How to Extend LTE Coverage with Limited RRU Capacity

Thananan Numatti (Radio Access Network)

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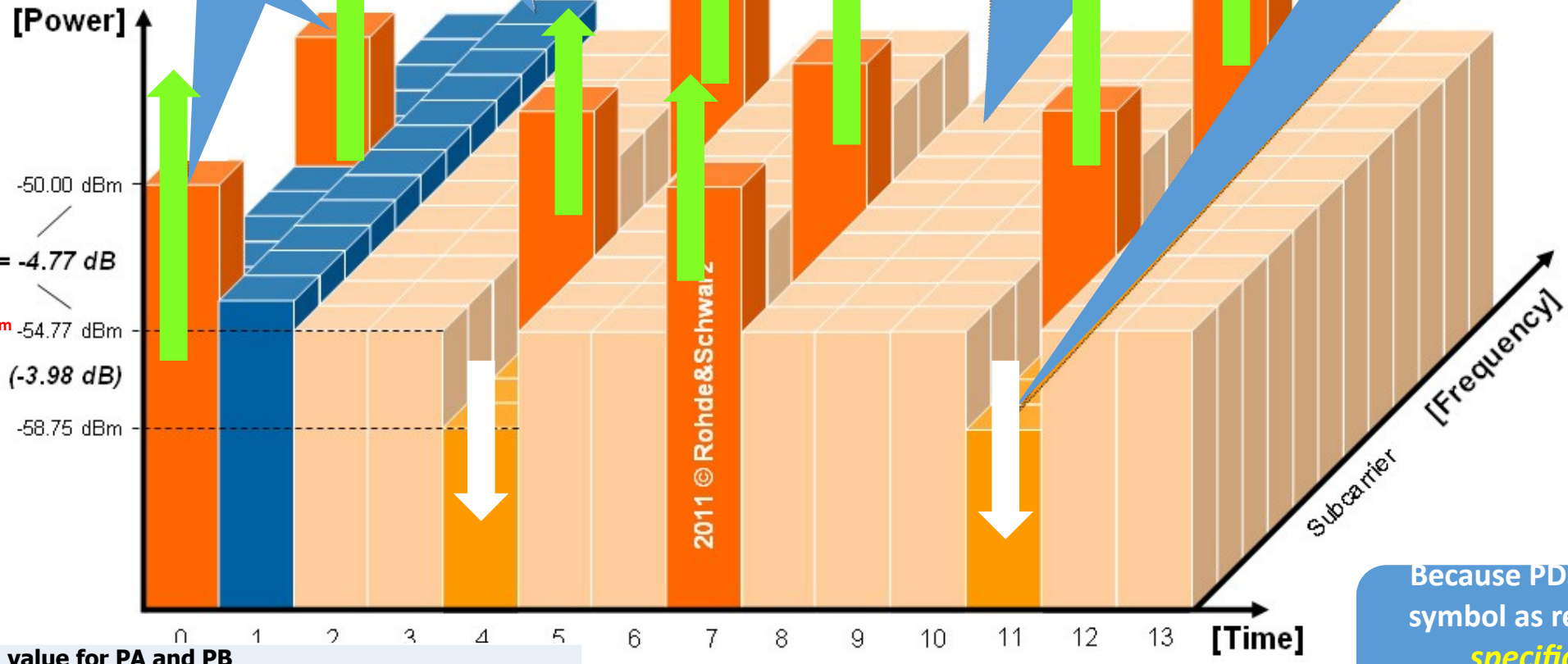
1. LTE Technology over all power consumptions

Cell-Specific reference signal power (RS power),signaled in SIB Type2

PDCCH power depending on ρA/ρB

PDSCH power to RS, where *NO* reference signals are present, is *UE specific* and signaled by higher layers as Pa (ρA).

For PDSCH power in same symbol as reference signal an additional *cell specific offset* is applied, that is signaled by higher layers as Pb (ρB).



Recommendation value for PA and PB		
PB	**PA**	**Remark**
0	3	RS -3dB but PDSCH type B +1dB
1	0	RS & PDSCH having same power(Existing Config)
1	-1.77	RS +1.77 dB
1	-3	RS +3 dB (2x2MIMO)
2	-4.77	RS +4.77 dB but PDSCH type B -1.2 dB
3	-6	RS +6 dB but PDSCH type B -3 dB(4x4MIMO)

Because PDSCH power in same symbol as reference signal *cell specific offset will be Compensates* Pb (ρB)

Credits form
https://www.wirelessdesignmag.com/blog/2011/02/understanding-downlink-power-allocation-lte
References: 1. 3GPP, TS 36.331.,2. 3GPP, TS 36.213

2. LTE Formula CRS gain (Cell Referent Signal by PB (Power Boosting)

CRS= RRU_single port(dBm) - 10log(PRB*12)+10Log(Pb+1)

1.Power per port antenna

@maxRRU 43dBm(20Watt),configuration 2T2R MIMO

@Power single port = pRRU-10Log (No. Antenna port)

= 43-10log (2)

@Power single port = 39.99 dBm ~10Watt/Antenna port

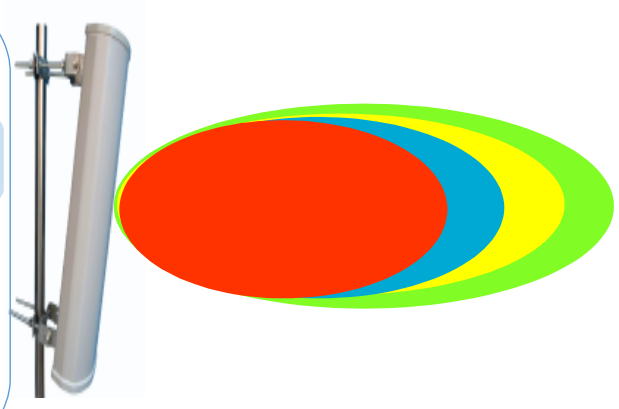
2. Extend Coverage by Power bossing (PB) Level 0 ,1 , 2 ,3

@PB:0 CRS = 39.9 – 10 log(25*12)+10Log(0+1) = 15.22 dBm

@PB:1 CRS = 39.9 – 10 log(25*12)+10Log(1+1) = 18.23 dBm

@PB:2 CRS = 39.9 – 10 log(25*12)+10Log(2+1) = 20.00 dBm

@PB:3 CRS = 39.9 – 10 log(25*12)+10Log(3+1) = 21.24 dBm



PB:0 is mean there is non power boosting incensement on CRS RE

CRS= RRU_single port(dBm) - 10log(PRB*12)+10Log(Pb+1)

1.Power per port antenna

@maxRRU 46dBm(40Watt),configuration 2T2R MIMO

@Power single port = pRRU-10Log (No. Antenna port)

= 46-10log (2)

@Power single port = 42.9 dBm or 20Watt/Antenna port

LTE1800

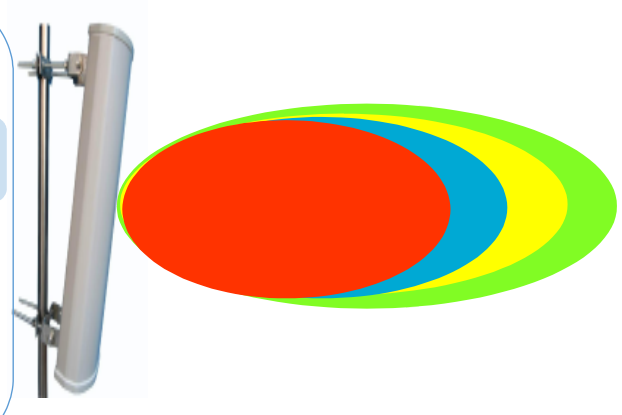
2. Extend Coverage by Power bossing (dB) Level 0 ,1 , 2 ,3

@PB:0 CRS = 42.9 – 10 log(100*12)+10Log(0+1) = 18.22 dBm

@PB:1 CRS = 42.9 – 10 log(100*12)+10Log(1+1) = 21.23 dBm

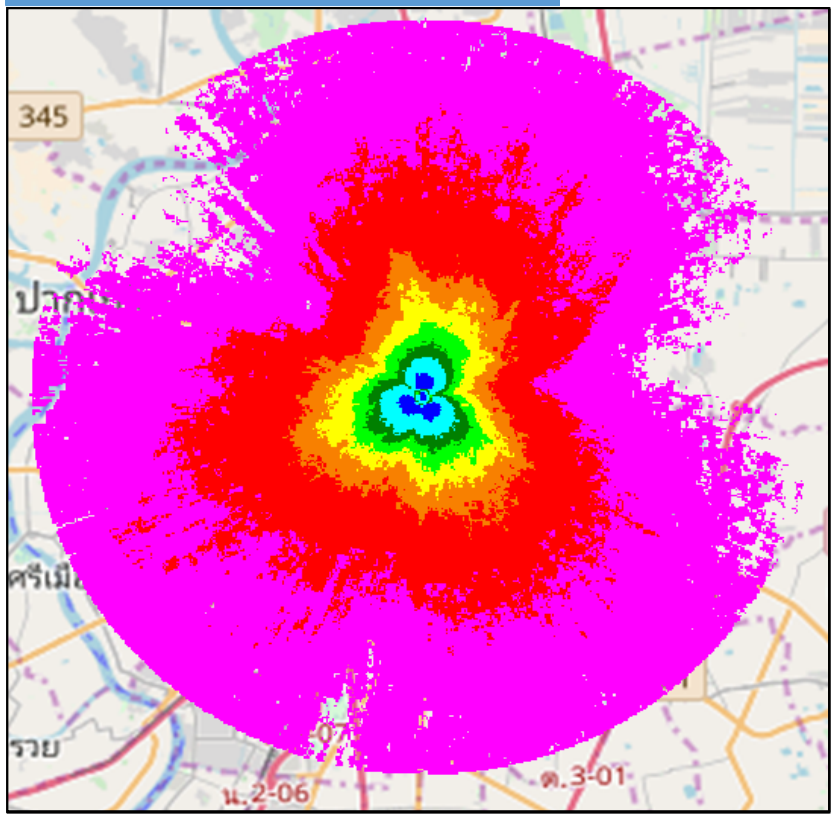
@PB:2 CRS = 42.9 – 10 log(100*12)+10Log(2+1) = 22.99 dBm

@PB:3 CRS = 42.9 – 10 log(100*12)+10Log(3+1) = 24.24 dBm



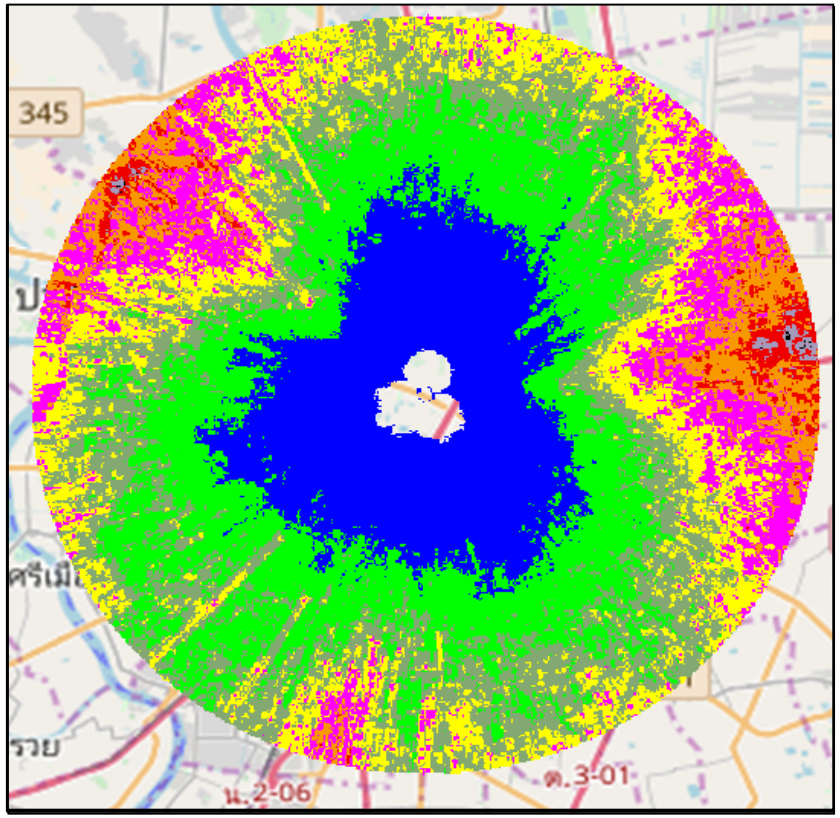
PB:0 is mean there is non power boosting incensement on CRS RE

21.24dBm,PA-3,PB3 gain LTE2100 by AIRCOM asset planning tool - RSRP, SINR, Downlink Throughput 2x2 MIMO



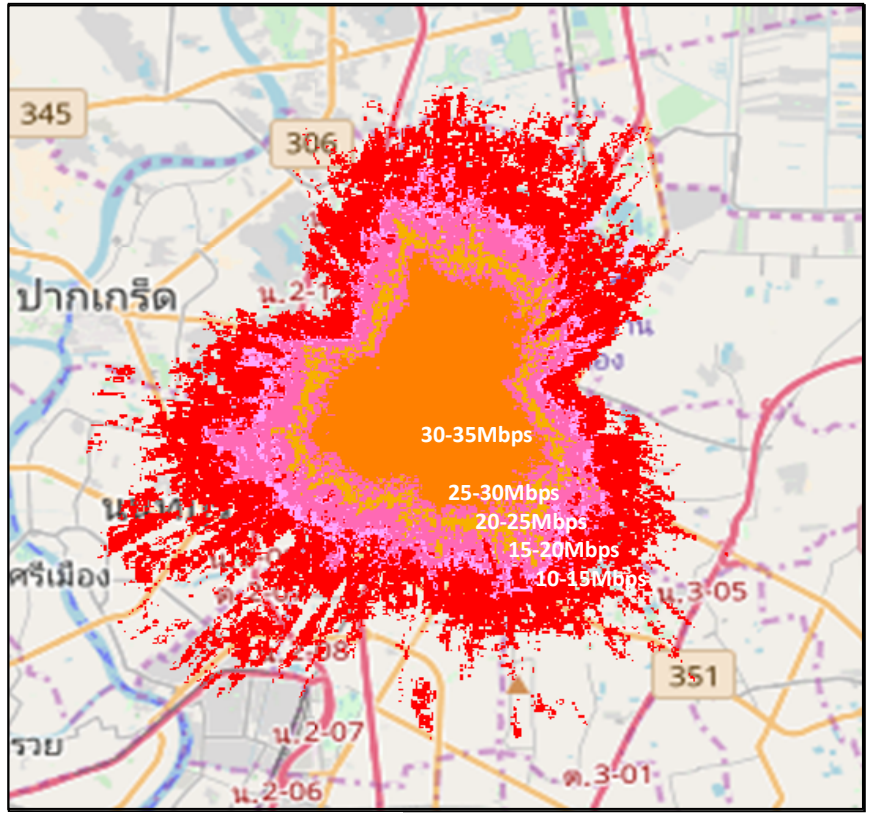
LTE: Best RSRP
- -130 <= x < -120 dBm
- -120 <= x < -110 dBm
- -110 <= x < -105 dBm
- -105 <= x < -100 dBm
- -100 <= x < -95 dBm
- -95 <= x < -90 dBm
- -90 <= x < -80 dBm
- -80 <= x < 0 dBm

RSRP



LTE: DLRS SINR
- 15 <= x < 40 dB
- 9 <= x < 15 dB
- 6 <= x < 9 dB
- 3 <= x < 6 dB
- 0 <= x < 3 dB
- -3 <= x < 0 dB
- -6 <= x < -3 dB
- -9 <= x < -6 dB
- -20 <= x < -9 dB

SINR

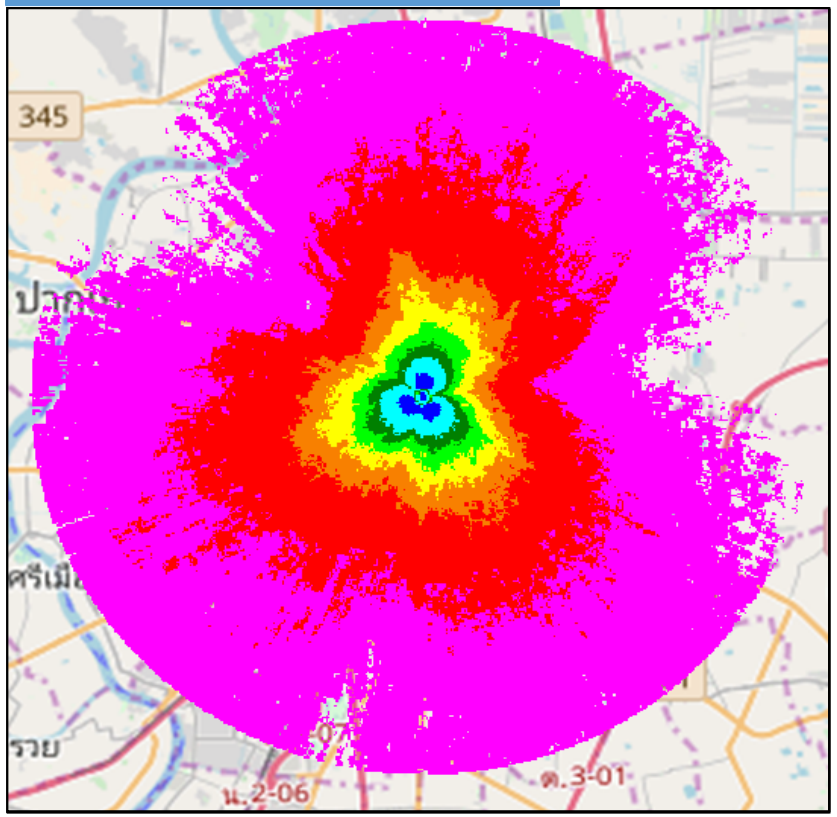


LTE: DL Achievable Throughput (Application) (kbps)
- 1 <= x < 2000
- 2000 <= x < 5000
- 5000 <= x < 10000
- 10000 <= x < 15000
- 15000 <= x < 20000
- 20000 <= x < 25000
- 25000 <= x < 30000
- 30000 <= x < 35000
- 35000 <= x < 40000
- 40000 <= x < 45000
- 45000 <= x < 50000
- 50000 <= x < 55000
- 55000 <= x < 100000

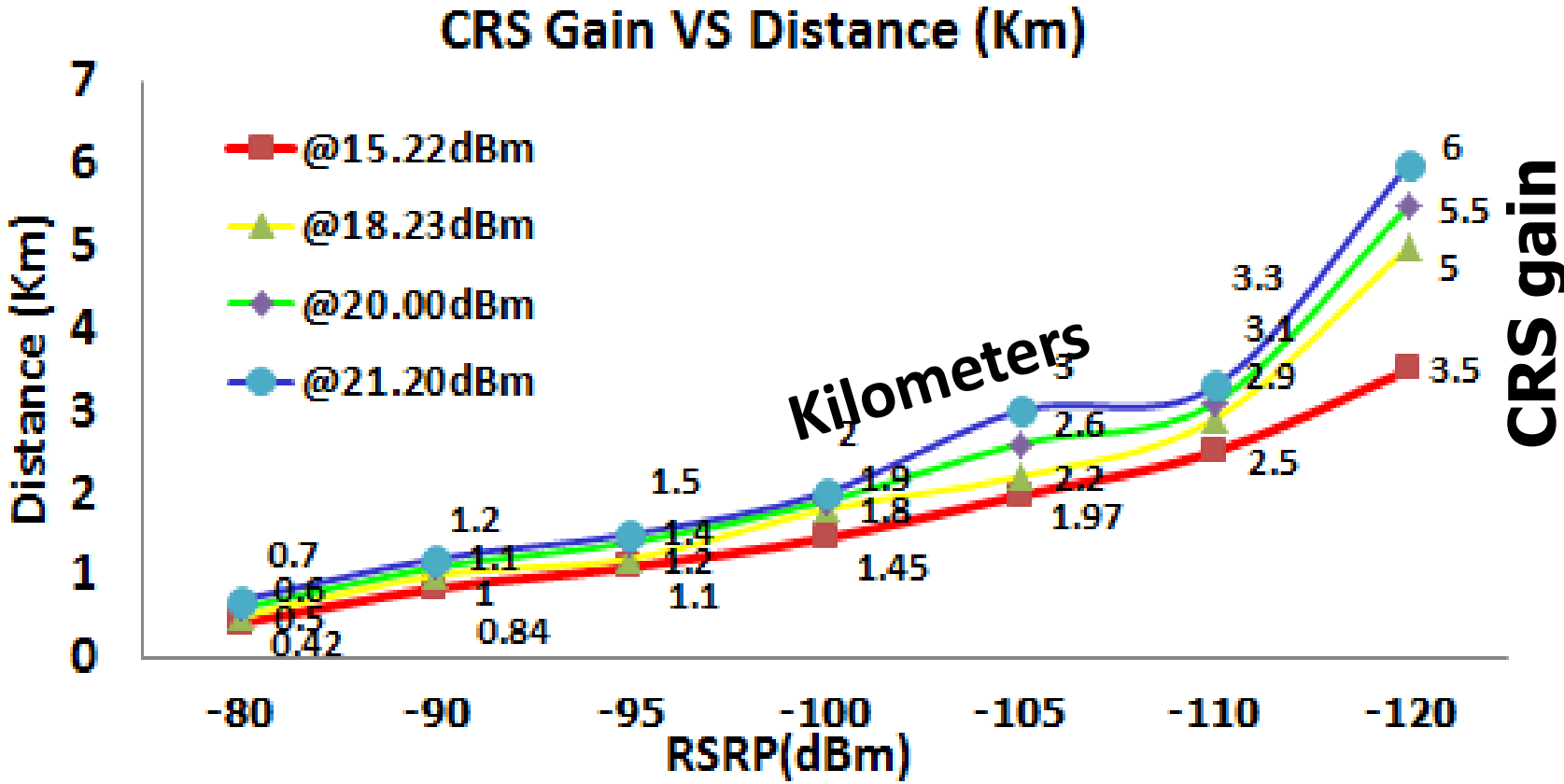
Downlink Throughput 2x2 MIMO

3. Demo prediction CRS gain LTE2100 by AIRCOM asset planning tool - CRS Gain Vs Distance (Kilometers)

21.24dBm,PA-3,PB3



RSRP



5. How to CRS gain configuration 3 Vendors (Huawei, Ericsson, Nokia)

Vendors	Parameter ID	Meaning	GUI Value Range	Unit	Defulte	Existing Configuration L21	Existing Configuration E18	Existing Configuration T23	Propose Configuration L21	Propose Configuration E18	Propose Configuration T23	Command
Huawei	ReferenceSignalPwr	Cell reference signal power of each physical antenna	-600~500	0.1dBm	None	212(21.23 dBm)	182(18.2dBm)		212(21.23 dBm)	242(24.2dBm)		MOD PDSCHCFG: LocalCellId=0, ReferenceSignalPwr=212;
	PdschPaAdjSwitch	Switch for adjusting the PA through power control on the PDSCH	OFF(Off), ON(On)	None	OFF	OFF	OFF		ON	ON		MOD CELLDLPCPDSCHPA: LocalCellId=0, PdschPaAdjSwitch=ON, PaPcOff=DB_6_P_A;
	Pb	Energy Per Resource Element (EPRE) on the PDSCH	0~3	None	None	1	1		3	3		MOD PDSCHCFG: LocalCellId=0, ReferenceSignalPwr=212; Pb=3;
	PaPcOff	PA to be used when PA adjustment for PDSCH power control	DB_6_P_A(-6 dB), DB_4DOT77_P_A(-4.77 dB), DB_3_P_A(-3 dB), DB_1DOT77_P_A(-1.77 dB), DB0_P_A(0 dB), DB1_P_A(1 dB), DB2_P_A(2 dB), DB3_P_A(3 dB)	dB	None	DB_3_P_A(-3 dB)	DB_3_P_A(-3 dB)		DB_6_P_A(-6 dB)	DB_6_P_A(-6 dB)		MOD CELLDLPCPDSCHPA: LocalCellId=0, PdschPaAdjSwitch=ON, PaPcOff=DB_6_P_A;
Ericsson	crsGain	Cell reference signal power of each physical antenna	0 { -300, -200, -100, 0, 177, 300, 477, 600 } Unit: 0.01dB	0.01dB	0(0dB)	0(0dB)	0(0dB)	0(0dB)	600(3dB)	600(3dB)	600(3dB)	[SectorEquipmentFunction]configuredOutputPower[EUtranCellFDD] crsGain 600 (6 dB)
	pdschTypeBgain	Energy Per Resource Element (EPRE) on the PDSCH	0 { 0, 1, 2, 3 } define the gains (5/4,1,3/4,1/2)	None	None	0	0	0	3	3	3	[EUtranCellFDD/TDD] pdschTypeBgain 3
Nokia	dlRsBoost	Cell reference signal power of each physical antenna	LNCEL: -3dB (700), 0dB(1000), 1.77dB (1177), 3dB(1300), 4.77dB (1477),6dB, (1600); 0dB	dB	None	3dB(1300)	-	3dB(1300)	6dB(1600)	-	6dB(1600)	[LNCEL] pMax[LNCEL] dlRsBoost 1600(6 dB)
	allowPbIndexZero	Energy Per Resource Element (EPRE) on the PDSCH	0 (false), 1 (true)	None	0 (false)	0 (false)	0 (false)	1	1	1	1	[LNCEL] pMax[LNCEL] allowPbIndexZero 1 (true)

Nokia set to 1 (Hard code)

Microsoft Excel Worksheet

5. How to CRS gain configuration 3 Vendors (Huawei, Ericsson, Nokia)

LST CELLDLPCPDSCHPA:;
KBI0106-UL
List Pa parameters for PDSCH power control

Local cell ID PA adjusting switch PA for even power distribution(dB)

1 Off -3 dB
2 Off -3 dB
3 Off -3 dB

ON

-4.77,-6

LST PDSCHCFG:;
KBI0106-UL
+++ KBI0106-UL 2018-01-22 14:49:22
Display PDSCHCfg

Local cell ID Reference signal power(0.1dBm) PB Reference Signal Power Margin(0.1dB) Offset of Ant0 to Tx Power(0.1dB) Offset of Ant1 to Tx Power(0.1dB) Offset of Ant2 to Tx Power(0.1dB) Offset of Ant3 to Tx Power(0.1dB)

1 212 1 0 255 255 255 255
2 212 1 0 255 255 255 255
3 212 1 0 255 255 255 255

200-600

2,3

(Number of results = 3)
--- END

Huawei

SiteName	CellName	MO	pMax	dlRsBoost	allowPbIndexZero
L21-CMI0130	L21-CMI0130-1A	PLMN-PLMN/MRBTS-100130/LNBTS-100130/LNCEL-1	430	1300	0
L21-CMI0130	L21-CMI0130-1B	PLMN-PLMN/MRBTS-100130/LNBTS-100130/LNCEL-2	448	1300	0
L21-CMI0130	L21-CMI0130-1C	PLMN-PLMN/MRBTS-100130/LNBTS-100130/LNCEL-3	430	1300	0

1477,1600

1

SiteName	CellName	MO	pMax	dlRsBoost	allowPbIndexRatio
L23-CMI0003	L23-CMI0003-1A	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-1	430 (43dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-1B	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-11	430 (43dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-1C	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-31	430 (43dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-2A	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-12	400 (40dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-2B	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-22	400 (40dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-2C	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-32	400 (40dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-3A	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-13	400 (40dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-3B	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-23	400 (40dBm)	1300 (3dB)	0 (false)
L23-CMI0003	L23-CMI0003-3C	PLMN-PLMN/MRBTS-400102/LNBTS-400102/LNCEL-33	400 (40dBm)	1300 (3dB)	0 (false)

NOKIA

1477,1600

1

BKK0009-L21> get . crsgain

MO	Attribute	Value
EUtranCellFDD=L21-BKK0009-1A	crsGain	0
EUtranCellFDD=L21-BKK0009-1B	crsGain	300
EUtranCellFDD=L21-BKK0009-1C	crsGain	0
EUtranCellFDD=L21-BKK0009-1D	crsGain	0

477,600

BKK0009-L21> get . pdschtypeb

MO	Attribute	Value
EUtranCellFDD=L21-BKK0009-1A	pdschTypeBGain	0
EUtranCellFDD=L21-BKK0009-1B	pdschTypeBGain	1
EUtranCellFDD=L21-BKK0009-1C	pdschTypeBGain	0
EUtranCellFDD=L21-BKK0009-1D	pdschTypeBGain	0

1,2,3

BKK0009-E18> get . crsgain

MO	Attribute	Value
EUtranCellFDD=E18-BKK0009-1A	crsGain	0
EUtranCellFDD=E18-BKK0009-1B	crsGain	0
EUtranCellFDD=E18-BKK0009-1C	crsGain	0
EUtranCellFDD=E18-BKK0009-1D	crsGain	0

477,600

BKK0009-E18> get . pdschtype

MO	Attribute	Value
EUtranCellFDD=E18-BKK0009-1A	pdschTypeBGain	0
EUtranCellFDD=E18-BKK0009-1B	pdschTypeBGain	0
EUtranCellFDD=E18-BKK0009-1C	pdschTypeBGain	0
EUtranCellFDD=E18-BKK0009-1D	pdschTypeBGain	0

1,2,3

Ericsson

BKK0024-L23> get . crsgain

MO	Attribute	Value
EUtranCellTDD=L23-BKK0024-1A	crsGain	0
EUtranCellTDD=L23-BKK0024-1B	crsGain	0
EUtranCellTDD=L23-BKK0024-1C	crsGain	0
EUtranCellTDD=L23-BKK0024-2A	crsGain	0
EUtranCellTDD=L23-BKK0024-2B	crsGain	0
EUtranCellTDD=L23-BKK0024-2C	crsGain	0
EUtranCellTDD=L23-BKK0024-3A	crsGain	0
EUtranCellTDD=L23-BKK0024-3B	crsGain	0
EUtranCellTDD=L23-BKK0024-3C	crsGain	0

477,600

BKK0024-L23> get . pdschtyp

MO	Attribute	Value
EUtranCellTDD=L23-BKK0024-1A	pdschTypeBGain	0
EUtranCellTDD=L23-BKK0024-1B	pdschTypeBGain	0
EUtranCellTDD=L23-BKK0024-1C	pdschTypeBGain	0

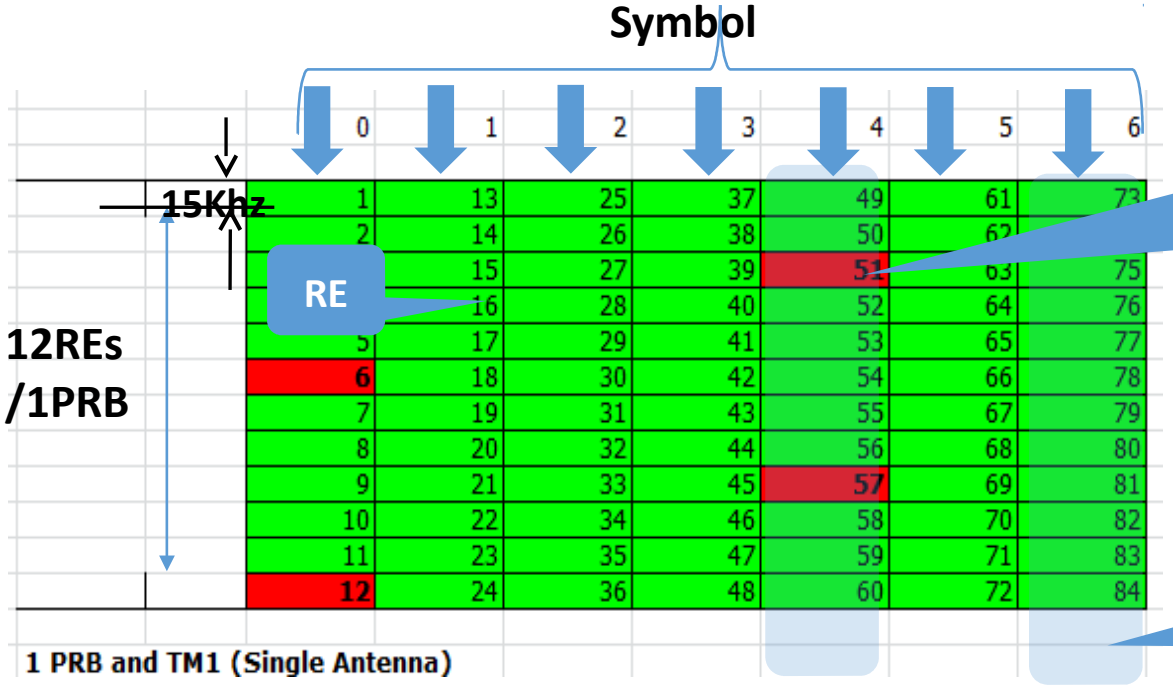
7. RAN Recommendations with PB value LTE Live Network

1. CRS gain configuration should be separate area coverage ,deep indoor or capacity area

Recommendation value for PA and PB			
PB	PA	Remark	Area
0	3	RS -3dB but PDSCH type B +1dB	
1	**0**	**RS & PDSCH having same power (Existing Network)**	**Existing Network**
1	-1.77	RS +1.77 dB	
1	-3	RS +3 dB (2x2MIMO)	Dens Urban ,Urban
2	-4.77	RS +4.77 dB but PDSCH type B -1.2 dB	Sub Urban ,Rural
3	-6	RS +6 dB but PDSCH type B -3 dB(4x4MIMO) or 2x2MIMO	Rural ,IBC

2. Trade off main KPIs site by site

How to calculate and find the Total Power of PDSCH become



Within Reference Signal
1.RSRP=(p(51)+p(57))/2
2.Total Power PDSCH= p(49)+p(52)+p(53)+p(55)+p(56)+p(58)+p(59)+p(60)
= EPRE PDSCH x 10 (In linear Scale)
3.Total Power PDSCH all Channel
=(RSRP x 2) + Total Power PDSCH
4.Total Power PDSCH all Channel
= EPRE for PDSCH x Number of PDSCH RE
= EPRE for PDSCH (in dBm) + 10 Log(Number of PDSCH RE)

Without Reference Signal
1.RSRP=N/A (since there is NO RS)
2Ttoal Power PDSCH
=p(25)+p(26)+p(27)+p(28)+p(29)+p(30)+p(31)+p(32)+p(33)+p(34)+p(35)+p(36)
=EPRE PDSCHx12 (In linear Scale)
3.Total Power PDSCH all Channel
=Total Power PDSCH
4.Total Power of PDSCH (Without Reference Signal)
= EPRE for PDSCH x Number of RB x 12 (assuming for the symbol with no Reference Signal)
= EPRE for PDSCH + 10 Log(Number of RB x 12)

1. RE(Resource Element)
'= Engergy (Power) allocated to 1 RE is calleds EPRE(Energy Per 1Resource Element)

2. RSRP =If there is no noise at all, RSRP would be same as EPRE you set for Reference Signal
'= RE for reference Signal Average Power of all the RS(Reference Signal within a Symbol)

3. Total Power PDSCH This value may vary with different symbols
-Symbol 0 in first slot is made up of multiple component - PCFICH, HICH, RS.
-Symbol 4 is made up of PDSCH and Reference signal).

How to calculate and find the Total Power of PDSCH become

Example

If Network allocated at -90 dBm/EPRE for PDSCH and allocated 100 RBs for the PDSCH(BW:20MHz),
Find the Total Power of PDSCH become as follows.
Total Power of PDSCH (in dB/dBm scale)

@ -90dBm

= **EPRE** for PDSCH + 10 Log(Number of RB x 12)
= **-90** + 10 Log(100 x 12)
= **-90** + 30.8
= **- 59.2** dBm

@ -95dBm

If allocated at -95 dBm Find the Total Power of PDSCH become as follows.
= **-95** + 10 Log(100 x 12)
= **-95** + 30.8
= **-64.2** dBm

@ -100dBm

If allocated at -100 dBm Find the Total Power of PDSCH become as follows.
= **-100** + 10 Log(100 x 12)
= **-100** + 30.8
= **-69.2** dBm

@ -105dBm

If allocated at -105 dBm Find the Total Power of PDSCH become as follows.
= **-105** + 10 Log(100 x 12)
= **-105** + 30.8
= **-74.2** dBm

@ -110dBm

If allocated at -110 dBm Find the Total Power of PDSCH become as follows.
= **-110** + 10 Log(100 x 12)
= **-110** + 30.8
= **-79.2** dBm

RSRP =If there is no noise at all, RSRP would be same as EPRE you set for Reference Signal

Table 5.2-1: The cell-specific ratio ρ_B / ρ_A for 1, 2, or 4 cell specific antenna ports

P_B	ρ_B / ρ_A	
	One Antenna Port	Two and Four Antenna Ports
0	1	5/4 1.25MIMO
1	4/5	1 1MIMO
2	3/5	3/4 0.75MIMO
3	2/5	1/2 0.5MIMO

Microsoft Excel Worksheet

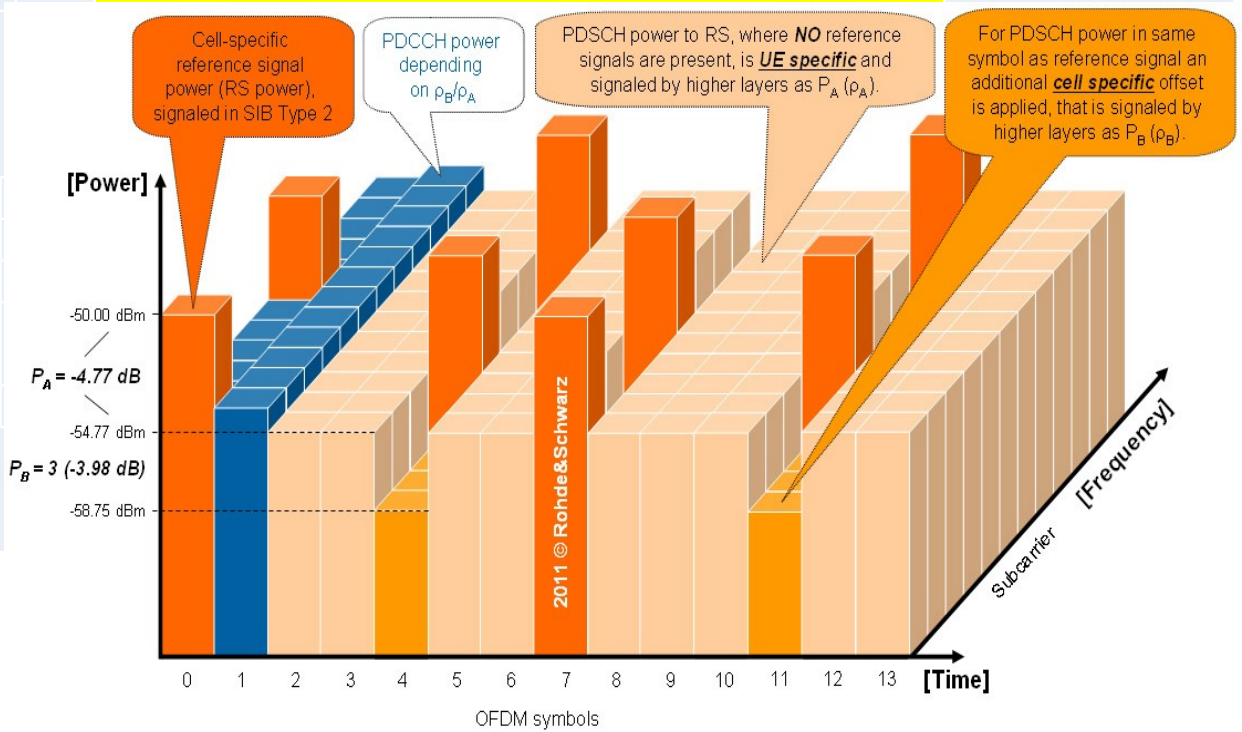
'@BW=5MHz	'@25PRB	'@RRU43dBm(20Watt)		MIMO		
			PB level	P_PDSCH_B		
Power RS ref power	P_PDSCH_B = P_PDSCH_A * ρA/ ρB		0	19.04 dBm	3.81	
Power RS ref power	P_PDSCH_B = P_PDSCH_A * ρA/ ρB		1	15.23 dBm	3.81	
Power RS ref power	P_PDSCH_B = P_PDSCH_A * ρA/ ρB		2	11.42 dBm	3.81	
power RS ref power	P_PDSCH_B = P_PDSCH_A * ρA/ ρB		3	7.61 dBm	3.81	
Power With out RS power	P_PDSCH_A = **EPRE_0** - mimoComp		15.23			

P_PDSCH_A = EPRE_0 - mimoComp

PSD =(pMax)-10*LOG10(PRBs_DL*12),@pmax=39.9dBm
RS Power = PSD - **PA**
PDSCH Type B =**PSD** +10*LOG10(**PB**)
RS= RRU_single port(dBm)-10log(PRB*12)+10Log(Pb+1)
EPRE_0 = 15.23 dBm

When
- PSD_CELL_RS = PSD_0_SISO + dlRsBoost (for 1Tx),
- PSD_CELL_RS = PSD_MIMO + dlRsBoost (for 2Tx)
- where PSD_0 = (pMax – CELL_PWR_RED) – 10log10(#PRBs_DL x 12)
- and PSD_MIMO = PSD_0 – MIMO_COMP

EPRE_0 = (pmax – dlCellPwrRed)-10log (#PRB * 12); @pmax=39.9dBm



LTE1894: Reference signal power de-boosting Example

dlChBw=10MHz (50 PRBs), dlMimoMode= Dynamic Open Loop MIMO, pMax=39dBm, dlCellPwrRed=0dB, dlpcMimoComp=0dB, dlRsBoost=-3dB

The even energy per Resource Element for 1 antenna system (1 TX Mode) is

EPRE_0 = (pmax – dlCellPwrRed) - 10 log (#PRB*12)

EPRE_0 = (39dBm - 0dBm) – 10*log10 (50*12) = 11.21dBm

The power of the Cell-specific Reference Symbols.

P_CRS = EPRE_0 + dlRSboost

P_CRS = 11.21dBm -3dB = 8.21dBm

The power of PDSCH on OFDMsymbols without CRS.

For 2 antenna system (MIMO TX diversity or Spatial Multiplexing) the parameter MIMO compensation has to be subtracted from the even energy per Resource Element.

P_PDSCH_A = EPRE_0 – dlcpMimoComp

P_PDSCH_A = 11.21dBm - 0dB = 11.21dBm

p-a is the ratio between P_PDSCH_A to P_CRS

p-a = 11.21dBm - 8.21dBm = 3dB

The power of PDSCH on OFDMsymbols with CRS.

With ***dlRsBoost*** index *p-b* is 0. From table we find $\rho_A / \rho_B = 5/4$.

P_PDSCH_B = PSD_UE_PDSCH_A + 10* log10 (ρ_A / ρ_B)

P_PDSCH_B = 11.21 + 10 * log10 (5/4) = 12.18dBm