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Postal address

3GPP support office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet
http://www.3gpp.org

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Foreword

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1 Scope

The present document is the Technical Report on Public safety broadband high power User Equipment (UE) for Band 14 for Region 2.

The purpose of this TR is to study the radio requirements for Public safety broadband high power User Equipment (UE) as part of the Rel-11 work item for a new Power Class for Band 14 for Region 2. The normative requirements resulting from this TR will be addressed in the applicable release 11 Technical Specifications (TS)

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.101: "User Equipment (UE) radio transmission and reception".

[3] 3GPP TS 36.104: "Base Station (BS) radio transmission and reception".

[4] 3GPP TR 36.803: "Base Station (BS) radio transmission and reception"

[5] 3GPP TR 36.804: "User Equipment (UE) radio transmission and reception"

[6] 3GPP TS 36.213: "Physical layer procedures".

[7] 3GPP TS 36.331: "Radio Resource Control (RRC); Protocol specification".

[8] 3GPP TS 36.321: "Medium Access Control (MAC) protocol specification".

[9] 3GPP TS 36.133: "Requirements for support of radio resource management".

[10] 3GPP TS36.304: "User Equipment (UE) procedures in idle mode"

[11] 3GPP TR 36.942: "Radio Frequency (RF) system scenarios".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Symbols

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

HPUE High Power User Equipment

4 Background

4.1 Justification

The FCC Public Safety and Homeland Security Bureau mandates LTE technology for the 700 MHz Public Safety band (3GPP Band 14). Currently there is only one power class defined for EUTRAN UE, i.e. power class 3 (+23dBm) for Band 14. This limitation on UL power is a bottleneck to enable higher achievable data rate with broader coverage, which are essential for Public Safety Broadband (PSBB) systems to provide the necessary population coverage and UL throughput requirements for Public Safety and US Homeland Security.

Band 14 PSBB will need to provide better coverage and availability/throughput performance than provided by commercial systems particularly in rural areas. This can be achieved by using higher power UE(s) for vehicular mobile applications by allowing “first responders” to send and receive video and data, thus providing the ability to co-ordinate response and protect lives in these scenarios.

LTE commercial rollout is normally planned with availability of up to 95% of the United States population. Using United States census data we find that 95% of the total population (307 million) resides in 1.26 million square miles or 36% of the land area of US (3.5 million square miles). However for PSBB we need to provide a > 95% populations coverage area. We find that 99% of the total resides in 2.03 million square miles or 58% of the land area of US. That means that we have to provide rural coverage for 0 .77 (2.03 – 1.26) million square miles with these higher power vehicular mobiles.

Since Band 14 LTE high-power UE OOBE into Band 13 LTE BS Rx band could be higher than a Power class 3 UE, it is recommended that Band 14 and Band 13 co-existence studies be performed to assess the throughput/OOB emission impact for the new B14 higher power class

A B14 Higher Power UE (HPUE) would have different RF specification requirements than the normal power Class 3 UE; therefore it is proposed to specify these additional (more stringent) requirements in terms of a new Band 14 power class (Power Class 1) in 3GPP TS36.101 [2] for PSBB deployment as part of a new RAN WID.

4.2 Objective

The objective is to write the RF core requirements that are applicable to Band 14 High Power UE for Region 2

1. The new requirements will only cover the transmission and reception requirements, but no baseband demodulation performance requirements for;
   a. Band 14
   b. E-UTRA UE Power Class 1 (+33dBm target)
   c. Public Safety broadband (PSBB) deployment
2. The following specification work is required
   a. Core RF requirements for RAN4 E-UTRA specifications for FDD Band 14
3. The work item should take into account the co-existence and compatibility of LTE systems deployed in the 700MHz band
4. The work item does not preclude additional co-existence scenarios.
5. Maintain the same co-existence impact in terms of throughput/OOB emissions from the B14 HPUE to B13 through tighter requirements for the HPUE where applicable

5 Deployment and co-existence studies

5.1 General

The purpose of this section is address the co-existence and compatibility studies for the Band 14 higher power class for Region 2

5.2 Upper 700MHz band

The Upper 700 MHz band includes the following spectrum blocks:

C Block: 746 MHz – 757 MHz: Down-link (Node B transmit, UE receive)

776 MHz - 787 MHz: Up-link (UE transmit, Node B receive)

A Block: 757 MHz – 758 MHz: Down-link (Node B transmit, UE receive)

787 MHz - 788 MHz: Up-link (UE transmit, Node B receive)

D Block: 758 MHz – 763 MHz: Down-link (Node B transmit, UE receive)

788 MHz – 793 MHz: Up-link (UE transmit, Node B receive)

F Block: 763 MHz – 768 MHz: Down-link (Node B transmit, UE receive)

793 MHz - 798 MHz: Up-link (UE transmit, Node B receive)

In 3GPP the Upper 700MHz band spectrum block are specified in terms of two operating bands. B13 and B14 as shown in Table 5.2.1 for UE Power Class 3 (+23 dBm ±2dB) in [2]

Table 5.2-1: 3GPP 700MHz EUTRA operating band

EUTRA Operating Band	Uplink (UL) band UE transmit BS receive FUL_low – FUL_high			Downlink (DL) band UE transmit BS receive FDL_low – FDL_high			Duplex Mode
12	698	–	716	728	–	746	FDD
13	777	–	787	746	–	756	FDD
14	788	–	798	758	–	768	FDD
17	704	–	716	734	–	746	FDD

Figure 5.2-1 shows the mapping of Upper 700MHz spectrum block and 3GPP EUTRA Band 13 and Band 14

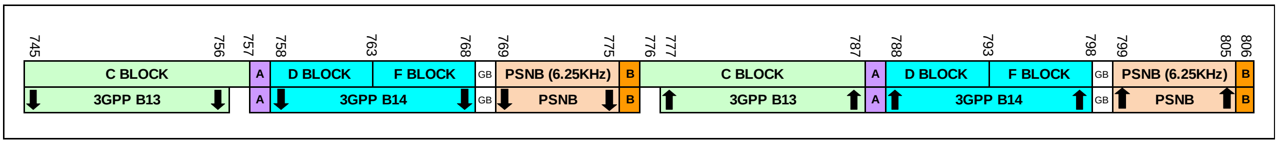


Figure 5.2-1: Upper 700MHz band plan / 3GPP EUTRA operating band

5.3 Regulatory requirements

This Regulatory requirement are based on FCC e-CFR Data current as of March 13, 2012,

NOTE: The term Block F is used to signify the 763–768/793–798 MHz band

5.3.1 MS transmit power

FCC Part 27.50 and Part 90.542 define the transmit power for D Block and F Block in the Upper 700MHz

a) Upper Band Segment – Block C, A and D block Power limits and duty cycle . (§ 27.50(b)

The following power and antenna height limits apply to transmitters operating in the 746–763 MHz, 775–793 MHz and 805–806 MHz bands:

(9) Control stations and mobile stations transmitting in the 746–757 MHz, 758–763 MHz, 776–793 MHz, and 805–806 MHz bands and fixed stations transmitting in the 787–788 MHz and 805–806 MHz bands are limited to 30 watts ERP.

(10) Portable stations (hand-held devices) transmitting in the 746–757 MHz, 758–763 MHz, 776–793 MHz, and 805–806 MHz bands are limited to 3 watts ERP.

b) Upper Band Segment – Block F Broadband transmitting power limits. (§ 90.542(a)

The following power limits apply to the 763–768/793–798 MHz band:

(6) Control stations and mobile stations transmitting in the 763–768 MHz band and the 793–798 MHz band are limited to 30 watts ERP.

(7) Portable stations (hand-held devices) transmitting in the 763–768 MHz band and the 793–798 MHz band are limited to 3 watts ERP.

5.3.2 Emission limits

The requirements for C block (B13) are specified in Part 27.53 while B14 requirements are specified in Part 27.53 for the D block and Part 90.543 for the F block

a) Upper Band Segment – Block C and A (§ 27.53(c)

For operations in the 746–758 MHz band and the 776–788 MHz band, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

(1) On any frequency outside the 746–758 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB;

(2) On any frequency outside the 776–788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB;

(3) On all frequencies between 763–775 MHz and 793–805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations;

(4) On all frequencies between 763–775 MHz and 793–805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations;

b) Upper Band Segment – Block D (§ 27.53(d)

For operations in the 758–763 MHz and 788–793 MHz bands, the power of any emission outside the licensee's frequency bands of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

(1) On all frequencies between 769–775 MHz and 799–805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations;

(2) On all frequencies between 769–775 MHz and 799–805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations;

(3) On any frequency between 775–788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB;

c) Upper Band Segment – Block F (§ 90.53(e)

For operations in the 763–768 MHz and the 793–798 MHz bands, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

(1) On all frequencies between 769–775 MHz and 799–805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations.

(2) On all frequencies between 769–775 MHz and 799–805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations.

The above requirements are summarized below in Figure 5.3.2-1. The requirements highlighted in red indicate the -35dBm/6.25KHz requirements for the protection of PSNB. The block coloured in black indicates where the requirements are not specified in the case of B14_D block. Additionally this Figure 5.3.2-1 shows the unnecessary -35dBm/6.25KHz emission requirements from C block (B13) to B14_F Block.

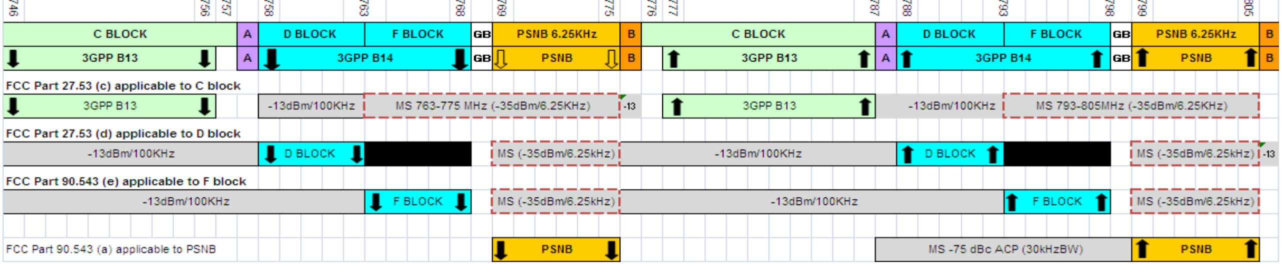


Figure 5.3.2-1: FCC emission limits for Upper 700MHz

In 3GPP TS36.101 [2] the following approach was specified to address these missing and unnecessary requirements;

- Since for B14_D block the emission requirements for 763-768MHz and 793-799MHz are not specified, a -13dBm/100KHz requirement was used in line with requirements for other UL scenarios in this and other operating bands.

- Currently C block is required to provide a -35dBm/6.25KHz protection limit from 763-775MHz and 793-805MHz (PSBB and PSNB spectrum), while a B14_D and B14_F block MS is only needed to protect a sub-set which is 768-775MHz and 799- 805 MHz (PSNB spectrum only). Therefore C block requirements are now aligned to be consistent with B14 i.e. protection limit of -35dBm/6.25KHz is specified only for PSNB (768-775MHz and 799- 805 MHz PSNB spectrum only)

With the recent allocation of D block to PSBB this now seems a reasonable assumption and would be in line with 3GPP TS36.101 emission requirement as shown below in Figure 5.3.2-2.

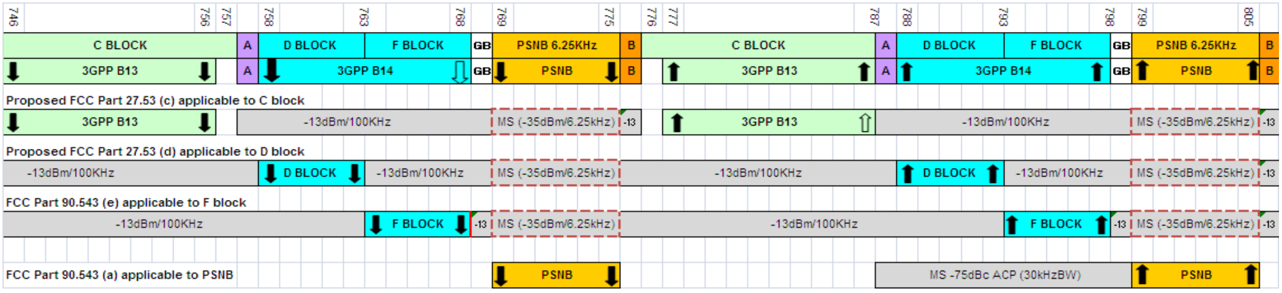


Figure 5.3.2-2: Release 8 emission limits for Upper 700MHz

5.3.3 Protection of GPS

In order to protect operations in the 1559-1610MHz band from interference for the Upper 700MHz D and F Block

27.53 Emission limits.

a) For operations in the 746–763 MHz, 775–793 MHz, and 805–806 MHz bands, emissions in the band 1559–1610 MHz shall be limited to −70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

90.543 Broadband transmitting power limits.

a) For operations in the 763–775 MHz and 793–805 MHz bands, all emissions including harmonics in the band 1559–1610 MHz shall be limited to -70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

5.4 Co-existence and compatibility of LTE systems deployed in the 700MHz band

5.4.1 Simulation assumptions

The simulation methodology and assumptions are mainly based on TS36.942 [11] with slight modifications.

5.4.1.1 Macro cell Propagation model - Rural Area

The HPUE will be mainly used for extending the coverage in rural areas. The following Hata rural model [2] is used,

$$L(R) = 69.55 + 26.16\log_{10}(f) - 13.82\log_{10}(Hb) + [44.9 - 6.55\log_{10}(Hb)]\log(R) - 4.78(\log_{10}(f))^2 + 18.33\log_{10}(f) - 40.94$$

where:

R is the base station-UE separation in kilometres

f is the carrier frequency in MHz

Hb is the base station antenna height above ground in metres

For carrier frequency of 790MHz and base station antenna height of 45m above the ground, the propagation model becomes:

$$\mathrm{L} = 94.5 + 34\log_{10}(\mathrm{R}) \qquad (1)$$

Also per 36.942[11], in rural area, Macro cell MCL is 80dB as show in the table below.

Table 5.4.1.1-1 3GPP TS36.942 [11] Minimal Coupling Loss

Environment	Scenario	MCL
Macro cell Urban Area	BS ↔ UE	70 dB
Macro cell Rural Area	BS ↔ UE	80 dB

5.4.1.2 Power control modelling

In [11], the following power control equation is used for the uplink coexistence simulations:

$$P_t = P_{\max} \times \min\left\{1, \max\left[R_{\min}, \left(\frac{CL}{CL_{x-ile}}\right)^{\gamma}\right]\right\}$$

where $P_{\max}$ is the maximum transmit power, $R_{\min}$ is the minimum power reduction ratio to prevent UEs with good channels to transmit at very low power level, CL is the coupling loss defined as max{path loss-G_Tx-G_Rx, MCL}, where path loss is propagation loss plus shadowfading, G_TX is the transmitter antenna gain in the direction of the receiver, G_RX is the receiver antenna gain in the direction of the transmitter and $CL_{x\text{-ile}}$ is the x-percentile CL value. With this power control equation, the x percent of UEs that have the highest coupling loss will transmit at $P_{\max}$. Finally, $0<\gamma<=1$ is the balancing factor for UEs with bad channel and UEs with good channel

For HPUEs, it is assumed that $R_{\min}$ has 10dB more dynamic range. The parameter sets for power control are also specified in [11] and showed here in table 5.4.1.2-1.

Table 5.4.1.2-1: Power control algorithm parameter for 2GHz band

Parameter set	Gamma	CLx-ile (10MHz bandwidth)
		0.5km cell range
Set 1	1	112
Set 2	0.8	129

However, the power control parameters were specified for carrier frequency of 2GHz with 500m cell range. The path loss model was based on Urban Hata model below:

$$\mathrm{L} = 128.1 + 37.6\log_{10}(\mathrm{R}) \qquad (3)$$

where:

R is the base station-UE separation in kilometres

Based on (1), and (3), the power control parameters can be modified to account for different propagation model, carrier frequency, BS antenna height and cell range. For example, in Table 5.4.1.2-1, CLx-ile = 112dB for set 1, which corresponds to R = 0.373km according to (3) assuming total antenna gain of 0dBi.. For 4km cell range at 700MHz band, use equation (1), we get CLx-ile = 94.5 + 34*log10(4/0.5*0.373) = 111dB. Similarly we can obtain modified power control parameters for other cases as showed in Table 5.4.1.2-2.

Table 5.4.1.2-2: Power control algorithm parameters for 23dBm UE at 700MHz band

Parameter set	Gamma	CLx-ile (10MHz bandwidth, 45m antenna height)
		4km cell range
Set 1	1	111
Set 2	0.8	126

5.4.1.3 Practical considerations for HPUE deployment

The fractional power control formula (2) can be simplified into the following

$$P_t = P_{\max} + \gamma CL - \gamma CL_{x-ile} \text{ for } CL < CL_{x-ile} \qquad (4)$$

Note that the unit in the formula above is dB. If a UE is close to its serving eNodeB so that $CL < CL_{x-ile}$, whether it's a 23dBm UE or a 33dBm UE, it should transmit similar power and the transmitted power should be less than 23dBm. The 33dBm UE extends the cell range by being able to transmit more than 23dBm power at areas where the 23dBm UE can only transmit its maximum power of 23dBm.

From (4), we have $P_{t1} = P_{\max 1} + \gamma CL - \gamma CL_{x-ile1}$ and $P_{t2} = P_{\max 2} + \gamma CL - \gamma CL_{x-ile2}$, where P_{t1} denotes the transmit power of a 23dBm UE at a location with coupling loss CL, and P_{t2} denotes the transmit power of a 33dBm UE at a location with the path loss of PL. Based on the reasoning above, we have $P_{t1} = P_{t2}$. Hence

$$CL_{x-ile2} = CL_{x-ile1} + {(P_{\max 2} - P_{\max 1})}/{\gamma} \qquad (5)$$

where:

$P_{\max 2} = 33dBm$ and $P_{\max 1} = 23dBm$

Based on (5) and Table 5.4.1.2-2, the new power control parameters for HPUE is obtained in the following table,

Table 5.4.1.3-1: Power control algorithm parameters for HPUE at 700MHz band

Parameter set	Gamma	CLx-ile (10MHz bandwidth, 45m antenna height)
		8km cell range
Set 1	1	121
Set 2	0.8	138.5

The power control parameters for both B13 system and B14 system are summarized in the Table 5.4.1.3-2.

Table 5.4.1.3-2: Power control algorithm parameters for LTE UE at 700MHz band

Parameter set	Gamma	CLx-ile (10MHz bandwidth, 45m antenna height)		
		4km cell range 200mW UE	8km cell range HPUE(33dBm)	8km cell range HPUE (31dBm)
Set 1A	1	111	121	119
Set 2A	0.8	126	138.5	136

In addition to the parameter sets defined in Table 5.4.1.3-2, it is also proposed to run simulations with the more aggressive power control parameter sets defined in Table 5.4.1.3-3

Table 5.4.1.3-3: Power control algorithm parameters for LTE UE at 700MHz band

Parameter set	Gamma	CLx-ile (10MHz bandwidth, 45m antenna height)	
		4km cell range 200mW UE	8km cell range HPUE
Set 1B	1	111	117
Set 2B	0.8	126	134.5

5.4.1.4 Cell layout

For B14 system with HPUE, the cell size should be bigger than a B13 system with 200mW UEs. Figure 5.4.1.4-1 shows overlay of two systems with different cell ranges. In particular, the cell range of B14 system (in green) is double the cell range of B13 (in blue). Figure 5.4.1.4-1 shows the worst case in the sense that some of the B13 sites are located at the cell edge of B14 system.

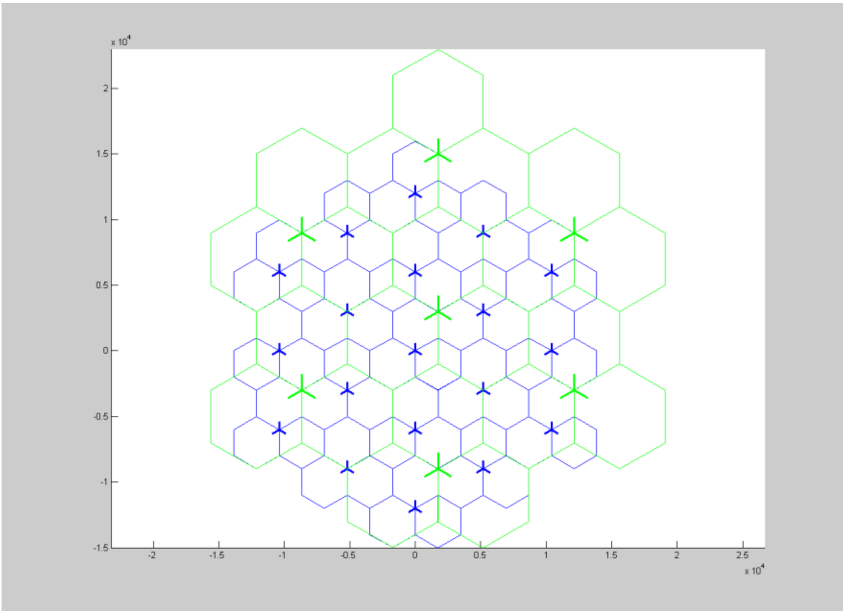


Figure 5.4.1.4-1 Multi system cell layout with different cell radius

5.4.1.5 Other simulation assumptions

Other simulation assumptions are summarized in the following tables:

Table 5.4.1.5-1: Simulation parameters for Band 13 or B14 LTE system with low power UE

	Base Station	UE
Carrier frequency	790 MHz	
Channel bandwidth	10 MHz	
Cell range	4km	
Cell layout	Wrap-around 19 tri-sector cells, uncoordinated	
Frequency reuse	1x3x1	
Pathloss model	94.5+34 log(R), R in km	
Lognormal fading	10 dB	
Antenna gain and horizontal antenna pattern	$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right]$ 15 dBi, θ_{3dB} = 65 degrees, *Am* = 20 dB	Omni-directional antenna with -6 dBi.
Noise figure	5 dB	9 dB
Transmit power	46 dBm	23 dBm
Antenna height	45 m	1.5 m
ACLR	45 dB	Use Table 5.2 in [2] ACLR1: 30+X, ACLR2: 43+X
ACS	45 dB	33 dB

Table 5.4.1.5-2: Simulation parameters for Band 14 LTE system with HPUE

	Base Station	HPUE
Carrier frequency	790 MHz	
Channel bandwidth	10 MHz	
Cell range	8km	
Cell layout	Wrap-around 7 tri-sector cells, uncoordinated (see Figure 5.4.1.4-1)	
Frequency reuse	1x3x1	
Pathloss model	94.5+34log(R), R in km	
Lognormal fading	10 dB	
Antenna gain and horizontal antenna pattern	$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right]$ 15 dBi, θ_{3dB} = 65 degrees, *Am* = 20 dB	Omni-directional antenna -1dBi for vehicle mounted mobile.
Noise figure	5 dB	9 dB
Transmit power	46 dBm	33 dBm/31 dBm
Antenna height	45 m	1.5 m
ACLR	45 dB	Use Table 5.2 in [2] ACLR1: 30+X, ACLR2: 43+X
ACS	45 dB	33 dB

5.4.1.6 Simulation procedure

For the co-existence study, the following should be performed:

1) Run the B14 UL to B13 UL coexistence study assuming parameters of both systems are according to Table 5.4.1.5-1. Power control parameters in Table 5.4.1.3-2 (set 1A and 2A) and 5.4.1.3-3 (set 1B and 2B) are used . This corresponds to the coexistence of two commercial LTE networks operating in adjacent bands and with similar deployment parameters. This is used as the reference. B13 system performance degradation results in this scenario are used as the baseline.

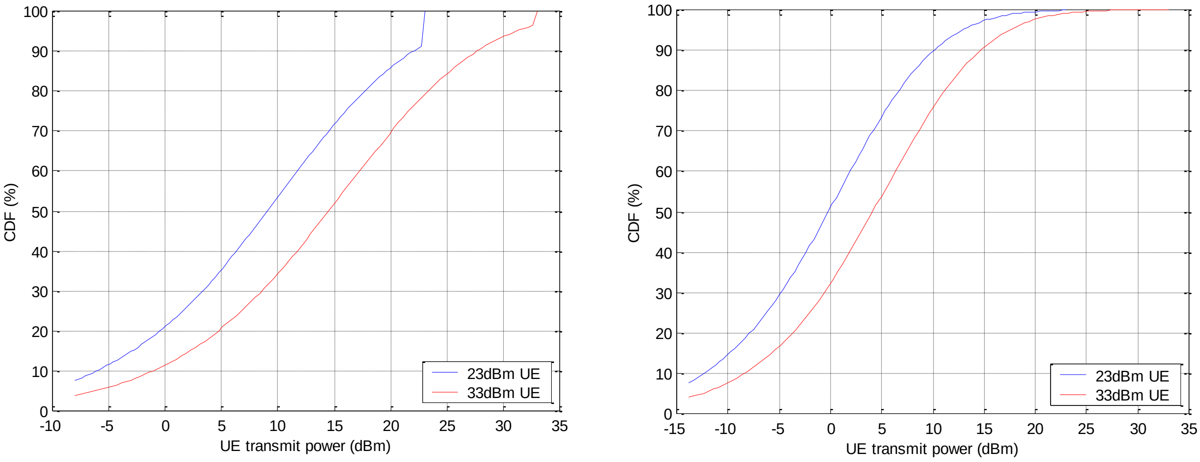
2) Run the B14 UL to B13 UL coexistence study assuming [+33dBm] power class UE is deployed in B14, obtain the B13 system performance degradation results The power control parameters in Table 5.4.1.3-2 and Table 5.4.1.3-3 are used.

3) Compare the B13 system performance degradation in 2) and 1), choose ACLR value for the HPUE so that the B13 performance degradation due to HPUE in 2) is comparable to 1).

5.4.2 Simulation results

5.4.2.1 Alcatel-Lucent simulation results

The UE transmit power CDFs are plotted in figure 5.4.2.1-1 for both B14 200mW UE and HPUE UE using power control parameter sets 1A/2A.



5.4.2.1-1 B14 UE Tx power CDF using power control set 1A (left figure) and 2A (right figure)

Table 5.4.2.1-1 shows the simulation results using power control parameter sets 1A/2A.

Table 5.4.2.1-1 B13 uplink relative throughput loss due to B14 UE interference with power control set 1A/2A

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	10.88%	14.85%	8.04%	11.36%	16.59%	34.71%	10.7%	18.35%
-10	4.88%	4.95%	3.39%	3.86%	8.38%	13.04%	4.91%	6.73%
-5	2.05%	1.68%	1.35%	1.09%	3.98%	4.8%	2.12%	2.5%
0	0.87%	0.47%	0.55%	0.37%	1.91%	1.55%	0.93%	0.92%
+5	0.43%	0.26%	0.27%	0.21%	1.05%	0.6%	0.47%	0.4%
+10	0.28%	0.13%	0.17%	0.14%	0.72%	0.25%	0.31%	0.2%
+15	0.23%	0.06%	0.14%	0.12%	0.6%	0.17%	0.26%	0.17%

Figure 5.4.2.1-2 and 5.4.2.1-3 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1A and set 2A, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

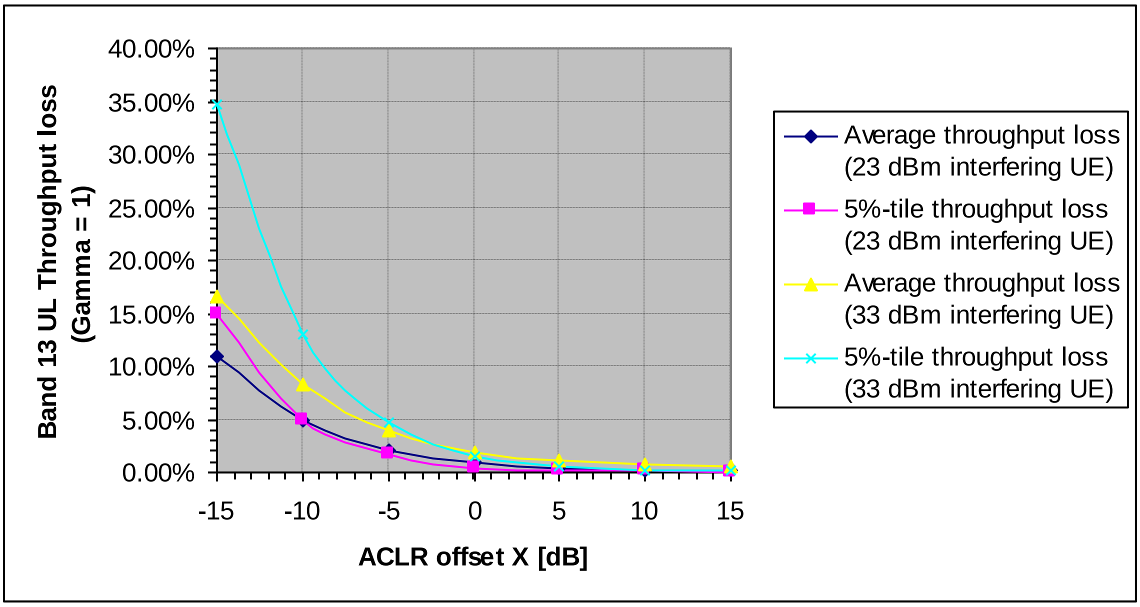


Figure 5.4.2.1-2 B13 uplink throughput degradation with power control parameter set 1A

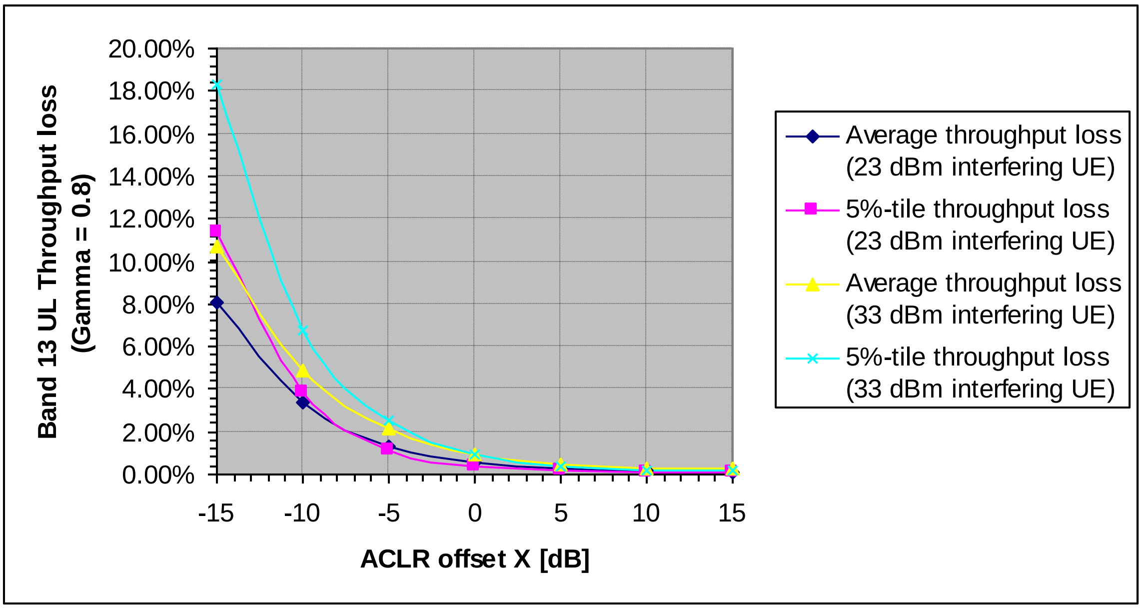
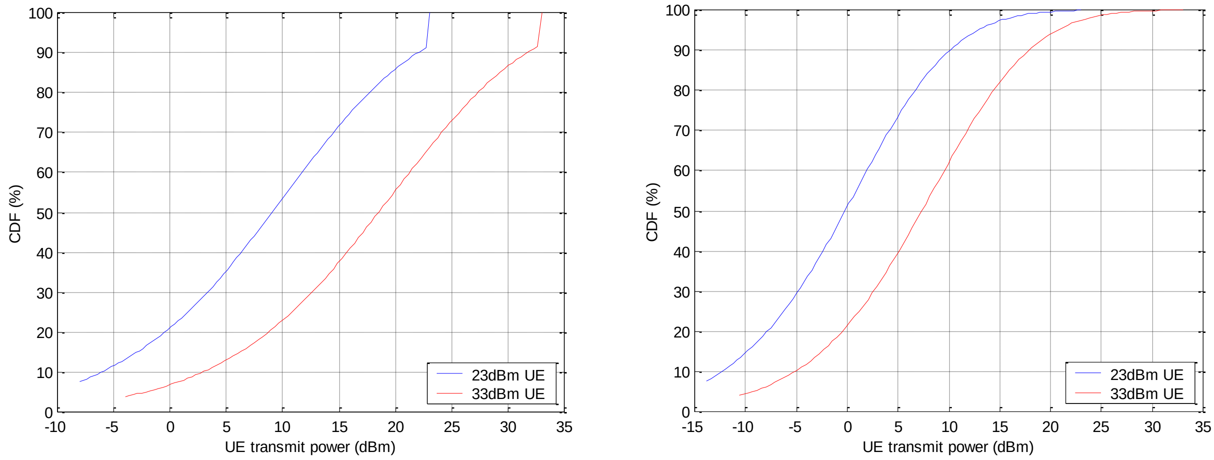


Figure 5.4.2.1-3 B13 uplink throughput degradation with power control parameter set 2A

The UE transmit power CDFs are plotted in figure 5.4.2.1-4 for both B14 200mW UE and HPUE UE using power control parameter sets 1B/2B.



5.4.2.1-4 B14 UE Tx power CDF using power control set 1B (left figure) and 2B (right figure)

Table 5.4.2.1-2 shows the simulation results using power control parameter sets 1B/2B.

Table 5.4.2.1-2 B13 uplink relative throughput loss due to B14 UE interference with power control set 1B/2B

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
	Power control set 1B		Power control set 2B		Power control set 1B		Power control set 2B	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	10.88%	14.85%	8.04%	11.36%	25.92%	58.34%	16.8%	31.96%
-10	4.88%	4.95%	3.39%	3.86%	14.14%	26.98%	8.28%	13.17%
-5	2.05%	1.68%	1.35%	1.09%	7.17%	9.52%	3.8%	5.06%
0	0.87%	0.47%	0.55%	0.37%	3.63%	3.33%	1.76%	1.94%
+5	0.43%	0.26%	0.27%	0.21%	2.07%	1.37%	0.93%	0.98%
+10	0.28%	0.13%	0.17%	0.14%	1.45%	0.66%	0.62%	0.52%
+15	0.23%	0.06%	0.14%	0.12%	1.22%	0.52%	0.52%	0.45%

Figure 5.4.2.1-5 and 5.4.2.1-6 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1B and set 2B, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

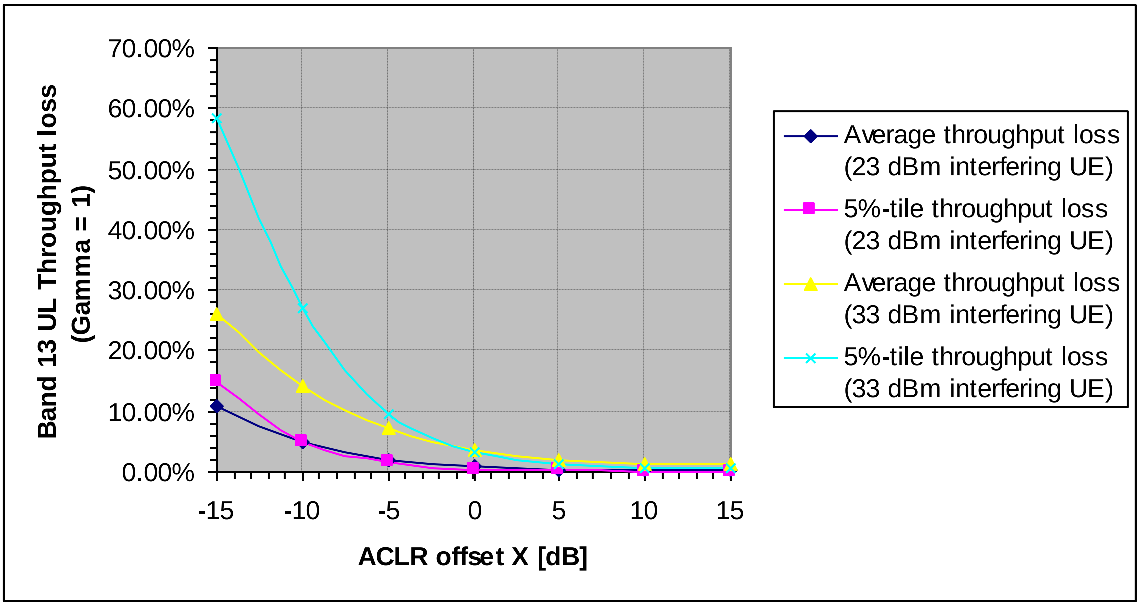


Figure 5.4.2.1-5 B13 uplink throughput degradation with power control parameter set 1B

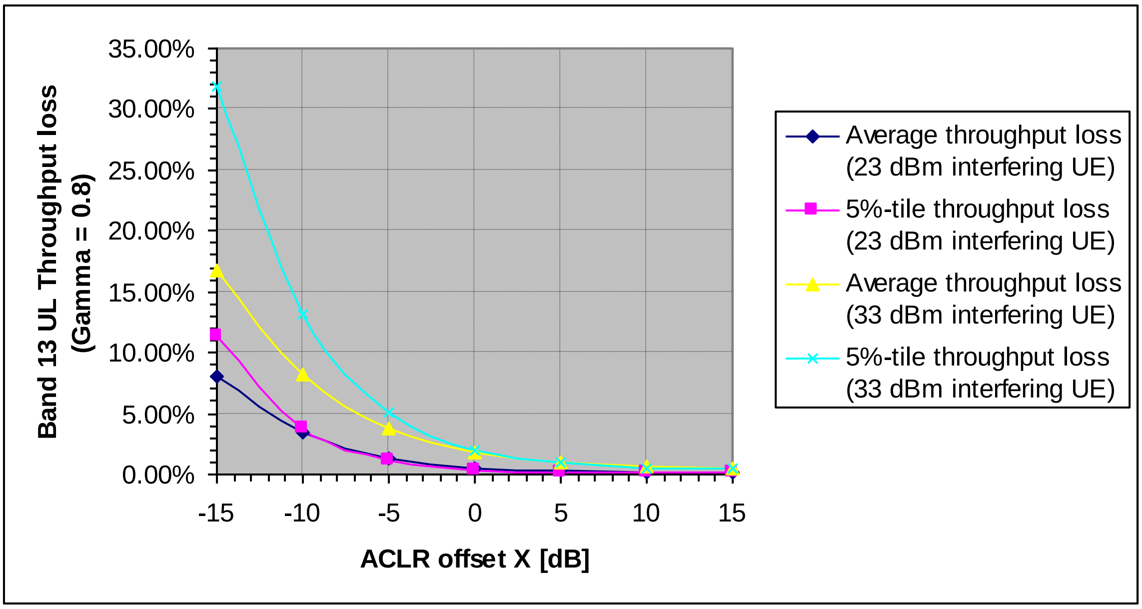
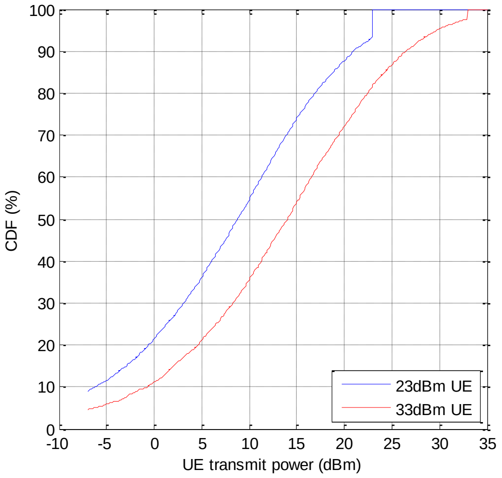


Figure 5.4.2.1-6 B13 uplink throughput degradation with power control parameter set 2B

5.4.2.2 EADS simulations results

The UE transmit power CDFs are plotted in figure 5.4.2.2-1 for both B14 200mW UE and HPUE UE using power control parameter sets 1A/2A.



5.4.2.2-1 B14 UE Tx power CDF using power control set 1A (left figure) and 2A (right figure)

Table 5.4.2.2-1 shows the simulation results using power control parameter sets 1A/2A.

Table 5.4.2.2-1 B13 uplink relative throughput loss due to B14 UE interference with power control set 1A/2A

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-10	5.8%	10.2%	4.2%	5.5%	9.2%	18.3%	5.3%	9.3%
-5	2.6%	3.6%	1.8%	1.8%	4.4%	7.3%	2.3%	3.3%
0	1.1%	1.0%	0.8%	0.6%	2.1%	2.5%	1.0%	1.2%
+5	0.54%	0.3%	0.35%	0.2%	1.1%	0.9%	0.5%	0.5%
+10	0.33%	0.2%	0.2%	0.16	0.7%	0.4%	0.3%	0.2%

Figure 5.4.2.2-2 and 5.4.2.2-3 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1A and set 2A, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

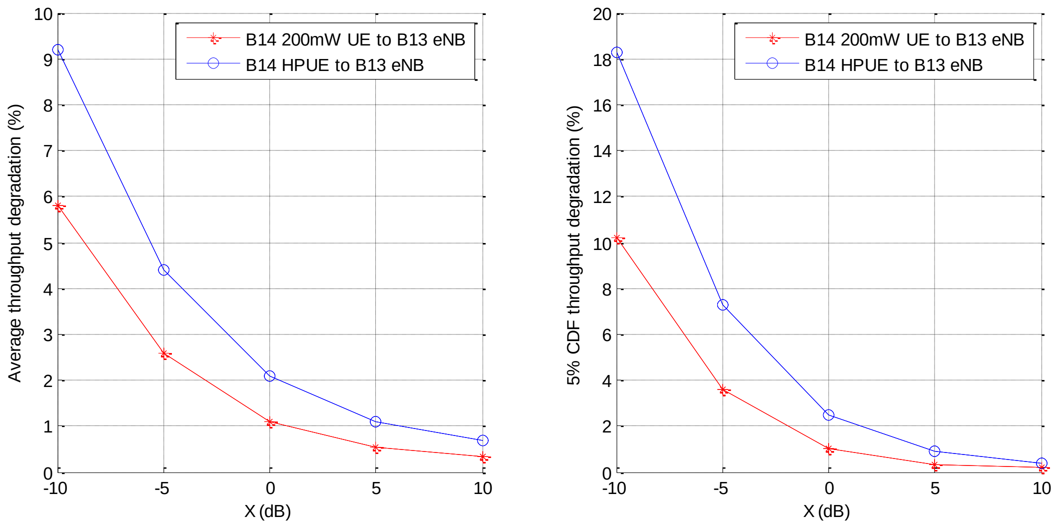


Figure 5.4.2.2-2 B13 uplink throughput degradation with power control parameter set 1A

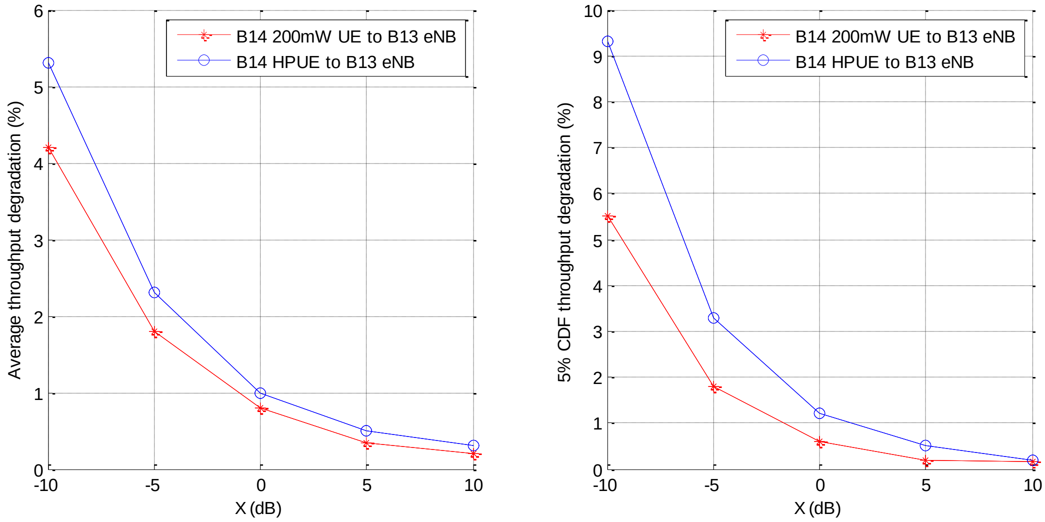
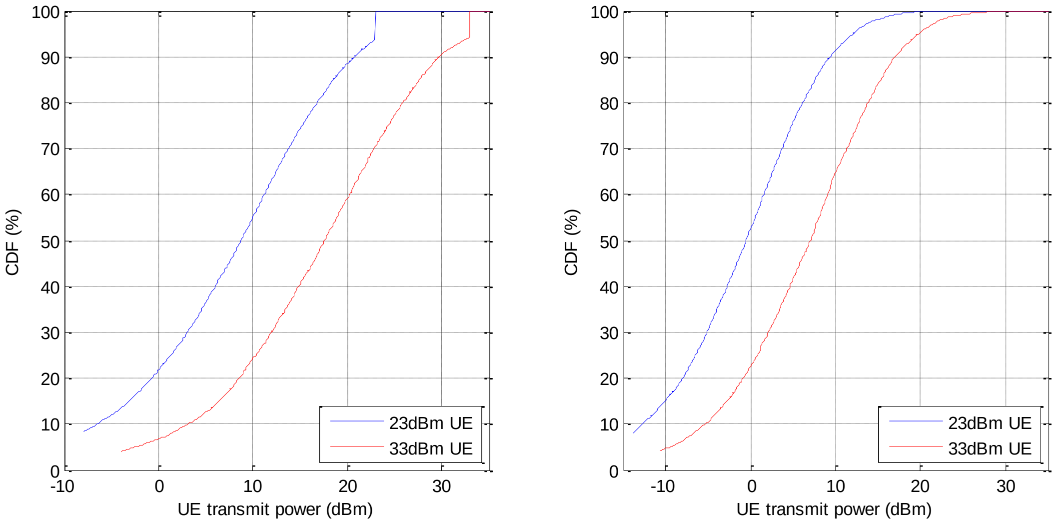


Figure 5.4.2.2-3 B13 uplink throughput degradation with power control parameter set 2A

The UE transmit power CDFs are plotted in figure 5.4.2.2-4 for both B14 200mW UE and HPUE UE using power control parameter sets 1B/2B.



5.4.2.2-4 B14 UE Tx power CDF using power control set 1B (left figure) and 2B (right figure)

Table 5.4.2.2-2 shows the simulation results using power control parameter sets 1B/2B.

Table 5.4.2.2-2 B13 uplink relative throughput loss due to B14 UE interference with power control set 1B/2B

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
	Power control set 1B		Power control set 2B		Power control set 1B		Power control set 2B	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-10	5.8%	10.2%	4.2%	5.5%	14.9%	34.4%	8.9%	17.3%
-5	2.6%	3.6%	1.8%	1.8%	7.6%	13.3%	4.1%	6.5%
0	1.1%	1.0%	0.8%	0.6%	3.8%	5.1%	1.9%	2.5%
+5	0.54%	0.3%	0.35%	0.2%	2.1%	2.0%	1.0%	0.8%
+10	0.33%	0.2%	0.2%	0.16%	1.4%	0.9%	0.6%	0.5%
+15					1.2%	0.6%	0.5%	0.4%

Figure 5.4.2.2-5 and 5.4.2.2-6 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1B and set 2B, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

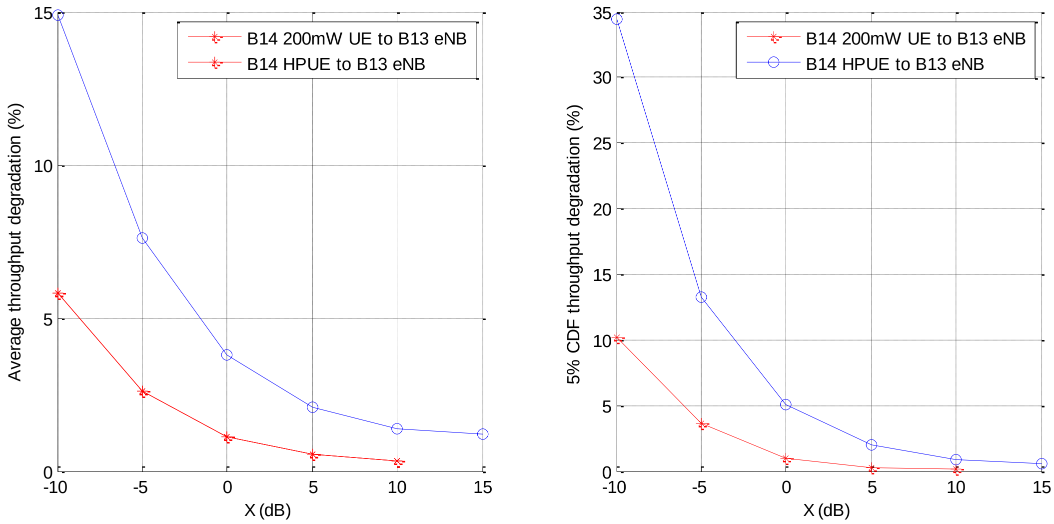


Figure 5.4.2.2-5 B13 uplink throughput degradation with power control parameter set 1B

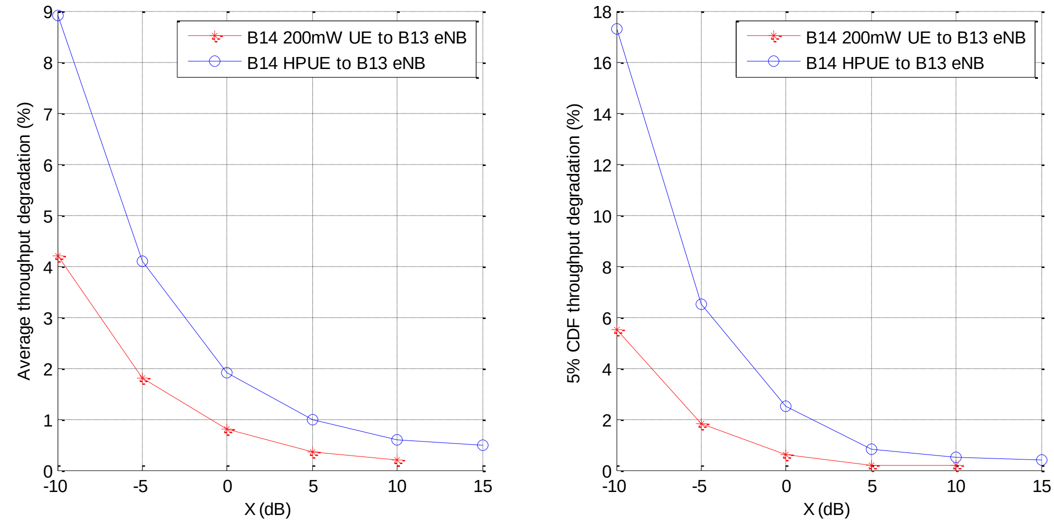


Figure 5.4.2.2-6 B13 uplink throughput degradation with power control parameter set 2B

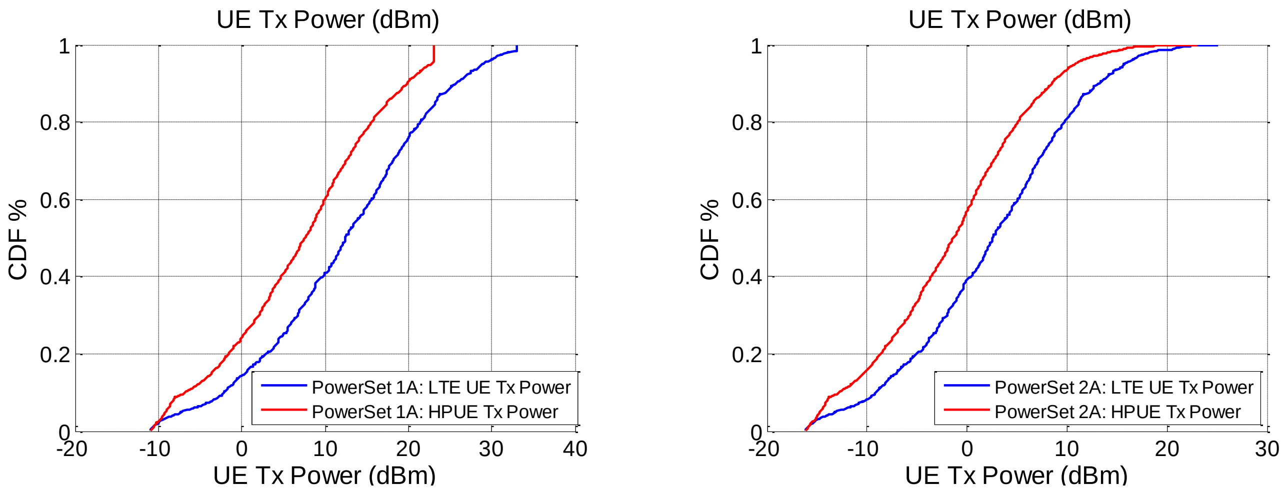
Table 5.4.2.2-3 shows the simulation results for 31dBm B14 HPUE using power control parameter sets 1A/2A.

Table 5.4.2.2-3 B13 uplink relative throughput loss due to B14 HPUE (31dBm) interference with power control set 1A/2A

	Baseline coexistence scenario				B14 HPUE (31dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-10	5.8%	10.2%	4.2%	5.5%	8.8%	16.7%	5.4%	9%
-5	2.6%	3.6%	1.8%	1.8%	4.2%	5.6%	2.4%	3.5%
0	1.1%	1.0%	0.8%	0.6%	1.9%	1.8%	1.0%	1.0%
+5	0.54%	0.3%	0.35%	0.2%	1.0%	0.7%	0.5%	0.45%
+10	0.33%	0.2%	0.2%	0.16%	0.7%	0.3%	0.3%	0.2%

5.4.2.3 Ericsson/ST-Ericsson simulation results

The UE transmit power CDFs are plotted in figure 5.4.2.3-1 for both B14 200mW UE and HPUE UE using power control parameter sets 1A/2A.



5.4.2.3-1 B14 UE Tx power CDF

Table 5.4.2.3-1 shows the simulation results using power control parameter sets 1A/2A.

Table 5.4.2.3-1 B13 uplink relative throughput loss (%) due to B14 UE interference with power control set 1A/2A

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	11.397849	15.676938	7.192663	11.781807	15.053181	27.480135	8.673625	14.588505
-10	5.473223	6.471574	3.148966	2.290374	7.665799	7.705104	3.992258	3.673097
-5	2.389756	2.183139	1.245274	0.757831	3.584052	3.237913	1.709417	0.716087
0	0.949274	0.683560	0.445704	0.009825	1.559678	1.494178	0.671539	0.098748
+5	0.344621	0.387275	0.148709	0.003107	0.629098	0.780903	0.242966	0.010779
+8	0.180986	0.083965	0.075584	0.001557	0.348901	0.172286	0.127417	0.005402
+10	0.116516	0.000937	0.047948	0.000983	0.231160	0.108775	0.081971	0.003409

Figure 5.4.2.3-2 and 5.4.2.3-3 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1A and set 2A, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

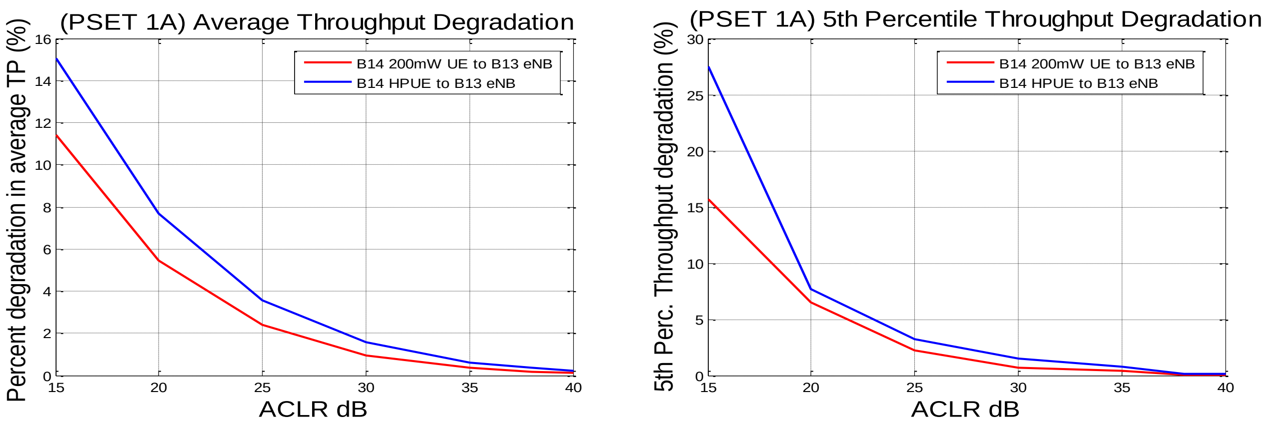


Figure 5.4.2.3-2 B13 uplink throughput degradation with power control parameter set 1A

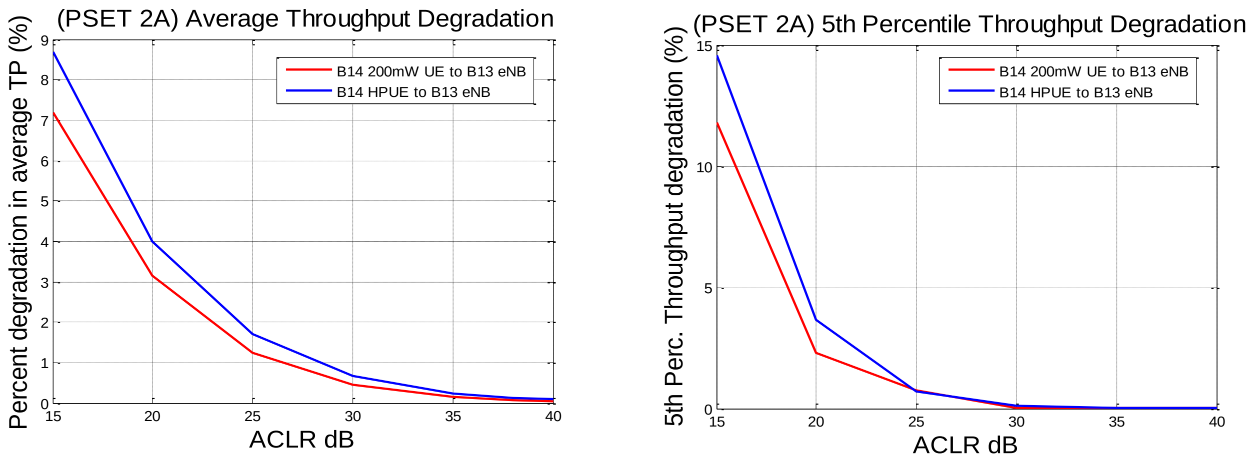
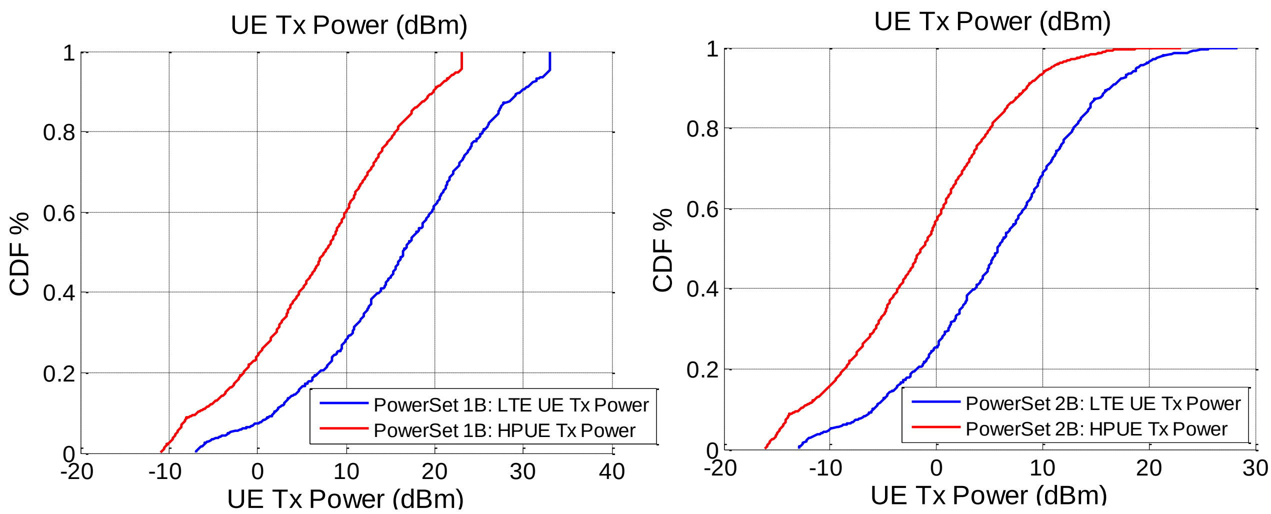


Figure 5.4.2.3-3 B13 uplink throughput degradation with power control parameter set 2A

The UE transmit power CDFs are plotted in figure 5.4.2.3-4 for both B14 200mW UE and HPUE UE using power control parameter sets 1B/2B.



5.4.2.3-4 B14 UE Tx power CDF

Table 5.4.2.3-2 shows the simulation results using power control parameter sets 1B/2B.

Table 5.4.2.3-2 B13 uplink relative throughput loss (%) due to B14 UE interference with power control set 1B/2B

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
	Power control set 1B		Power control set 2B		Power control set 1B		Power control set 2B	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	11.397849	15.676938	7.192663	11.781807	23.378193	49.449412	13.564972	27.482387
-10	5.473223	6.471574	3.148966	2.290374	12.802092	21.205633	6.609237	10.099587
-5	2.389756	2.183139	1.245274	0.757831	6.315554	6.569621	2.952202	1.539614
0	0.949274	0.683560	0.445704	0.009825	2.878830	2.078105	1.222221	0.254836
+5	0.344621	0.387275	0.148709	0.003107	1.223578	1.025349	0.465787	0.085555
+8	0.180986	0.083965	0.075584	0.001557	0.701760	0.787467	0.250640	0.022145
+10	0.116516	0.000937	0.047948	0.000983	0.476735	0.738735	0.163407	0.007121

Figure 5.4.2.3-5 and 5.4.2.3-6 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1B and set 2B, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

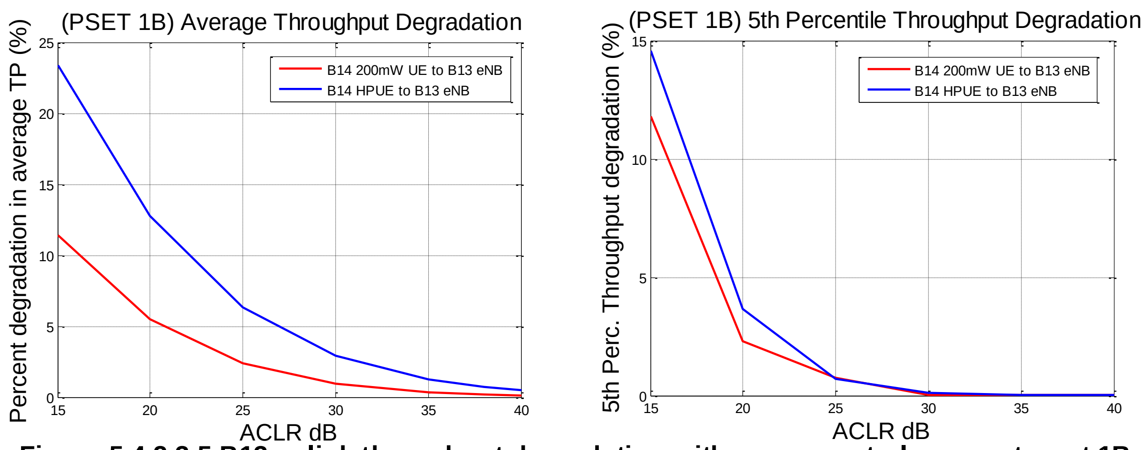


Figure 5.4.2.3-5 B13 uplink throughput degradation with power control parameter set 1B

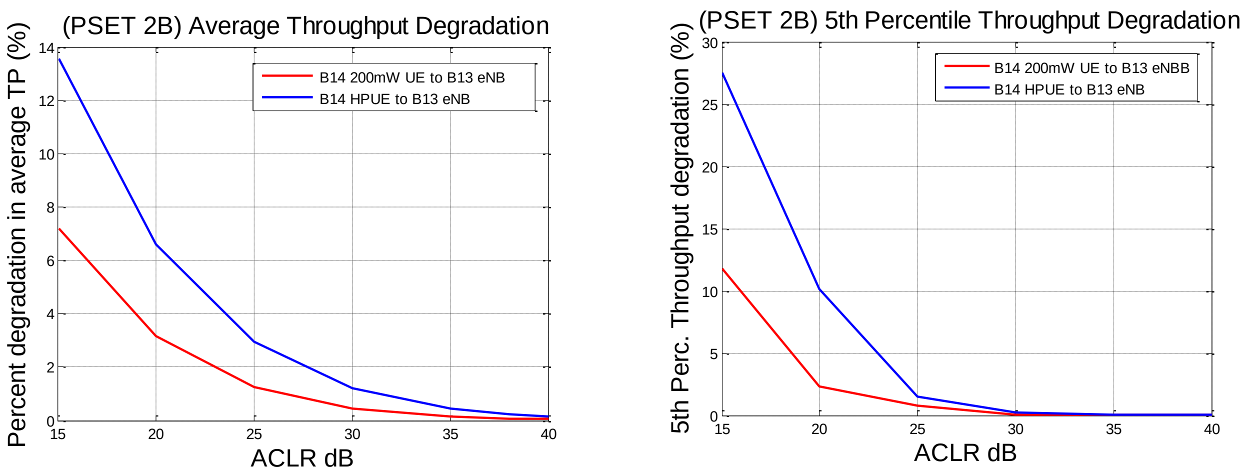


Figure 5.4.2.3-6 B13 uplink throughput degradation with power control parameter set 2B

Table 5.4.2.3-3 shows the simulation results for 31dBm B14 HPUE using power control parameter sets 1A/2A.

Table 5.4.2.3-3 B13 uplink relative throughput loss due to B14 HPUE (31dBm) interference with power control set 1A/2A

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (31dBm) coexistence scenario			
	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	10.6179	17.8487	7.5870	10.9312	13.9812	27.5762	7.9134	13.2569
-10	4.9198	4.6206	3.2761	4.3368	6.9268	9.3609	3.5101	4.1050
-5	2.1167	1.9407	1.3002	1.1260	3.1278	3.3470	1.4391	1.1041
0	0.8468	0.6873	0.4724	0.1374	1.3180	1.4474	0.5494	0.6815
+5	0.3100	0.0038	0.1596	0.0435	0.5173	0.0281	0.1947	0.0721
+8	0.1631	0.0019	0.0815	0.0218	0.2863	0.0141	0.1013	0.0247
+10	0.1051	0.0012	0.0518	0.0138	0.1903	0.0089	0.0649	0.0156

5.4.2.4 General Dynamics Broadband simulation results

Table 5.4.2.4-1 shows the simulation results using power control parameter sets 1A/2A.

Table 5.4.2.4-1 B13 uplink relative throughput loss due to B14 UE interference with power control set 1A/2A

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	11.81	20.62	9.27	17.05	17.15	41.94	11.51	25.10
-10	5.57	7.00	4.17	6.14	8.69	15.26	5.38	8.62
-5	2.43	2.34	1.75	1.87	4.15	5.15	2.35	2.87
0	1.06	0.57	0.73	0.54	2.00	1.67	1.04	0.91
+5	0.53	0.23	0.35	0.20	1.06	0.72	0.51	0.38
+8	0.32	0.11	0.21	0.10	0.67	0.27	0.31	0.19
+10	0.25	0.09	0.16	0.08	0.52	0.21	0.24	0.14

Table 5.4.2.4-2 shows the simulation results using power control parameter sets 1B/2B.

Table 5.4.2.4-2 B13 uplink relative throughput loss due to B14 UE interference with power control set 1B/2B

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1B		Power control set 2B		Power control set 1B		Power control set 2B	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	11.81	20.62	9.27	17.05	26.44	60.50	17.84	40.73
-10	5.57	7.00	4.17	6.14	14.66	34.24	8.93	17.65
-5	2.43	2.34	1.75	1.87	7.47	11.55	4.20	6.20
0	1.06	0.57	0.73	0.54	3.80	4.19	1.96	2.24
+5	0.53	0.23	0.35	0.20	2.07	1.50	0.99	0.86
+8	0.32	0.15	0.21	0.10	1.38	0.70	0.62	0.46
+10	0.25	0.09	0.16	0.08	1.13	0.51	0.51	0.35

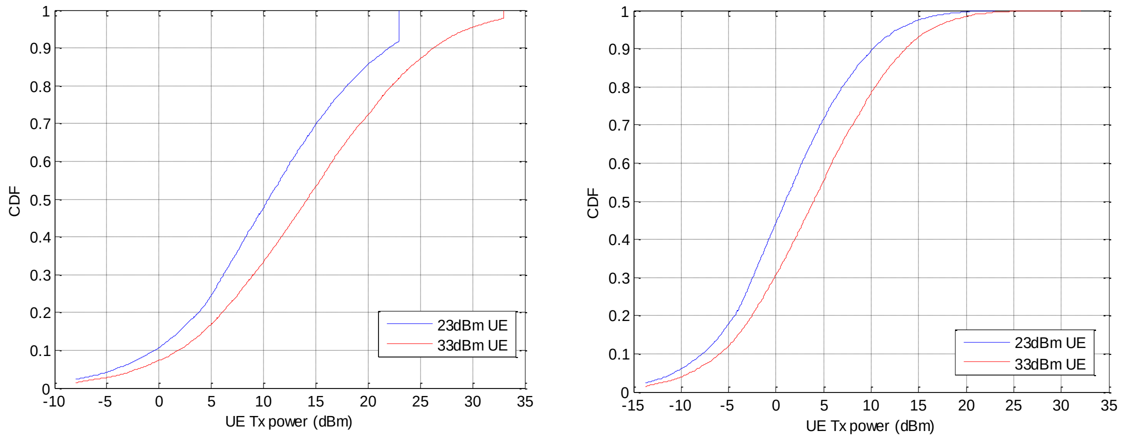
Table 5.4.2.4-3 shows the simulation results for 31dBm B14 HPUE using power control parameter sets 1A/2A.

Table 5.4.2.4-3 B13 uplink relative throughput loss due to B14 HPUE (31dBm) interference with power control set 1A/2A

	Baseline +23dBm UE coexistence scenario				HPUE (+31dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average	5th %ile	Average	5th %ile	Average	5th %ile	Average	5th %ile
-15	11.81	20.62	9.27	17.05	16.8	42.0	11.51	24.9
-10	5.57	7.00	4.17	6.14	8.5	14.7	5.37	8.90
-5	2.43	2.34	1.75	1.87	4.1	4.9	2.33	2.80
0	1.06	0.57	0.73	0.54	1.94	1.68	1.04	0.93
+5	0.53	0.23	0.35	0.20	1.00	0.60	0.50	0.33
+10	0.32	0.11	0.21	0.10	0.65	0.29	0.31	0.19
+15	0.25	0.09	0.16	0.08	0.52	0.19	0.25	0.13

5.4.2.5 Motorola Solutions simulation results

The UE transmit power CDFs are plotted in figure 5.4.2.5-1 for both B14 200mW UE and HPUE UE using power control parameter sets 1A/2A.



5.4.2.5-1 B14 UE Tx power CDF using power control set 1A (left) and 2A (right)

Table 5.4.2.5-1 shows the simulation results using power control parameter sets 1A/2A.

Table 5.4.2.5-1 B13 uplink relative throughput loss due to B14 UE interference with power control set 1A/2A

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	8.8%	14.6%	6.9%	13%				
-10	3.9%	5.2%	2.9%	4.8%	7.2%	12%	4.5%	7.5%
-5	1.6%	1.8%	1.2%	1.6%	3.3%	4.2%	1.9%	2.5%
0	0.72%	0.6%	0.5%	0.5%	1.5%	1.4%	0.8%	0.9%
+5	0.37%	0.28%	0.27%	0.21%	0.8%	0.6%	0.4%	0.36%
+10					0.55%	0.28%	0.2%	0.2%

Figure 5.4.2.5-2 and 5.4.2.5-3 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1A and set 2A, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

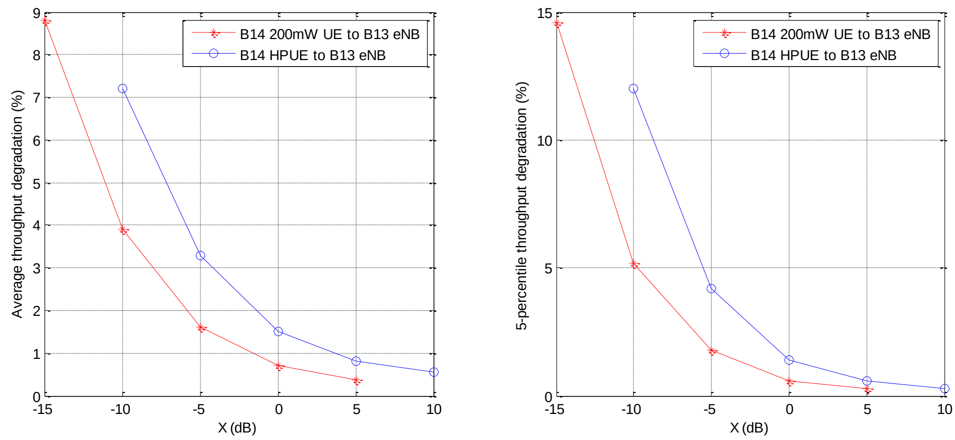


Figure 5.4.2.5-2 B13 uplink throughput degradation with power control parameter set 1A

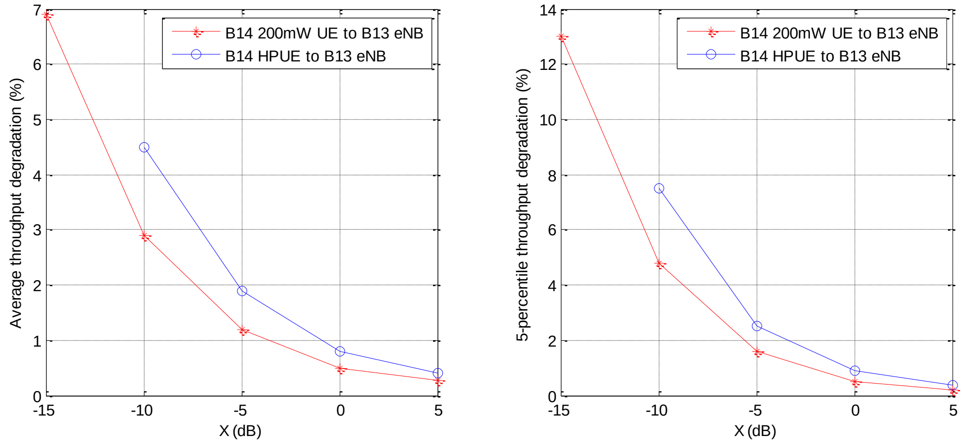
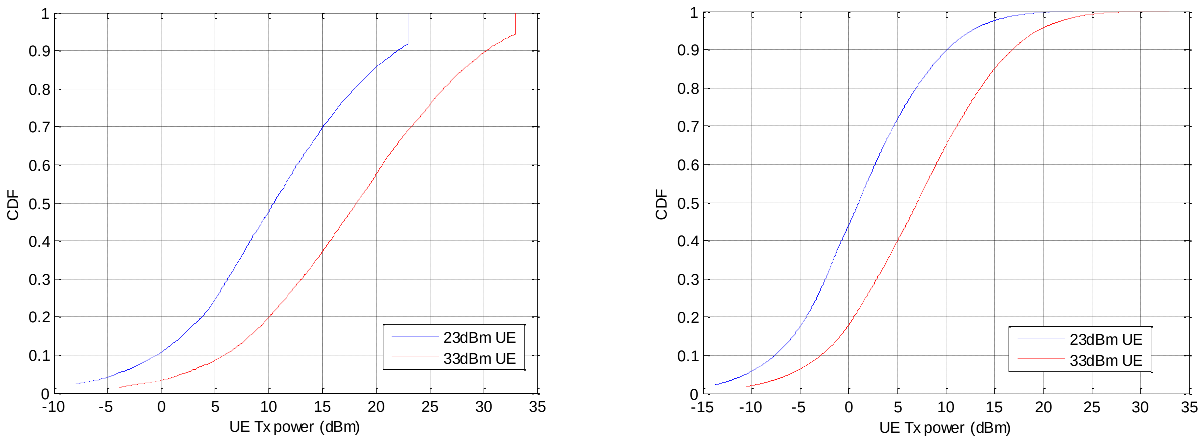


Figure 5.4.2.5-3 B13 uplink throughput degradation with power control parameter set 2A

The UE transmit power CDFs are plotted in figure 5.4.2.5-4 for both B14 200mW UE and HPUE UE using power control parameter sets 1B/2B.



5.4.2.5-4 B14 UE Tx power CDF using power control set 1B (left) and 2B (right)

Table 5.4.2.5-2 shows the simulation results using power control parameter sets 1B/2B.

Table 5.4.2.5-2 B13 uplink relative throughput loss due to B14 UE interference with power control set 1B/2B

	Baseline coexistence scenario				B14 HPUE (33dBm) coexistence scenario			
ACLR offset X (dB)	Power control set 1B		Power control set 2B		Power control set 1B		Power control set 2B	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	8.8%	14.6%	6.9%	13%				
-10	3.9%	5.2%	2.9%	4.8%	12%	24%	7.7%	14%
-5	1.6%	1.8%	1.2%	1.6%	6.2%	9.2%	3.5%	5.5%
0	0.72%	0.6%	0.5%	0.5%	3%	3.4%	1.6%	1.8%
+5	0.37%	0.28%	0.27%	0.21%	1.7%	1.3%	0.8%	0.7%
+10					1.2%	0.6%	0.5%	0.36%

Figure 5.4.2.5-5 and 5.4.2.5-6 shows the comparison of the HPUE coexistence scenario with the baseline scenario for power control parameter set 1B and set 2B, respectively. For the baseline scenario, X = 0dB corresponds to the ACLR value of 30dB.

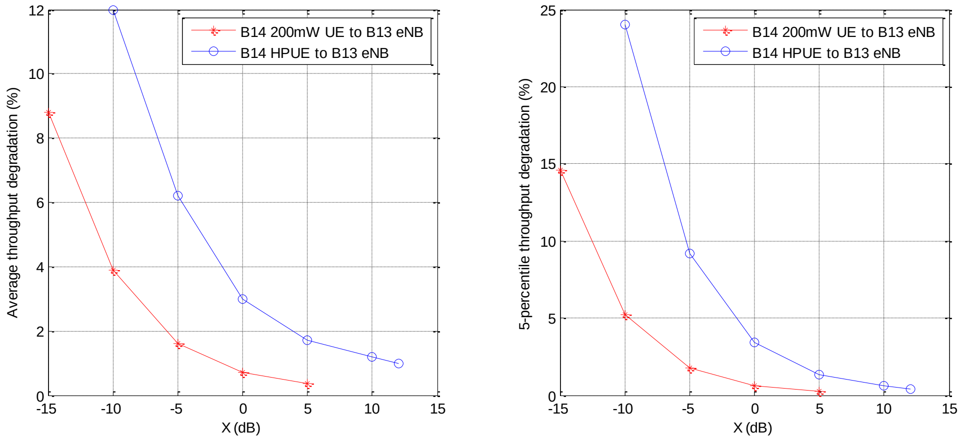


Figure 5.4.2.5-5 B13 uplink throughput degradation with power control parameter set 1B

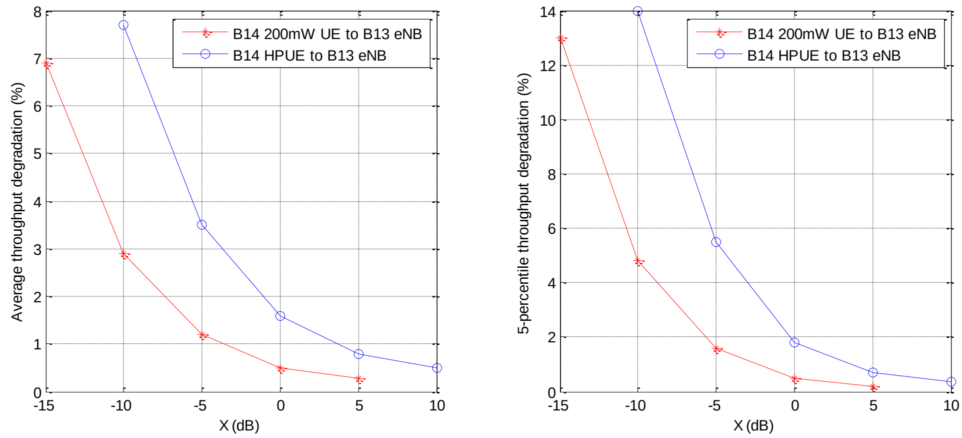


Figure 5.4.2.5-6 B13 uplink throughput degradation with power control parameter set 2B

Table 5.4.2.5-3 shows the simulation results for 31dBm B14 HPUE using power control parameter sets 1A/2A.

Table 5.4.2.5-3 B13 uplink relative throughput loss due to B14 HPUE (31dBm) interference with power control set 1A/2A

ACLR offset X (dB)	Baseline coexistence scenario				B14 HPUE (31dBm) coexistence scenario			
	Power control set 1A		Power control set 2A		Power control set 1A		Power control set 2A	
	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF	Average throughput	5% CDF
-15	8.8%	14.6%	6.9%	13%				
-10	3.9%	5.2%	2.9%	4.8%	6.3%	10.3%	4.5%	7.5%
-5	1.6%	1.8%	1.2%	1.6%	3.2%	4%	1.9%	2.5%
0	0.72%	0.6%	0.5%	0.5%	1.5%	1.4%	0.8%	0.8%
+3					1%	0.65%	0.5%	0.5%
+5	0.37%	0.28%	0.27%	0.21%	0.69%	0.49%		
+8					0.5%	0.24%	0.27%	0.2%

5.4.2.6 Combined Simulation results

Table 5.4.2.6-1 summarized the results based on all the simulation results.

Table 5.4.2.6-1 B14 HPUE (+33dBm) ACLR offset value (dB) to achieve similar interference as the baseline

Power control parameters	Company	Power control set 1		Power control set 2	
		Average throughput	5% CDF	Average throughput	5% CDF
1A/2A	Alcatel-Lucent	8	7	4	6
	EADS/Cassidian	5	4	2	4
	Ericsson	5	8	5	8
	General Dynamics Broadband	5	5	3	3
	Motorola Solutions	5	5	5	5
1B/2B	Alcatel-Lucent	>15	>15	14.5	>15
	EADS	>15	9.5	7.5	8.5
	Ericsson	8	10	8	10
	General Dynamics Broadband	>15	15	8.5	8.5
	Motorola Solutions	>10	10	10	10

Table 5.4.2.6-2 summarized the results based on all the simulation results for MOP 31dBm HPUE.

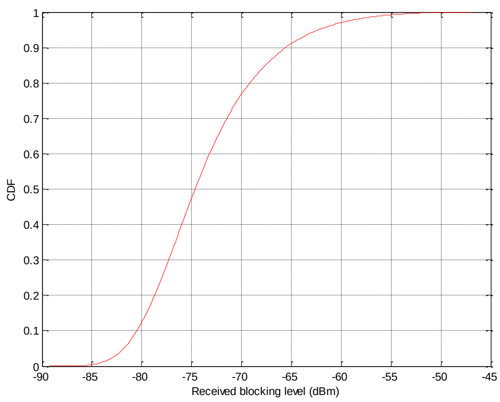
Table 5.4.2.6-2 B14 HPUE (+31dBm) ACLR offset value (dB) to achieve similar interference as the baseline

Power control Parameters	Company	Power control set 1A		Power control set 2A	
		Average throughput	5% CDF	Average throughput	5% CDF
1A/2A	Ericsson/ST-Ericsson	<5	<5	<5	<5
1A/2A	EADS	5	3.6	2	4
1A/2A	General Dynamics Broadband	4.6	5.4	2.9	3.3
1A/2A	Motorola Solutions	4.5	3.5	3	3

5.5 Additional co-existence scenarios

5.5.1 B14 HPUE blocking B13 eNB

This section looks at the blocking level received at B13 eNB due to B14 HPUE (33dBm MOP) by Monte Carlo simulation. The CDF curves of the interference seen by a victim B13 eNB based on different power control parameters are showed in figure 5.5.1-1 to 5.5.1-4.



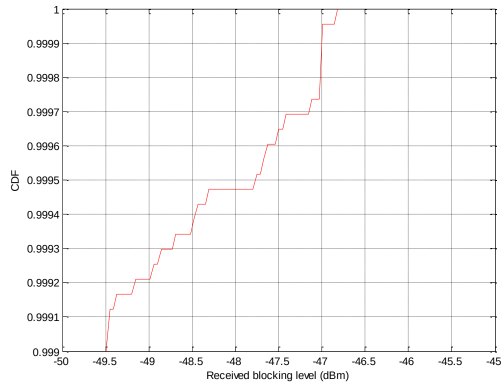


Figure 5.5.1-1 CDF of Band 13 eNB received blocking signal from 33 dBm Band 14 UE (PC set 1A)

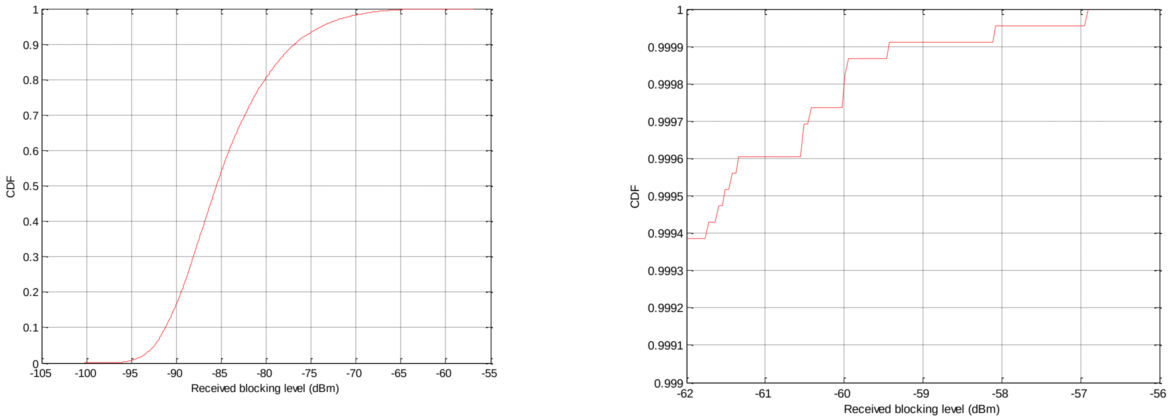


Figure 5.5.1-2 CDF of Band 13 eNB received blocking signal from 33 dBm Band 14 UE (PC set 2A)

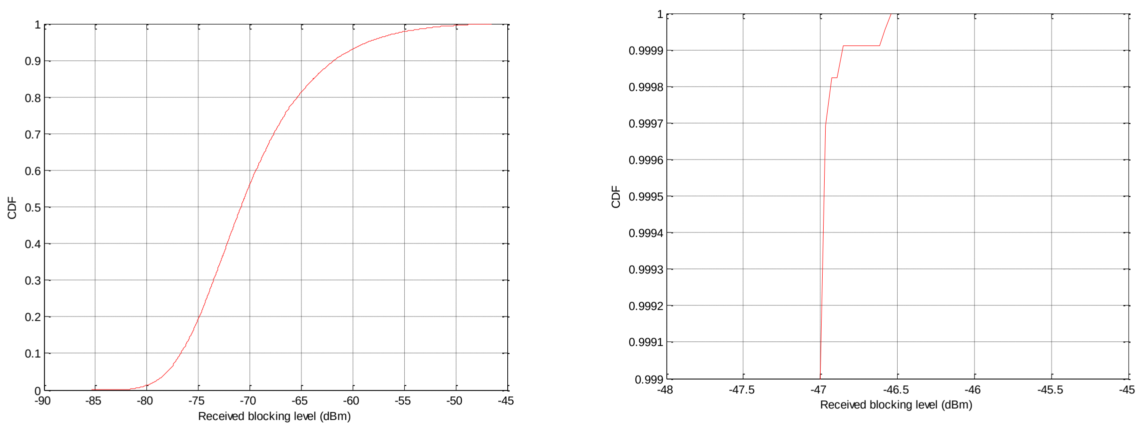


Figure 5.5.1-3 CDF of Band 13 eNB received blocking signal from 33 dBm Band 14 UE (PC set 1B)

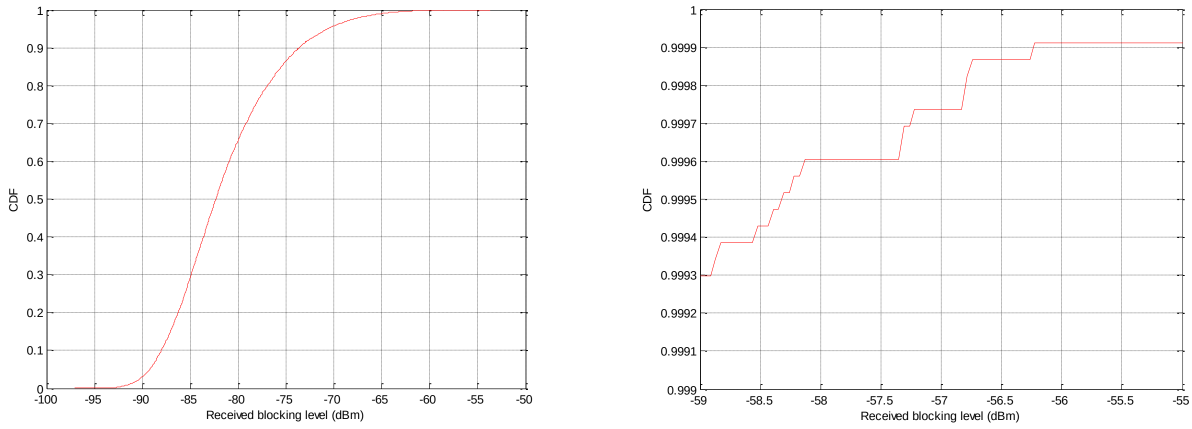


Figure 5.5.1-4 CDF of Band 13 eNB received blocking signal from 33 dBm Band 14 UE (PC set 2B)

Table 5.5.1-1 summarizes the blocking level at a probability of 99.99%.

Table 5.5.1-1: 99.99% point of Band 13 eNB received blocking signal level from Band 14 HPUE

	Power control parameters		Blocking for 99.99% probability
B14 HPUE	**1A**	Gamma = 1, CLxile = 121dB	-47dBm
	2A	Gamma = 0.8, CLxile = 138.5dB	-59.4dBm
	1B	Gamma = 1 CLxile = 117dB	-46.8dBm
	2B	Gamma = 0.8, CLxile = 134.5dB	-56.2dBm

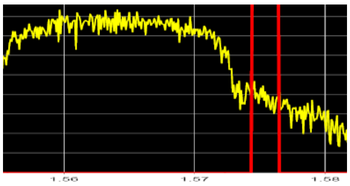
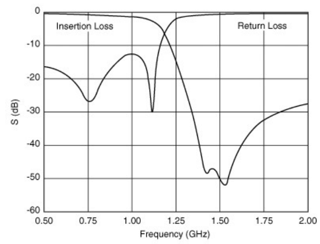
Note that the MOP for the HPUE has been reduced to 31dBm, the blocking level from 31dBm HPUE is expected to be 2dB lower.

5.5.2 B14 HPUE and GPS

In a typical UE handset the PA, SAW/BAW duplexer filter and antenna switch will generate 2nd harmonic component in the GPS pass-band. To provide mitigation it may be necessary to use a linear filter after the SAW/antenna switch. A HPUE will need to implement a high power linear PA, a high power linear mobile antenna switch and a high power linear ceramic duplexer filter which all help to reduce the 2nd harmonic component

In Table 5.5.2-1 we consider the GPS implementation issues for a HPUE B14 (vehicular devices) relative to a B14 (handset form factor)

Table 5.5.2-1; GPS considerations for B14 Power Class 1 and Power 3

Parameter	B14 handset form factor	B14 HPUE vehicular form factor
Transmit power	+23dBm	+31dBm target
PA 2nd harmonic emission level	-15 to -20 dBm	Similar since the linear PA is needed for HPUE but this is offset by the increase in MOT
2nd harmonic ACLR correction factor to PA 2nd harmonic emission 	20-30 dB PA 2nd harmonic emission level is reduced by ACLR correction factor which is a function of RB allocation , channel bandwidth and frequency offset to GPS band	For a HPUE the PA more stringent ACLR requirements can provide less 2nd harmonic emission into the GPS band
PA emission + duplexer filter rejection at GPS frequency	SAW / FBAR duplexer will also generate a 2nd harmonic component at GPS pass band which will reduce effective filter attenuation in GPS pass band  Typical IP2 is ~115 dBm	Ceramic duplex filter for HPUE has better IMD performance. Also filter attenuation is better & freq drift is low (Oppm)– offers better performance  Typical IP2 is ~170 dBm
Antenna switch	Typical handset antenna switches generate harmonics at GPS frequency and degrade the GPS sensitivity	High power mobile antenna switch has better IMD performance if used
Additional GPS linear filter	Additional linear low pass or notch filter can provide 20+dB attenuation at GPS frequency depending on implementation	Additional linear low pass filter can provide up to 50dB at GPS frequency if needed 
LTE – GPS isolation between GPS antenna port and LTE antenna port	Typically 10-15dB isolation for a handset form factor 	Typically 40-50dB isolation for a PSBB professional vehicle implementation 

The analysis show that that GPS impact due to an in-device GPS receiver will not be an issue for a HPUE vehicular deployment.

6 B14 HPUE transmitter characteristics

6.1 General

The LTE specification for HPUE Class 1 (vehicular mobile form factor) is expected to follow the general methodology in 3GPP TS36.101 for a Class 3 (handheld form factor) as closely as possible except where variations are warranted.

So that we can address these requirements we focus on a possible UE architecture in order to analyse the potential RF requirements. In order to minimize implementation complexity and utilise the Power Class 3 eco-system it is proposed that changes to the baseband IC and RF IC should be minimized and only changes to the discrete RF combining front end elements are considered. This follows the same approach as the single band LTE devices concept that is used to support multi-band operation where the complexity of multi band support is addressed in the RF combining front end.

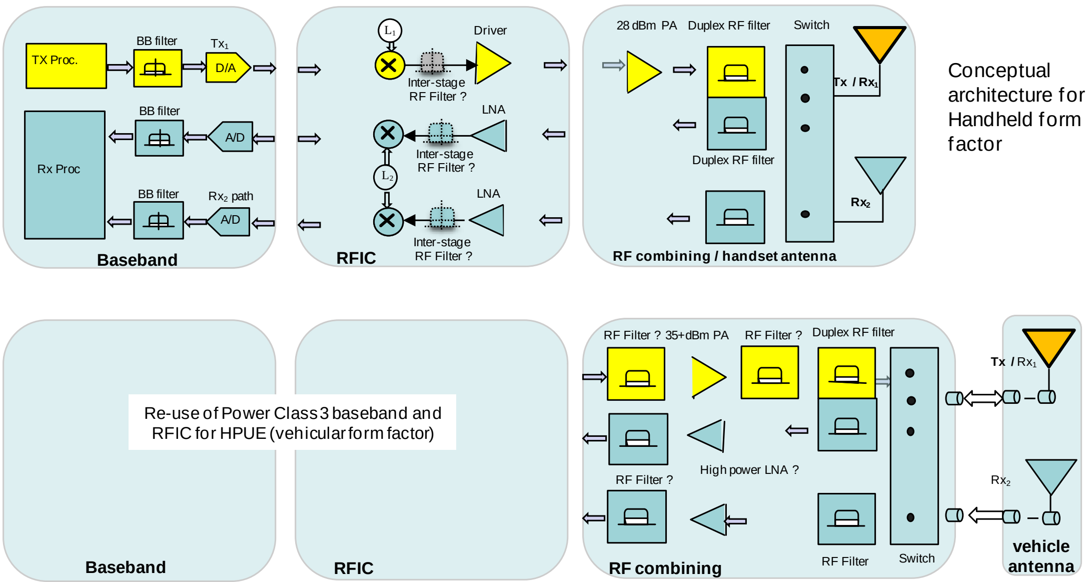


Figure 6-1; B14 RF architecture IC and RF IC for Power Class 1 and 3

The alignment of implementation assumptions for the RF combining front end would be similar to the methodology and components as used for the LTE base station.

The reason for this difference is that a conventional miniature Class 3 SAW handset duplexer filter cannot be used for the HPUE as they will not support the higher power rating/linearity or achieve the necessary filter attenuation and isolation between Tx and Rx ports due to the increase in Tx power from +23dBm to +31 dBm for a class 1 vehicular terminal.

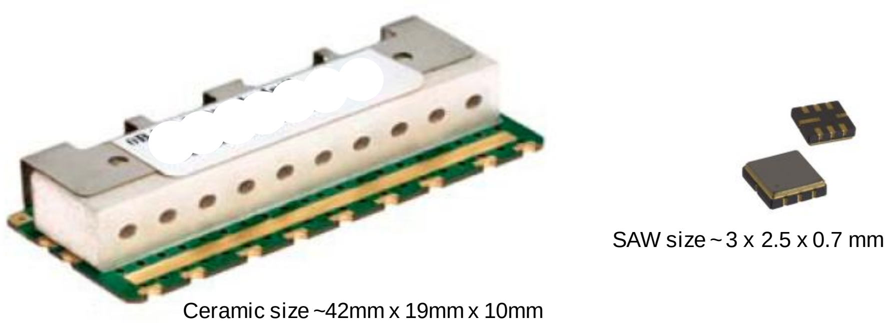


Figure 6-2; Typical B14 duplex filter for Power Class 1 (Ceramic) and Power Class 3 (SAW)

For the transmitter the key parameters which are affected by the increase in transmitter power are the RF spectrum emissions and associated tighter filtering requirements. To support this level of transmit power +31dBm and required linearity, larger (e.g. 42mm x 19mm x 10mm) ceramic or cavity filters will need to be used which have a different level of performance than the typical miniature low power SAW filters used for Power Class 3 terminals. In this case it should also be noted that the normal goals of a class 3 device in terms of size weight and battery are not key driver for vehicular deployment.

6.2 Transmit power

6.2.1 Void

6.2.2 UE maximum output power

In this subclause we propose the maximum output power, power class and tolerance should be defined as in line with the work item objectives as defined in RP-120362. This would be to add an additional higher Power class (Power Class 1) for B14 to the UE Power class table.

One key issue with the high power class is the associated MOP tolerance. The Power class tolerance is designed to address the following implementation issues;

- Maintaining the power tolerance over the increased dynamic range of +23 to +31/33 dBm
- Increase in operating temperature in a practical vehicular deployment for PS deployment
- Increased impact of temperature and mechanical tolerance with cascaded filter elements
- Additional filtering to support more 2nd harmonic suppression
- Additional filtering needed to support simultaneous multi-band operation for Public Safety deployment scenarios i.e. PSNB 700, PSNB 800MHz and commercial bands roaming

To address this aspect it is proposed the tolerance is specified as +2/-3 dB.

The following B14 UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth. The period of measurement shall be at least one sub frame (1ms)

Table 6.2.2-1: UE Power Class

EUTRA band	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)	Class 4 (dBm)	Tolerance (dB)
14	31	+2/-3			23	±2		

6.2.3 UE maximum output power for modulation / channel bandwidth

In this subclause we propose for Power Class 1 [33 dB] the maximum output power for modulation / channel bandwidth should follow the same methodology as the existing power class for B14 noting this requirement is band agnostic in TS36.101.

In this case we can remove the specific reference to Power class 3 in the existing TS36.101 specification or alternative add Power Class 1 as well. The preferred approach is to remove the specific reference to Power Class 3 so this requirement would be applicable to all the B14 power classes. The side conditions would be the same as i.e.

The allowed Maximum Power Reduction (MPR) for the maximum output power in Table 6.2.2-1due to higher order modulation and transmit bandwidth configuration (resource blocks) is specified in Table 6.2.3-1.

Table 6.2.3-1: Maximum Power Reduction (MPR)

Modulation	Channel bandwidth / Transmission bandwidth (N_{RB})						MPR (dB)
	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
QPSK	> 5	> 4	> 8	> 12	> 16	> 18	≤ [1]
16 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ [1]
16 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ [2]

6.2.4 UE maximum output power with additional requirements

Additional spectrum emission requirements can be signalled by the network to indicate that the UE shall also meet additional requirements in a specific deployment scenario. To meet these additional requirements, Additional Maximum Power Reduction (A-MPR) is allowed for the output power as specified in Table 6.2.2-1. Unless stated otherwise, an A-MPR of 0 dB shall be used.

Currently NS_06 is signalled for B14 in order to meet the FCC Part 27 requirements pertaining to D block. Since D block has been recently allocated to PSBB by US Congress it may be necessary to review if NS_06 should be mandatory signalled by the network to UE since PSBB would be expected to be covered by the Part 90 requirements for both B14 Power Class 1 and Power Class 3.

It is proposed to maintain the existing requirements for both Power Class 1 and Power Class 3 when NS_06 is signalled with an A-MPR of 0 dB

6.2.5 Configured transmitted power

The tolerances applicable to the measured configured maximum output power P_{UMAX} should be extended to accommodate the target transmit power of +31dBm referred to in subclause 6.2.3. Currently Table 6.2.5-1 [2] has an upper bound of +23dBm.

An additional row should be added into Table 6.2.5-1 as this gives the option for setting a different tolerance on the measured configured maximum output power for high power UEs, if so desired.

The number included in the proposed amendment should be enclosed within brackets for the following reasons:

- This can be used as a working assumption to until the conclusion of the co-existence work
- This can be used as a working assumption to progress the core RF requirements

Table 6.2.5-1: P_{CMAX} tolerance

P_{CMAX} (dBm)	Tolerance $T(P_{CMAX})$ (dB)
$23 \le P_{CMAX} \le 31$	2.0
$21 \le P_{CMAX} < 23$	2.0
$20 \le P_{CMAX} < 21$	2.5
$19 \le P_{CMAX} < 20$	3.5
$18 \le P_{CMAX} < 19$	4.0
$13 \le P_{CMAX} < 18$	5.0
$8 \le P_{CMAX} < 13$	6.0
$-40 \le P_{CMAX} < 8$	7.0

6.3 Output power dynamics

6.3.1 (Void)

6.3.2 Minimum output power

The minimum controlled output power of the UE is defined as the broadband transmit power of the UE, i.e. the power in the channel bandwidth for all transmit bandwidth configurations (resource blocks), when the power is set to a minimum value

The current B14 Power class 3 requirements are -40dBm for the supported channel bandwidth. If the same Power Class 3 requirements are specified for the HPUE, this results in a tighter implementation since a HPUE will need to support a larger dynamic range of 71dB (+31 to -40dBm) compared to the Power class 3 requirement of 63dB (+23 to -40dBm)

Proposal; to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device

6.3.3 Transmit OFF power

Transmit OFF power is defined as the mean power when the transmitter is OFF. The transmitter is considered to be OFF when the UE is not allowed to transmit or during periods when the UE is not transmitting a sub-frame. During DTX and measurements gaps, the UE is not considered to be OFF.

The current B14 Power class 3 requirements are -50dBm for supported channel bandwidth. If the same requirements are applicable for the HPUE, this results in a tighter implementation in OFF noise power ratio from 82dB (+31 to -50dBm) compared to the Power class 3 requirements of 73dB (+23 to -50dBm)

Proposal; to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device

6.3.4 ON/OFF time mask

The General ON/OFF time mask defines the observation period between Transmit OFF and ON power and between Transmit ON and OFF power. ON/OFF scenarios include; the beginning or end of DTX, measurement gap, contiguous, and non contiguous transmission. The OFF power measurement period is defined in a duration of at least one sub-frame excluding any transient periods. The ON power is defined as the mean power over one sub-frame excluding any transient period.

If the same requirements are applicable for the HPUE, this results in an implementation increase in the ratio of ON to OFF power within the same allowed time duration compared to the Power class 3 requirements

Proposal: to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device

6.3.5 Power control

Absolute power tolerance is the ability of the UE transmitter to set its initial output power to a specific value for the first sub-frame at the start of a contiguous transmission or non-contiguous transmission with a transmission gap larger than 20ms. In the case of a PRACH transmission, the absolute tolerance is specified for the first preamble. The absolute power tolerance includes the channel estimation error (the absolute RSRP accuracy requirement specified in subclause 9.1 of TS 36.133).

The relative power tolerance is the ability of the UE transmitter to set its output power in a target sub-frame relatively to the power of the most recently transmitted reference sub-frame if the transmission gap between these sub-frames is ≤ 20 ms. For PRACH transmission, the relative tolerance is the ability of the UE transmitter to set its output power relatively to the power of the most recently transmitted preamble

Aggregate power control tolerance is the ability of a UE to maintain its power in non-contiguous transmission within 21 ms in response to 0 dB TPC commands with respect to the first UE transmission, when the power control parameters specified in TS 36.213 are constant.

If the same requirements are applicable for the HPUE, this results in an increase in required implementation complexity since dynamic range is now [73]dB (+[33] to -40dBm) compared to the Power class 3 requirements of 63dB (+23 to -40dBm)

Proposal to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device

6.4 Void

6.5 Transmit signal quality

6.5.1 Frequency error

The UE modulated carrier frequency shall be accurate to within ±0.1 PPM observed over a period of one time slot (0.5 ms) compared to the carrier frequency received from the E-UTRA Node B

Proposal to set HPUE Power Class 1 to be the same as Power Class 3

6.5.2 Transmit modulation quality

Transmit modulation quality defines the modulation quality for expected in-channel RF transmissions from the UE. The transmit modulation quality is specified in terms of:

- Error Vector Magnitude (EVM) for the allocated resource blocks (RBs)
- EVM equalizer spectrum flatness derived from the equalizer coefficients generated by the EVM measurement process
- Carrier leakage (caused by IQ offset)
- In-band emissions for the non-allocated RB

If the same requirements are applicable for the HPUE, this results in a further increase in required implementation performance due to the higher transmit power and the need for additional filtering requirements, noting that the image and IQ performance has tightened in release 11

Proposal; to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device

6.6 Output RF spectrum emissions

The output UE transmitter spectrum consists of the three components; the emission within the occupied bandwidth (channel bandwidth), the Out Of Band (OOB) emissions and the far out spurious emission domain

6.6.1 Occupied bandwidth

Occupied bandwidth is defined as the bandwidth containing 99 % of the total integrated mean power of the transmitted spectrum on the assigned channel. The occupied bandwidth for all transmission bandwidth configurations (Resource Blocks) shall be less than the specified channel bandwidth

Proposal: to set HPUE Power Class 1 to be the same as Power Class 3 to maintain the same occupied bandwidth

6.6.2 Out of band emission

The Out of band emissions are unwanted emissions immediately outside the assigned channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. This out of band emission limit is specified in terms of a spectrum emission mask and an Adjacent Channel Leakage power Ratio.

6.6.2.1 Spectrum emission mask

The general spectrum emission mask of the UE applies to frequencies (Δf_{OOB}) starting from the ± edge of the assigned E-UTRA channel bandwidth. For frequencies greater than (Δf_{OOB}) as specified in Table 6.6.2.1.1-1 the spurious requirements in subclause 6.6.3 are applicable.

It is proposed to maintain the existing requirements for both Power Class 1 and Power Class 3 when NS_06 is signalled with an A-MPR of O dB. This represents tighter requirement for a Power Class 1 device

6.6.2.2 Additional spectrum emission mask

This requirement is specified in terms of an "additional spectrum emission" requirement.

6.6.2.2.1 Minimum requirement (network signalled value "NS_03" and “NS_11”)

N/A

6.6.2.2.2 Minimum requirement (network signalled value "NS_04")

N/A

6.6.2.2.3 Minimum requirement (network signalled value "NS_06" or “NS_07”)

The Additional spectrum emission requirements are signalled as part of the cell handover/broadcast message to address the FCC Part 27 requirements for the upper and lower 700MHz bands.

To address these FCC Part 27 requirements NS_06 needs to be mandatory signalled with no A-MPR mitigation. With the recent allocation of D block to Public safety the Part 27 requirements are not applicable for B14 since B14 would now be expected to be covered by the FCC Part 90 requirements. Hence it makes sense to revise the requirements for both Power Class 1 and Power Class 3 to align with the updated FCC requirements when available.

For Power Class 1 NS_06 requirement represents a tighter implementation requirement compared to a Power Class 3 device (as per emission profile shown below).

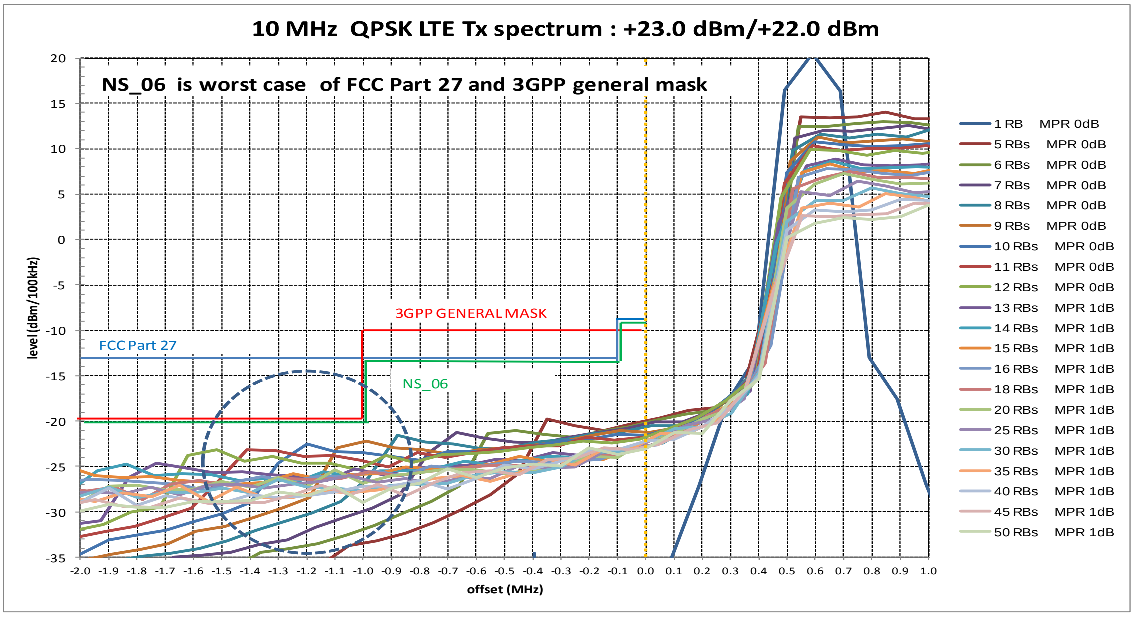


Figure 6.6.2.2.3-1

Proposal: to set HPUE Power Class 1 to be the same as Power Class 3 (i.e. NS_06 should be met if signalled) else the general spectrum mask is applicable. This represents tighter requirements for a Power Class 1 device

6.6.2.3 Adjacent Channel Leakage Ratio

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency. ACLR requirements are specified for two scenarios for an adjacent E -UTRA and /or UTRA channel as shown in Figure 6.6.2.3 -1.

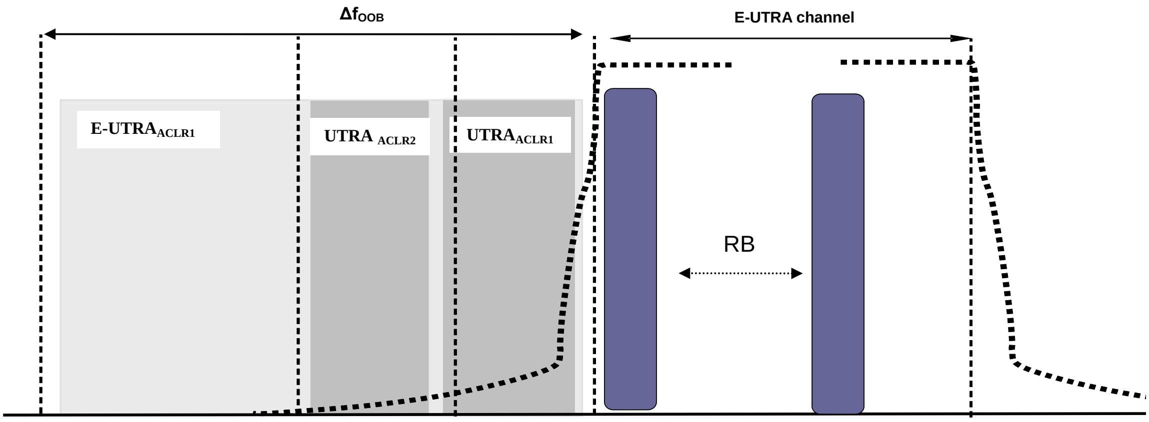


Figure 6.6.2.3-1: Adjacent Channel Leakage requirements

6.6.2.3.1 Minimum requirement E-UTRA

It is proposed that this E-UTRA$_{ACLR1}$ requirements is specified as a new table in TS36.101 for Power Class 1 and this tighter requirement shall be applicable for >23dBm as shown in Table 6.6.2.3.1-2.

Table 6.6.2.3.1-2: General requirements for E-UTRA$_{ACLR}$ for Power Class 1

	Channel bandwidth / E-UTRA$_{ACLR1}$ / Measurement bandwidth					
	1.4 MHz	**3.0 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
E-UTRA$_{ACLR1}$			[tbd] dB	[tbd] dB		
E-UTRA channel Measurement bandwidth			4.5 MHz	9.0 MHz		
Adjacent channel centre frequency offset [MHz]			+5 / -5	+10 / -10		
NOTE 1; E-UTRA$_{ACLR1}$ shall be applicable for >23dBm						

6.6.2.3.2 Minimum requirements UTRA

UTRA Adjacent Channel Leakage power Ratio (UTRA$_{ACLR}$) is the ratio of the filtered mean power centred on the assigned E-UTRA channel frequency to the filtered mean power centred on an adjacent(s) UTRA channel frequency.

The ACLR requirements for UTRA were specified as a general requirement for LTE devices to address operators for deployment next to UTRA FDD and TDD networks. This is indicated as by the note 1 and note 2 in Table 6.6.2.3.2-2.

NOTE 1: Applicable for E-UTRA FDD co-existence with UTRA FDD in paired spectrum.

NOTE 2: Applicable for E-UTRA TDD co-existence with UTRA TDD in unpaired spectrum.

Since B14 is only adjacent to B13 E-UTRA (LTE) (this requirements seems unnecessary for a B14 Power Class 1 and Power Class 3 terminal and therefore should not be part of the RAN5 conformance test requirements for B14.

Proposal that this UTRA$_{ACLR1/2}$ requirements is specified as a new table in TS36.101 for Power Class 1 and this tighter requirement shall be applicable for >23dBm as shown below

Table 6.6.2.3.2-2: Requirements for $UTRA_{ACLR1/2}$ for Power Class 1

	Channel bandwidth / $UTRA_{ACLR1/2}$ / Measurement bandwidth					
	1.4 MHz	**3.0 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
$UTRA_{ACLR1}$			[tbd] dB	[tbd] dB		
Adjacent channel centre frequency offset [MHz]			$+2.5+BW_{UTRA}/2$ / $-2.5-BW_{UTRA}/2$	$+5+BW_{UTRA}/2$ / $-5-BW_{UTRA}/2$		
$UTRA_{ACLR2}$			[tbd] dB	[tbd] dB		
Adjacent channel centre frequency offset [MHz]			$+2.5+3*BW_{UTRA}/2$ / $-2.5-3*BW_{UTRA}/2$	$+5+3*BW_{UTRA}/2$ / $-5-3*BW_{UTRA}/2$		
E-UTRA channel Measurement bandwidth			4.5 MHz	9.0 MHz		
UTRA 5MHz channel Measurement bandwidth (Note 1)			3.84 MHz	3.84 MHz		
NOTE 1: Applicable for E-UTRA FDD co-existence with UTRA FDD in paired spectrum. NOTE 2: Applicable for E-UTRA TDD co-existence with UTRA TDD in unpaired spectrum. NOTE 3: E-$UTRA_{ACLR1}$ shall be applicable for >23dBm.						

6.6.3 Spurious emissions

Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products, but exclude out of band emissions unless otherwise stated. The spurious emission limits are specified in terms of general requirements in line with ITU –R SM.329 and E-UTRA operating band requirement to address UE co-existence.

6.6.3.1 Minimum requirements

For B14, the spurious emission limits apply for the frequency ranges that are more than Δf_{OOB} (MHz) in Table 6.6.3.1-1 from the edge of the channel bandwidth. The spurious emission limits in Table 6.6.3.1-2 below

Table 6.6.3.1-2: Spurious emissions limits

Frequency Range	Maximum Level	Measurement bandwidth	Note
9 kHz ≤ f < 150 kHz	-36 dBm	1 kHz	
150 kHz ≤ f < 30 MHz	-36 dBm	10 kHz	
30 MHz ≤ f < 1000 MHz	-36 dBm	100 kHz	
1 GHz ≤ f < 12.75 GHz	-30 dBm	1 MHz	

This is applicable for all transmitter band configurations (N_{RB}) for the supported B14 channel bandwidth

Table 6.6.3.1-1: Boundary between E-UTRA Δf_{OOB} and spurious emission domain

Channel bandwidth	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Δf_{OOB} (MHz)	n/s	n/s	10	15	n/s	n/s

If the same requirements are applicable for the HPUE, this results in an increase in required performance for frequency ranges greater than 10/15 MHz from the edge of the channel bandwidth due to the higher transmit Proposal to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device.

6.6.3.2 Spurious emission band UE co-existence

This clause specifies the requirements for the specified E-UTRA band, for coexistence with protected bands. The applicable requirements for a B14 Power Class 3 devices is as follows

Table 6.6.3.2-1: Requirements

Spurious emission							
E-UTRA Band	**Protected band**	**Frequency range (MHz)**			**Maximum Level (dBm)**	**MBW (MHz)**	**Comment**
14	E-UTRA Band 2, 4, 5, 10, 12, 13, 14, 17	FDL_low	–	FDL_high	-50	1	
	Frequency range	769	–	775	-35	0.00625	Note[2], Note[3]
	Frequency range	799	–	805	-35	0.00625	Note[1], Note[2], Note[3]

Note 1: Whether the applicable frequency range should be 793-805MHz instead of 799-805MHz is TBD.
Note 2: The emissions measurement shall be sufficiently power averaged to ensure a standard deviation < 0.5 dB.
Note 3: These requirements also apply for the frequency ranges that are less than ΔfOOB (MHz) in Table 6.6.3.1-1 from the edge of the channel bandwidth.

If the same requirements are applicable for the HPUE, this results in a tighter implementation requirement for a Power Class 1 terminal compared to a Power Class 3 terminal due to the higher transmit power.

Proposal to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirements for a Power Class 1 device

6.7 Transmit intermodulation

The transmit intermodulation performance is a measure of the capability of the transmitter to inhibit the generation of signals in its non linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter via the antenna

If the same requirements are applicable for the HPUE, this results an increase in required implementation performance due to the higher transmit power.

Proposal: to set HPUE Power Class 1 to be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device

7 B14 HPUE receiver characteristics

7.1 General

The LTE specification for HPUE Class 1 (vehicular mobile form factor) is expected to follow the general methodology in 3GPP TS36.101 for a Class 3 (handheld form factor) as closely as possible except where variations are warranted.

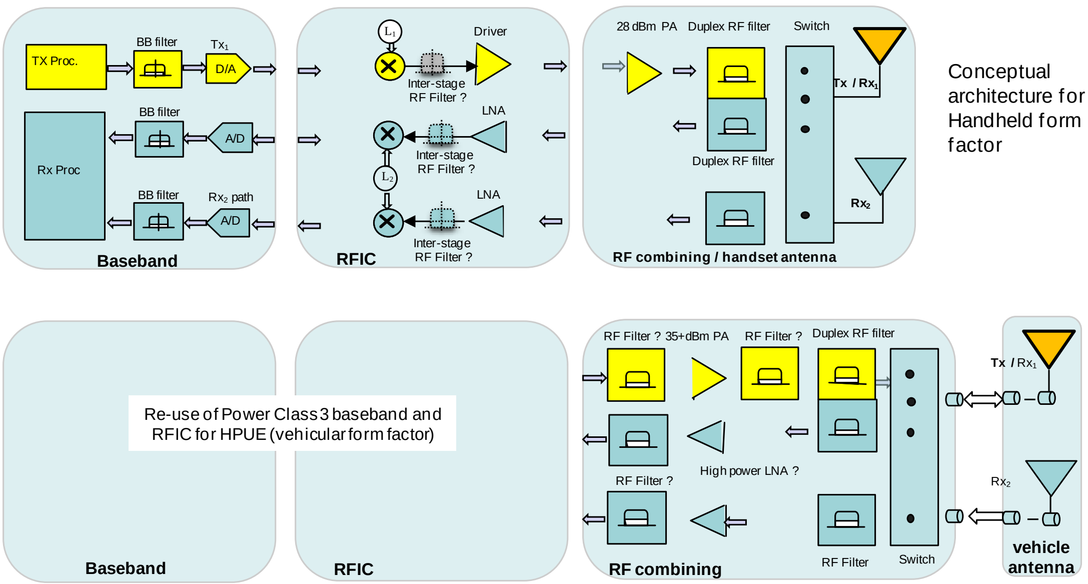


Figure 7.1-1 B14 RF architecture IC and RF IC for Power Class 1 and 3

The alignment of implementation assumptions for the RF combining front end would be similar to the methodology and components as used for the LTE base station.

The reason for this difference is a conventional miniature Class 3 SAW handset duplexer filter cannot be used for the HPUE as they will not support the higher power rating/linearity or achieve the necessary filter attenuation and isolation between Tx and Rx ports due to the increase in Tx power from +23dBm to +31 dBm for a class 1 vehicular terminal.

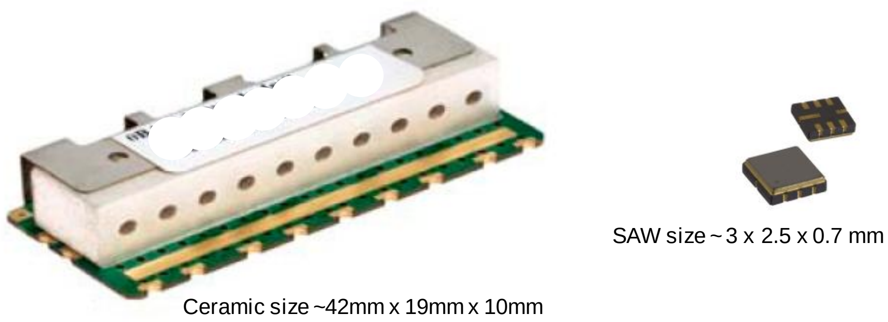


Figure 7-2; Typical duplex filter for Power Class 1 (Ceramic) and Power Class 3 (SAW)

For the receiver, the key parameter that is affected by the increase in Tx power is RFSENS due to the possible increase in Tx noise at the receive frequency due to the higher transmit power. Receiver performance can also be affected due to a higher Tx leakage signal which can impact the blocking performance unless additional Tx- Rx filter isolation or high power LNA is provided. It should also be noted that the normal goals of a class 3 device, in terms of size, weight and battery, are not key driver for vehicular deployment.

7.2 Diversity characteristics

The requirements for Power Class 3 assume that the receiver is equipped with two Rx ports as a baseline. These requirements apply to all UE categories unless stated otherwise. Requirements for 4 ports are FFS. With the exception of subclause 7.9 all requirements shall be verified by using both (all) antenna ports simultaneously.

Proposal; the requirement for Power Class 1 should be the same as Power Class 3

7.3 Reference sensitivity power level

The reference sensitivity power level REFSENS is the minimum mean power applied to both the UE antenna ports at which the throughput shall meet or exceed the requirements for the specified reference measurement channel.

For Power Class 1, the same methodology will be used as Power Class 3 i.e. the transmitter will be set to P_{UMAX} +31dBm, with the UL resource blocks shall be located as close as possible to the downlink operating band. For the HPUE, this would result in a less implementation since Tx noise leakage into the Rx chain is expected to increase due to the high transmit power unless mitigated by addition TX –RX isolation in the RF combining network

Proposal: the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{UMAX} defined as a side condition

7.4 Maximum input level

This is defined as the maximum mean power received at the UE antenna port, at which the specified relative throughput shall meet or exceed the minimum requirements for the specified reference measurement channel.

Requirements for Power Class 1 will be the same as Power Class 3 however, in the case of Power Class 3 the performance will need to be met at 4dB below P_{CMAX_L} which is +26dBm for Power Class 1

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.5 Adjacent Channel Selectivity (ACS)

Adjacent Channel Selectivity (ACS) is a measure of a receiver's ability to receive a E-UTRA signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the centre frequency of the assigned channel. ACS is the ratio of the receive filter attenuation on the assigned channel frequency to the receive filter attenuation on the adjacent channel(s).

Requirements for Power Class 1 will be the same as Power Class 3 however in the case of Power Class 3 the performance will need to be met at 4dB below P_{CMAX_L} which is +26 dBm for Power Class 1

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition.

7.6 Blocking characteristics

The blocking characteristic is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the spurious response or the adjacent channels, without this unwanted input signal causing a degradation of the performance of the receiver beyond a specified limit. The blocking performance shall apply at all frequencies except those at which a spurious response occur.

7.6.1 In-band blocking

In-band blocking is defined for an unwanted interfering signal falling into the UE receive band or into the first 15 MHz below or above the UE receive band at which the relative throughput shall meet or exceed the minimum requirement for the specified measurement channels..

Requirements for Power Class 1 will be the same as Power Class 3 however in the case of Power Class 3 the performance will need to be met at 4dB below P_{CMAX_L} which is +26 dBm for Power Class 1

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.6.2 Out-of-band blocking

Out-of-band band blocking is defined for an unwanted CW interfering signal falling more than 15 MHz below or above the UE receive band. For the first 15 MHz below or above the UE receive band the appropriate in-band blocking or adjacent channel selectivity in subclause 7.5.1 and subclause 7.6.1 shall be applied.

Requirements for Power Class 1 will be the same as Power Class 3 however in the case of Power Class 3 the performance will need to be met at 4dB below P_{CMAX_L} which is [+28] dBm for Power Class 1

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.6.3 Narrow band blocking

This requirement is a measure of a receiver's ability to receive a E-UTRA signal at its assigned channel frequency in the presence of an unwanted narrow band CW interferer at a frequency, which is less than the nominal channel spacing.

Requirements for Power Class 1 will be the same as Power Class 3 however, in the case of Power Class 3 the performance will need to be met at 4dB below P_{CMAX_L} which is [+28] dBm for Power Class 1

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.7 Spurious response

Spurious response is a measure of the receiver's ability to receive a wanted signal on its assigned channel frequency without exceeding a given degradation due to the presence of an unwanted CW interfering signal at any other frequency at which a response is obtained i.e. for which the out of band blocking limit as specified in subclause 7.6.2 is not met.

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.8 Intermodulation characteristics

Intermodulation response rejection is a measure of the capability of the receiver to receive a wanted signal on its assigned channel frequency in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal

7.8.1 Wide band intermodulation

The wide band intermodulation requirement is defined following the same principles using modulated E-UTRA carrier and CW signal as interferer.

Proposal the requirement for Power Class 1 should be the same as Power Class 3 which represents a tighter requirement for a Power Class 1 device due to the higher value required for P_{CMAX_L} defined as a side condition

7.9 Spurious emissions

The spurious emissions power is the power of emissions generated or amplified in a receiver that appear at the UE antenna connector.

Proposal: the requirement for Power Class 1 should be the same as Power Class 3

7.10 Receiver image

8 Other specification impacts (if applicable)

8.1 Impacts on RAN1 specifications

The impact of the change of power class is checked for procedure involving UE transmit power:

- uplink power control
- power headroom reporting

Power setting for PUSCH and power headroom reporting are defined in section 5.1.1 of TS 36.213 [6].

Power setting for PUCCH and SRS are defined respectively in section 5.1.2 and 5.1.3 of TS 36.213 [6].

Power levels for the various uplink signals are computed by the UE from higher layer parameters, current transmission configuration (number of RBs, carrier aggregation with/without simultaneous PUSCH/PUCCH transmission) and power control commands. $P_{CMAX,C}$ is used as the limit the computed value shall not exceed.

Changing the power class will impact the value of $P_{CMAX,C}$. However, it has no impact on the principle and the formula of the uplink power control defined in TS 36.213 [6].

In a similar manner, $P_{CMAX,C}$ is used as the reference for computing the power headroom but the change of the power class has not impact on the section 5.1.1.2 of TS 36.213 [6]

8.2 Impacts on signalling

8.2.1 Signalling of the maximum output power of the UE

The following is an extract of the TS 36.331 [7] specification:

P-Max

The IE *P-Max* is used to limit the UE's uplink transmission power on a carrier frequency and is used to calculate the parameter *Pcompensation* defined in TS 36.304 [10]. Corresponds to parameter P_{EMAX} or $P_{EMAX,c}$ in TS 36.101 [2]. The UE transmit power on one serving cell shall not exceed the configured maximum UE output power of the serving cell determined by this value as specified in TS 36.101 [2 clause 6.2.5 or 6.2.5A].

P-Max information element

```
-- ASN1START


P-Max ::=               INTEGER (-30..33)


-- ASN1STOP
```

p-Max is used by the UE to compute the limits of its configured power P_{CMAX}:(p-Max is equal to P_{EMAX} is the equations below):

- $P_{CMAX\_L} = MIN \{ P_{EMAX} – \square T_C,\ P_{PowerClass} – MAX(MPR + A\text{-}MPR, P\text{-}MPR) – \square T_C \}$
- $P_{CMAX\_H} = MIN \{ P_{EMAX},\ P_{PowerClass} \}$

In case this value is signalled by the eNodeB, the maximum output power of the UE cannot be configured to a value higher than P-Max. The upper value of P-Max has driven the choice for the target value of the new power class at 31dBm.

With the introduction of the extended power headroom report (see TS 36.321 [8], section 6.1.3.6a), the value of $P_{CMAX,C}$ is reported. The mapping for $P_{CMAX,C}$ can be found in 3GPP TS36.133 [9] section 9.6.1.

Table 9.6.1-1 Mapping of $P_{CMAX,c}$, 3GPP TS36.133 [9]

Reported value	Measured quantity value	Unit
PCMAX_C_00	$P_{CMAX,c} < -29$	dBm
PCMAX_C_01	$-29 \le P_{CMAX,c} < -28$	dBm
PCMAX_C_02	$-28 \le P_{CMAX,c} < -27$	dBm
…	…	…
PCMAX_C_61	$31 \le P_{CMAX,c} < 32$	dBm
PCMAX_C_62	$32 \le P_{CMAX,c} < 33$	dBm
PCMAX_C_63	$33 \le P_{CMAX,c}$	dBm

The upper limit is also equal to +33dBm. However, this report is only applicable in case of carrier aggregation and there is currently no carrier aggregation configurations that include band 14.

8.2.2 Power Headroom reporting

The reporting range of the PHR is defined in 3GPP TS36.133 [9], section 9.1.8.4:

The power headroom reporting range is from -23 ...+40 dB. Table 9.1.8.4-1 defines the report mapping.

Table 9.1.8.4-1: Power headroom report mapping, 3GPP TS36.133 [9]

Reported value	Measured quantity value (dB)
POWER_HEADROOM_0	$-23 \le PH < -22$
POWER_HEADROOM_1	$-22 \le PH < -21$
POWER_HEADROOM_2	$-21 \le PH < -20$
POWER_HEADROOM_3	$-20 \le PH < -19$
POWER_HEADROOM_4	$-19 \le PH < -18$
POWER_HEADROOM_5	$-18 \le PH < -17$
…	…
POWER_HEADROOM_57	$34 \le PH < 35$
POWER_HEADROOM_58	$35 \le PH < 36$
POWER_HEADROOM_59	$36 \le PH < 37$
POWER_HEADROOM_60	$37 \le PH < 38$
POWER_HEADROOM_61	$38 \le PH < 39$
POWER_HEADROOM_62	$39 \le PH < 40$
POWER_HEADROOM_63	$PH \ge 40$

The main purpose of the PHR is to assist the BS scheduler in the selection of the MCS and the number of RBs so that the terminal is not power limited. Since the reference of the power headroom is P_{CMAX} which is directly linked with the power class of the UE, there is no reason to extend the range of the PHR with the introduction of a higher power class.

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2012-03	RAN4#62bis	R4-121510			TR36.837v0.0.1		0.0.1
2012-03	RAN4#62bis	*R4-121514*			Upper 700MHz regulatory requirements		0.1.0
2012-03	RAN4#62bis	*R4-121372*			3GPP TR 36.837: Text proposal for section 8		0.1.0
2012-03	RAN4#62bis	*R4-121522*			Band 14 PSBB HPUE Power class and MPR		0.1.0
2012-03	RAN4#62bis	*R4-121342*			Band 14 PSBB HPUE Configured Transmitted Power		0.1.0
2012-05	RAN4#63	R4-122349			3GPP TR 36.837: Text proposal for section 5.4.1	0.1.0	0.2.0
2012-05	RAN4#63	R4-122350			3GPP TR 36.837: Text proposal for section 5.4.2	0.1.0	0.2.0
2012-08	RAN4#64	R4-124892			3GPP TR 36.837: Text proposal for section 5.4.1	0.2.0	0.3.0
2012-08	RAN4#64	R4-124893			3GPP TR 36.837: Text proposal for section 5.4.2	0.2.0	0.3.0
2012-08	RAN4#64	R4-123893			TP for section 6 (Tx characteristics) for TR36.837	0.2.0	0.3.0
2012-08	RAN4#64	R4-123897			TP for section 6 (ACLR) for TR36.837	0.2.0	0.3.0
2012-08	RAN4#64	R4-123902			TP for section 7(Rx characteristics) for TR36.837	0.2.0	0.3.0
2012-08	RAN#64	R4-123094			TP for Annex A for TR36.837	0.2.0	0.3.0
2012-08	RAN#64	R4-124954			HPUE Tx-Rx architecture	0.2.0	0.3.0
2012-08	RAN#64	R4-123886			Annex A for TR36.837	0.2.0	0.3.0
2012-10	RAN4#64Bis	R4-125039			Text proposal on simulation results on ACLR for Public Safety Broadband High Power UE	0.3.0	0.4.0
2012-10	RAN4#64Bis	R4-125121			TP for section 5.4.2.5 B14 PSBB HPUE UL to B13 eNB coexistence	0.3.0	0.4.0
2012-10	RAN4#64Bis	R4-125649			Text proposal for section 5.4.2.2 (EADS simulations results)	0.3.0	0.4.0
2012-10	RAN4#64Bis	R4-125578			TP to TR 36.837: HPUE ACLR	0.3.0	0.4.0
2012-10	RAN4#64Bis	R4-125213			Simulation results for coexistence studies of Band 14 HPUE	0.3.0	0.4.0
2012-11	RAN4#65	R4-126405			Simulation results for coexistence studies of Band 14 +31dBm HPUE	0.4.0	0.5.0
2012-11	RAN4#65	R4-126170			B14 PSBB HPUE UL to B13 eNodeB co-existence results	0.4.0	0.5.0
2012-11	RAN4#65	R4-126733			Simulations results for B14 HPUE with MOP=31dBm	0.4.0	0.5.0
2012-11	RAN4#65	R4-126752			HPUE ACLR	0.4.0	0.5.0
2012-11	RAN4#65	R4-126167			B14 HPUE GPS considerations	0.4.0	0.5.0
2012-11	RAN4#65	R4-126902			B14 PSBB HPUE blocking B13 eNB	0.4.0	0.5.0
2012-11	RAN4#65	R4-126903			TP for B14 PSBB HPUE Maximum Output Power (MOP)	0.4.0	0.5.0
2012-11	RAN4#65	R4-126904			CR for LTE B14 HPUE	0.4.0	0.5.0
2012-12	RAN-58				Presented to TAN for approval	0.5.0	1.0.0
2012-12	RAN-58				TR Approved by RAN	1.0.0	2.0.0