mask** (LTE Tx Meas.)

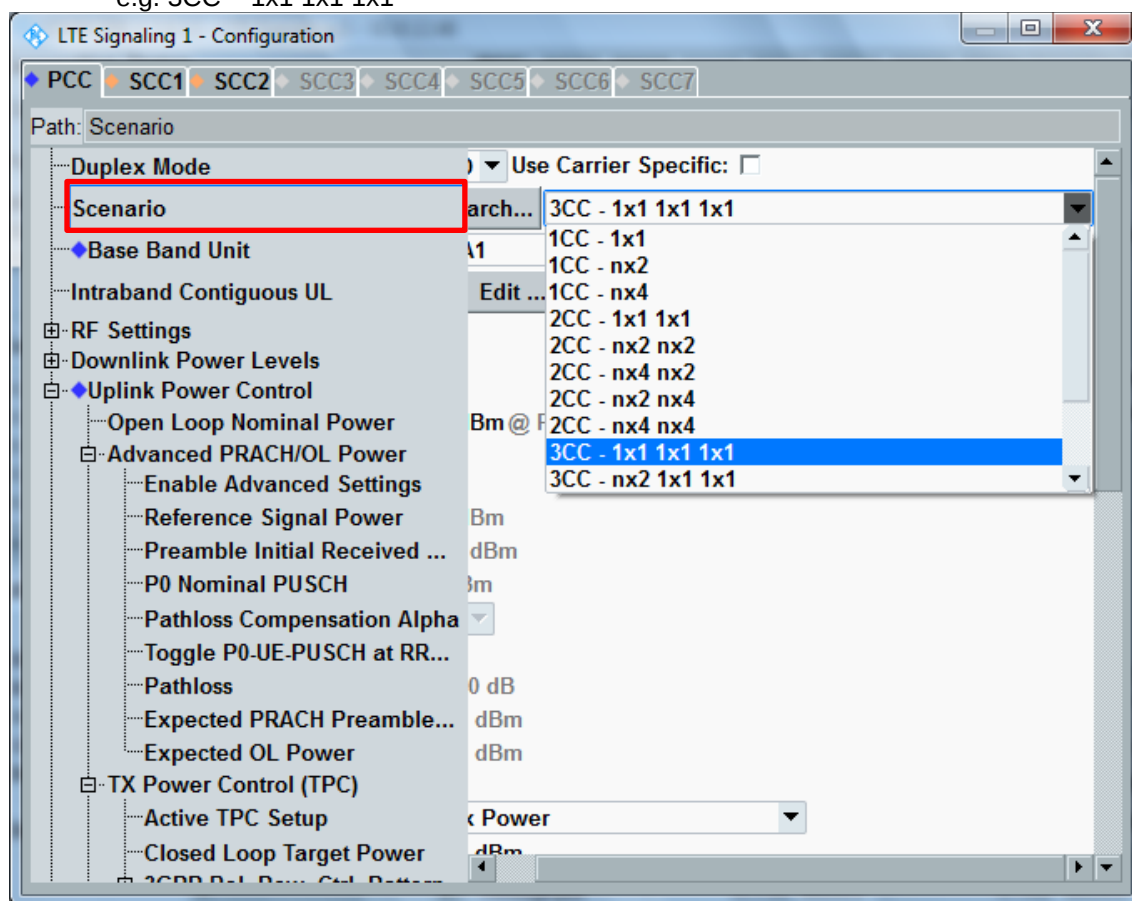


- Read the output power of UL CA in **TX Measurement** (LTE Tx Meas.)

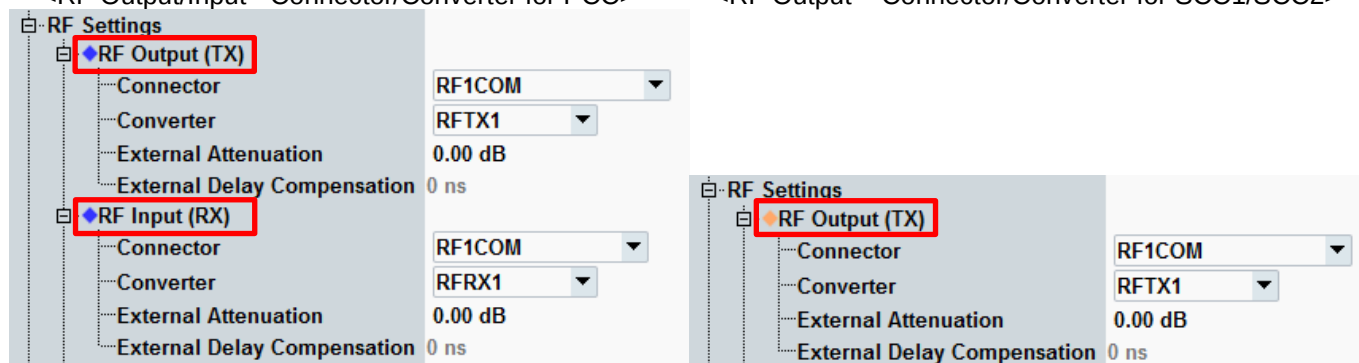


LTE Downlink Carrier Aggregation - Output Power measurement procedures

- 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

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

Connection Status

Cell:  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 Pr...: IMS PS Voice preferred CS Voi
 UE's Usage Setti...: Data centric
 Default Bearer: IPv4 address IPv6 prefix
 ...5 (cmw500.r...: 192.168.48.129
 Dedicated Bearer: TFT Port Range DL / UL
 ...6 (->5, Default): 5005 - 5008 / 5005 - 5008

Operating Band: Band 66 FDD

Channel: 67036 Ch 132572 Ch

Frequency: 2170.0 MHz 1770.0 MHz

Cell Bandwidth: 20.0 MHz 20.0 MHz

RS EPRE: -85.0 dBm/15kHz

Full Cell BW Pow.: -54.2 dBm

PUSCH Open Loop Nom.Power: 23 dBm

PUSCH Closed Loop Target Power: 24.0 dBm

Sched.: User def. Channels

Downlink Multicenter: ☐ Uplink Multicenter: ☐

RB: 100 1

Start RB: 0 0

Mod / TBSI: QPSK 5 QPSK 10

Code Rate / TBS: 0.330 8760 0.583 144

Throughput: 8.734 Mbit/s 0.144 Mbit/s

64/256-QAM: ☐ **Multicenter**: ☐

LTE Signaling: ON

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

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
5 (cmw50...) 192.168.48.129
Dedicated Be... TFT Port Range DL / UL
6 (->5, Def... 5005 - 5008 / 5005 - 5008

Operating Band: Co-location active with PCC
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

Downlink: Multicliaster ☐
RB: 100
Start RB: 0
Mod / TBSI: QPSK 5
Code Rate / TBS: 0.330 8760
Throughput: 8.734 Mbit/s

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

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
5 (cmw50...) 192.168.48.129
Dedicated Be... TFT Port Range DL / UL
6 (->5, Def... 5005 - 5008 / 5005 - 5008

Operating Band: Band 71
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

Downlink: Multicliaster ☐
RB: 100
Start RB: 0
Mod / TBSI: QPSK 5
Code Rate / TBS: 0.330 8760
Throughput: 8.734 Mbit/s

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

- Connect and Activate MAC for all SCCs

The screenshot shows the CMW 500 V 3.8.12 - LTE Signaling 1 - X3.8.12.48 interface. The 'Connection Status' tab is active, showing the PCC and SCC1, SCC2, SCC3, SCC4, SCC5, SCC6, and SCC7 tabs. The 'Operating Band' is set to Band 71, and the 'Downlink' and 'Uplink' are both set to FDD. The 'Channel' is 68761 Ch, 'Frequency' is 634.5 MHz, 'Cell Bandwidth' is 20.0 MHz, 'RS EPRE' is -85.0 dBm/15kHz, and 'Full Cell BW Pow.' is -54.2 dBm. The 'Event Log' shows the following events:

- 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

The 'UE Info' tab shows the following information:

- IMEI: 355346630026654
- IMSI: 001010123456063
- Voice Domain: IMS PS Voice prefer
- UE's Usage: Data centric
- Default Bearer: IPv4 address IPv6
- 5 (cmw50...): 192.168.48.129
- Dedicated Be...: TFT Port Range DL
- 6 (->5, Def...): 5005 - 5008 / 500

The 'Multiple SCC Actions' dialog box is open, showing the following actions:

- activate MAC (highlighted in red)
- activate MAC (highlighted in red)
- SynSet A ---
- SCC1 SCC2
- SynSet B ---
- SCC1 SCC2

The 'Multiple SCC Actions' button is highlighted in red. The 'LTE Signaling' status is ON.

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

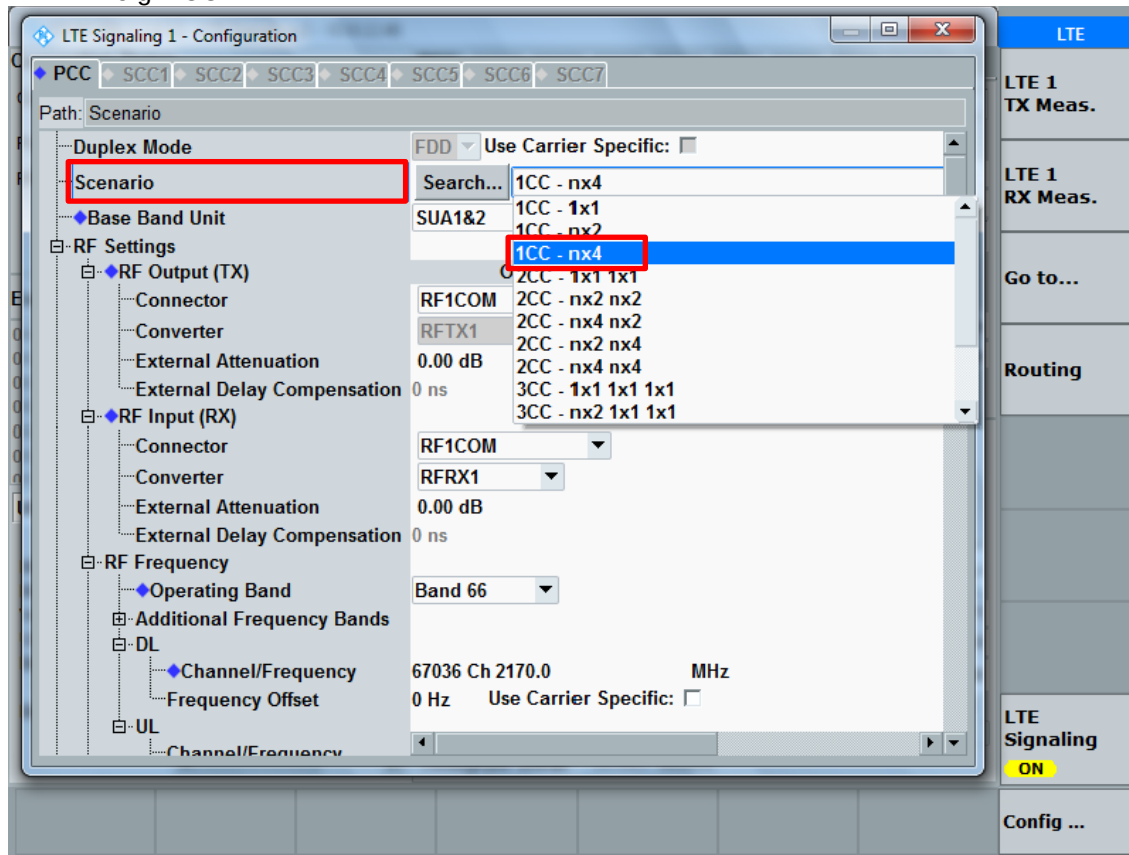
The screenshot shows the CMW 500 V 3.8.12 - LTE Measurement - X3.8.12.48 - TX Measurement interface. The 'Multi Evaluation' tab is active, showing the 'PRACH' and 'SRS' tabs. The 'FDD' frequency is 1770.0 MHz, 'Ref. Level' is 41.00 dBm, 'BW' is 20.0 MHz, 'CP' is Normal, and 'Meas Subfr/Slot' is 0 / All. The 'TX Measurement' table shows the following results:

	Current	Average	Extreme	StdDev
EVM RMS [%] I/h	0.64	0.71	0.68	0.71
EVM Peak [%] I/h	1.51	2.64	1.96	2.23
EVM DMRS [%] I/h	0.61	0.65	0.61	0.60
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

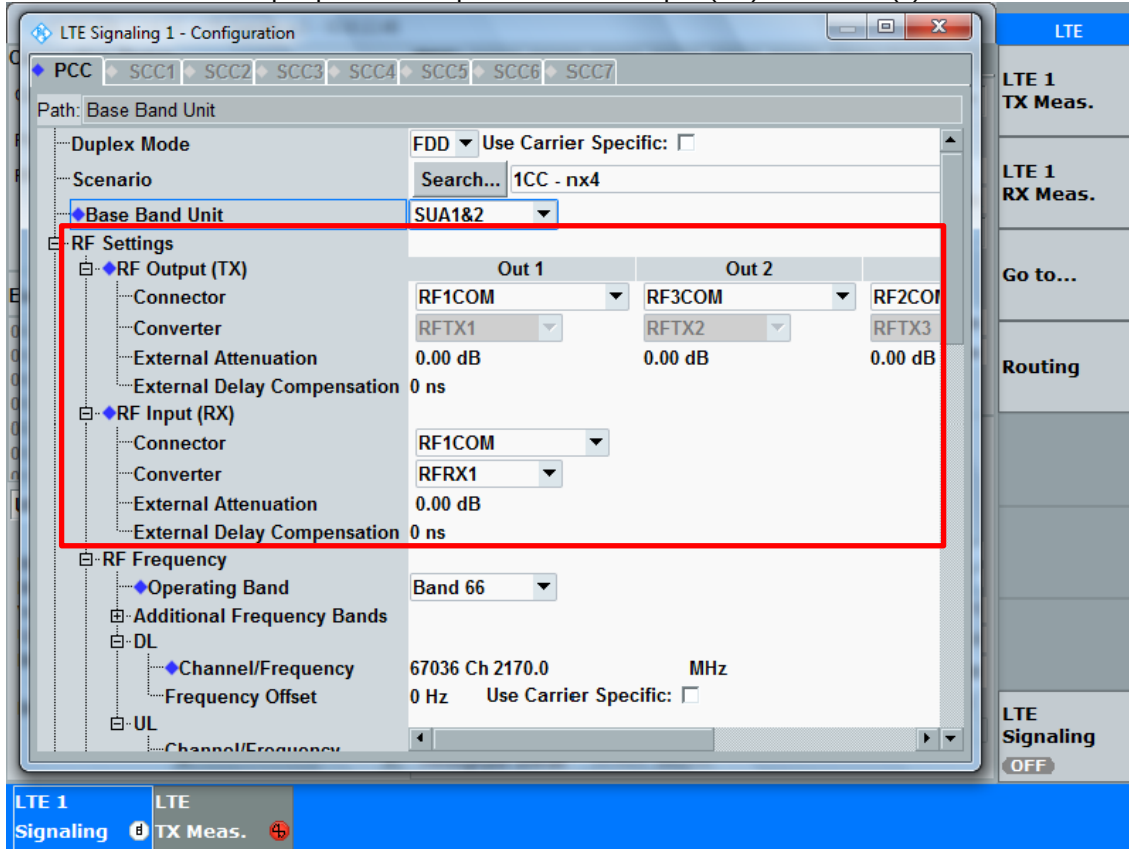
The 'Average' value for TX Power is highlighted in red. The 'Statistic Count' is 100 / 100, 'Out of Tolerance' is 0.00 %, 'Detected Modulation' is QPSK, 'Detected Channel Type' is PUSCH, and 'View Filter Throughput' is 100.0 %. The 'LTE Signaling' status is ON.

LTE Downlink 4x4 MIMO - Output Power measurement procedures

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

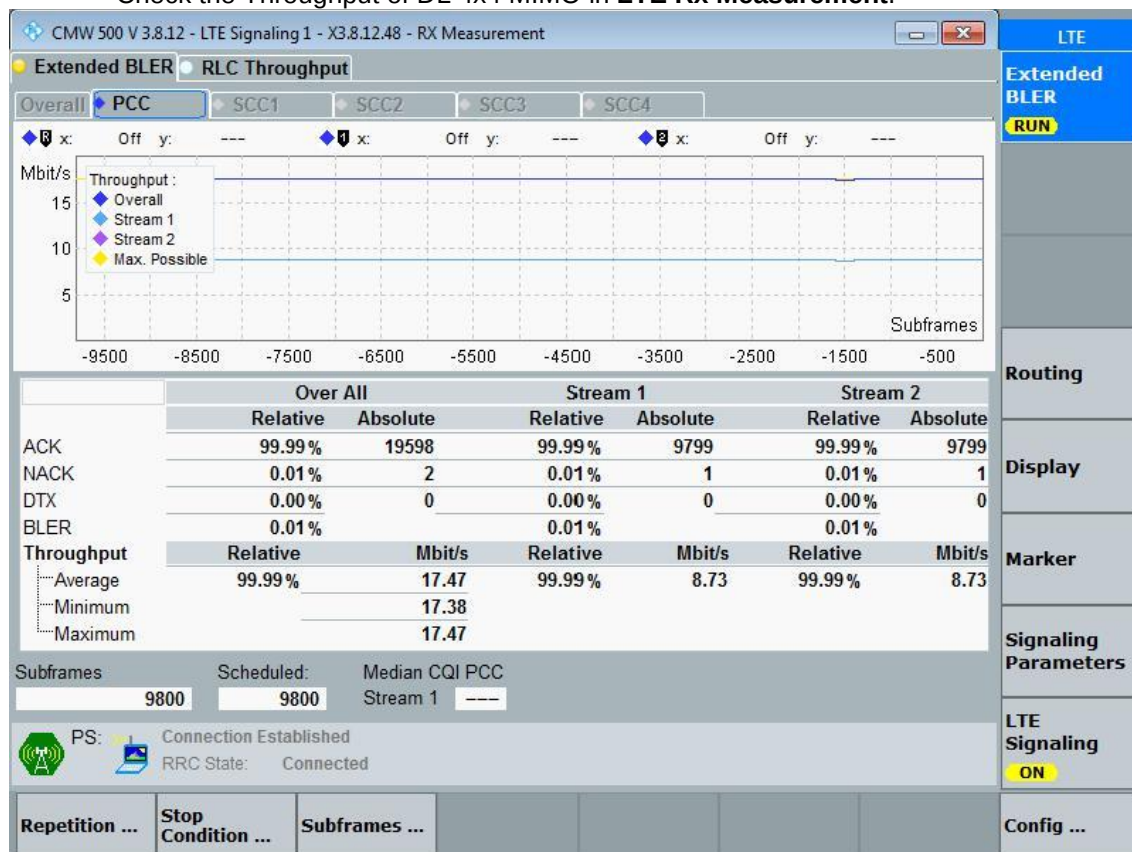


- Set the RF Output/Input Connector and Converter for PCC.
DL MIMO output ports correspond with RF Output (TX) Connector(s).

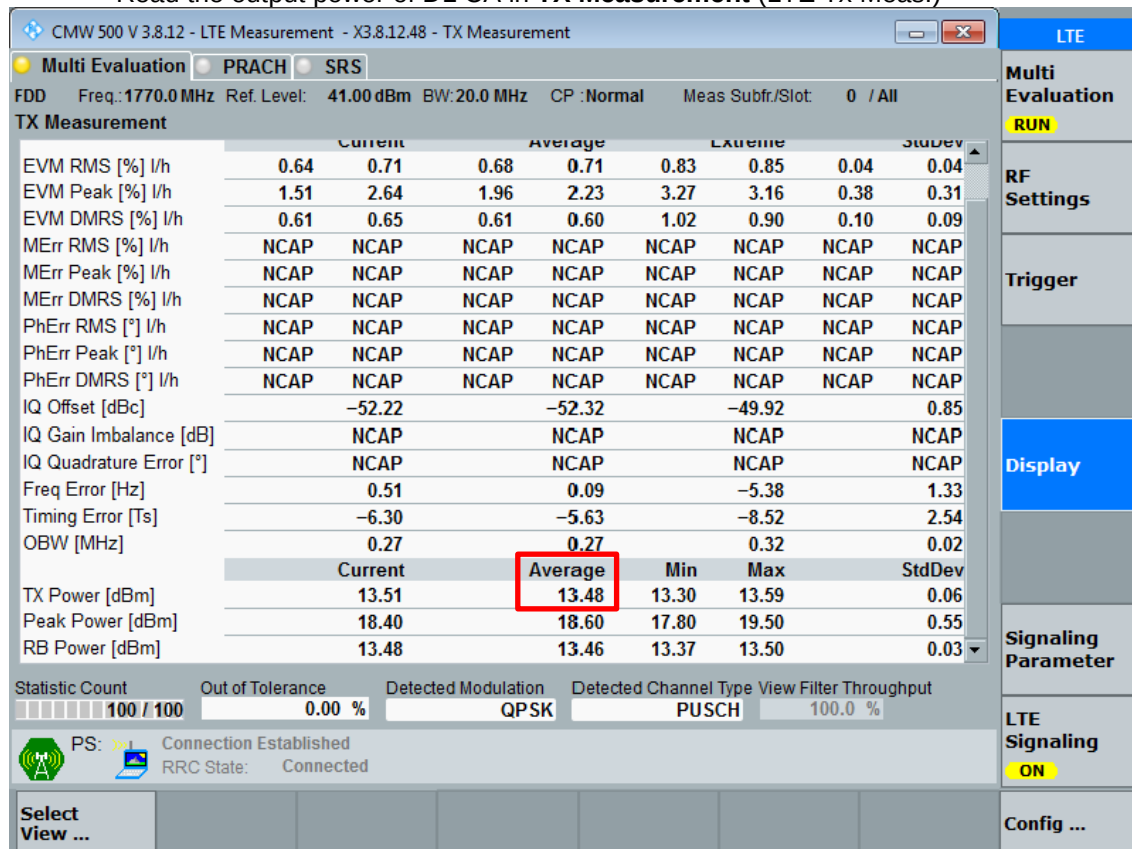


- Back to the LTE Signal screen, set operating band, BW, channel and RB configurations for PCC

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



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



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	Index	3CC	Restriction	Completely Covered by Measurement Superset
2CC#1	41C			3CC#1	41D		

LTE Uplink Carrier Aggregation Combinations**Maximum Output Power (Tune-up Limit) for LTE UL Carrier Aggregation**

UL CA shall be tested based on the worst-case SAR configuration determined from non-CA SAR testing result. The channel BW, channel number, RB Allocation, etc. would be selected to allow contiguous CA of PCC and SCC. Uplink output power for UL CA is the total power measured across the PCC and SCC.

UL CA power measurements were performed with QPSK modulation based on the worst-case standalone SAR. The tune-up limits are provided in table below. The UL CA mode power measurements represent the total power across both carriers. Measurements were made for all supported PCC bandwidths using the channel/RB combination resulting in the highest standalone output power at the least MPR (0 dB). SCCs were set to use configurations similar to the PCC to establish conservative or worst case equivalent SAR test conditions (highest maximum power with MPR of 0 dB).

The standalone power measurement is the power for the PCC in the non-CA mode (i.e. single carrier power). In all cases the UL CA power is less than or equal to the standalone power, which is in accordance with the tune-up limits in table below.

According to November 2017 TCB workshop, Uplink CA SAR Test Guidance as follows;

- a) When the maximum output for UL CA is $\leq$ standalone LTE mode (without CA)
 - PCC is configured according to the highest standalone SAR configuration tested
 - SCC and subsequent CCs are configured according to procedures used for power measurement and parameters (BW, RB etc.) similar to that used for the PCC.
- b) When the Reported SAR for UL CA configuration, described above, is > 1.2 W/kg, UL CA SAR is also required for all required test channels (PCC based).
- c) UL CA SAR is also required for standalone SAR configurations > 1.2 W/kg when they are scaled to the UL CA power level.

SAR measurement is not required for the 16QAM and 64QAM. When the highest maximum output power for 16QAM and 64QAM is ≤ 0.25 dB higher than the QPSK or when the reported SAR for the QPSK configuration is ≤ 1.45 W/kg.

RF Exposure conditions	Antenna	E-UTRA CA configuration (BCS)	Bands		UL																			
			PCC	SCC	PCC						SCC						MPR	Standalone	PCC + SCC					
			1st	2nd	Modulation	RB	Offset	BW	Freq	ch	Modulation	RB	Offset	BW	Freq	ch			Aggregated BW	MPR	Tune-Up Limit	CA power (total PCC+SCC)	Delta	3GPP Rel.
Head	Ant.B	CA_41C(0)(1)(2)(3)	41C	41C	QPSK	1	0	20	2636.5	41055	QPSK	1	99	20	2616.7	40857	0	24.33	40	0	25.0	24.38	-0.05	16
Bodyworn & Hotspot	Ant.B	CA_41C(0)(1)(2)(3)	41C	41C	QPSK	1	0	20	2593.0	40620	QPSK	1	99	20	2573.2	40422	0	23.55	40	0	24.0	23.30	0.25	16
Head	Ant.F	CA_41C(0)(1)(2)(3)	41C	41C	QPSK	1	0	20	2680.0	41490	QPSK	1	99	20	2660.2	41292	0	19.13	40	0	20.0	19.03	0.10	16
Bodyworn & Hotspot	Ant.F	CA_41C(0)(1)(2)(3)	41C	41C	QPSK	1	0	20	2680.0	41490	QPSK	1	99	20	2660.2	41292	0	21.65	40	0	22.5	21.40	0.25	16

Note:

Standalone output power values are referenced from Sec.9.3 in the SAR Part.1 Test Report.

LTE Release 10 Carrier Aggregation with 4x4 MIMO

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

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
41	QPSK	20	41055	2636.5	1/0	24.33	24.27	-0.06

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.

DL CA output power results

E-UTRA CA configuration (BCS)	Bands				UL								DL												LTE Rel 8 Tx. Power [dBm]	LTE Rel 10 Tx. Power [dBm]	Delta							
	PCC	SCC1	SCC2	SCC3	PCC								PCC				SCC1				SCC2							SCC3						
					1st	2nd	3rd	4th	Band	Mode	BW (MHz)	Channel	Freq. (MHz)	RB Allocatio	RB offset	Band	BW (MHz)	Channel	Freq. (MHz)	Band	BW (MHz)	Channel	Freq. (MHz)	Band				BW (MHz)	Channel	Freq. (MHz)	Band	BW (MHz)	Channel	Freq. (MHz)
41C	41C	41C			41	QPSK	20	41055	2636.5	1	0	41	20	41055	2636.5	41	20	41253	2656.3											24.33	24.36	0.03		
41D	41D	41D	41D		41	QPSK	20	41055	2636.5	1	0	41	20	41055	2636.5	41	20	41253	2656.3	41	20	41451	2676.1							24.33	24.45	0.12		

Note:

1. Per KDB 941225 D05A LTE Rel. 10 KDB Inquiry Sheet: SAR is excluded for Carrier Aggregation when measured power does not exceed LTE Release 8 by more than a 1/4 dB.
2. When the same frequency band is used for both contiguous and non-contiguous in DL CA Intra band, power was measured using the configuration with the largest aggregated bandwidth and maximum output power among the contiguous and non-contiguous in DL CA Intra band configurations.

DL CA with 4x4 MIMO output power results

E-UTRA CA configuration (BCS)	Bands				UL							DL														LTE Rel 8 Tx. Power [dBm]	LTE Rel 10 Tx. Power [dBm]	Delta		
	PCC	SCC1	SCC2	SCC3	PCC							PCC				SCC1				SCC2				SCC3						
	1st	2nd	3rd	4th	Band	Mode	BW (MHz)	Channel	Freq. (MHz)	RB Allocatio	RB offset	Band	BW (MHz)	Channel	Freq. (MHz)	Band	BW (MHz)	Channel	Freq. (MHz)	Band	BW (MHz)	Channel	Freq. (MHz)	Band	BW (MHz)				Channel	Freq. (MHz)
[41C]	[41C]	[41C]			[41]	QPSK	20	41055	2636.5	1	0	[41]	20	41055	2636.5	[41]	20	41253	2656.3									24.33	24.37	0.04
[41D]	[41D]	[41D]	[41D]		[41]	QPSK	20	41055	2636.5	1	0	[41]	20	41055	2636.5	[41]	20	41253	2656.3	[41]	20	41451	2676.1					24.33	24.41	0.08

Note:

1. Per KDB 941225 D05A LTE Rel. 10 KDB Inquiry Sheet: SAR is excluded for Carrier Aggregation when measured power does not exceed LTE Release 8 by more than a 1/4 dB.
2. When the same frequency band is used for both contiguous and non-contiguous in DL CA Intra band, power was measured using the configuration with the largest aggregated bandwidth and maximum output power among the contiguous and non-contiguous in DL CA Intra band configurations.

- END -