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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

This document is a technical report which was requested in the Objective 2 of the RAN4 work item description “FDD Home NodeB RF requirements” [5]. The goal of this technical report is to describe the agreed approach towards the RF related issues raised in [5]:

A) The existing UTRA BS classes did not fully address the RF requirements of the HNB application. Proposals for changes to radio performance requirement specifications TS 25.104 are therefore provided in this report, together with the proposals for the test specification TS 25.141. Most of the HNB-specific additions to TS 25.104 / 25.141 were accommodated in a manner similar to the other BS classes.

Editors note:

- Where square bracketed values are suggested in 3GPP TR 25.820, to conduct further work as required to agree appropriate values.
- Where it is suggested that performance values in 3GPP TS 25.104 may be subject to change to conduct further work as required to see if this is necessary.

B) The report intends to ensure that operators are provided with sufficient information to fully understand the issues concerning the deployment of HNBs:

- Deployment scenarios and their potential bottlenecks.
- Guidance on how to control the interference to surrounding macro networks and provide good coverage for the HNB
- Testing of the HNB.

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] R4-083117, “Feedback on output power requirement for TS 25.104, Picochip”, 3GPP RAN WG4, 49th meeting, Prague, 2008

[2] R4-083355, “CR on TS25.104 HNB adjacent channel protection requirements”, 3GPP RAN WG4, 49th meeting, Prague, 2008

[3] R4-083249, “Meeting minutes of the ad-hoc meeting”, 3GPP RAN WG4, 49th meeting, Prague, 2008

[4] R4-083087, “Meeting minutes of the phone meeting”, 3GPP RAN WG4, 49th meeting, Prague, 2008

[5] RP-080234, “RAN4 work item description “FDD Home NodeB RF Requirements,”

[6] R4-071211, “Recommendations on transmit power of Home NodeB”, Alcatel-Lucent

R4-071231, “Open and Closed Access for Home NodeBs”, Nortel, Vodafone

[7] R4-071241, “Regulatory aspects on Home Node B in the network architecture impacting RAN4 work”, BMWi

[8] R4-080409, "Home NodeB Interference Analysis", QUALCOMM Europe

[9] R4-071540, "LTE Home Node B downlink simulation results with flexible Home Node B power", Nokia Siemens Networks

[10] R4-071578, "Simulation results of macro-cell and co-channel Home NodeB with power configuration and open access", Alcatel-Lucent

[11] R4-071617, "HNB and HNB-Macro Propagation Models", Qualcomm Europe

[12] R4-071660, "Impact of HNB with fixed output power on macro HSDPA capacity" ,Ericsson

[13] R4-072004, "Performance Evaluation about HNB coexistence with Macro networks", Huawei

[14] R4-071661, "Impact of HNB with controlled output power on macro HSDPA capacity", Ericsson

[15] R4-080149, "Simulation assumptions for the block of flats scenario", Ericsson

[16] R4-070970, "Initial simulation results for Home Node B receiver sensitivity", Ericsson

[17] R4-070971, "Initial simulation results for Home Node B receiver blocking", Ericsson

[18] R4-071231, "Open and Closed Access for Home NodeBs", "Nortel, Vodafone"

[19] R4-071619, "Analysis of Uplink Performance under Co-channel Home NodeB-Macro Deployment", Qualcomm Europe

[20] R4-080409, "Home NodeB Interference Analysis", QUALCOMM Europe

[21] R4-071185, "The analysis for Home NodeB receiver blocking requirements", Huawei

[22] R4-071263, "System simulation results for Home NodeB interference scenario #2", Ericsson

[23] R4-070902, "Initial home NodeB coexistence simulation results", Nokia Siemens Networks

[24] R4-080151, "Simulation results for Home NodeB to macro UE downlink co-existence within the block of flats scenario", Ericsson

[25] R4-071211, "Recommendations on transmit power of Home NodeB", Alcatel-Lucent

[26] R4-071554, "The analysis for low limit for Home NodeB transmit power requirement", Huawei

[27] R4-072025, "Proposed HNB Output Power Range", QUALCOMM Europe

[28] R4-071150, "Home BTS output power", Orange

[29] R4-071253, "Minutes of Home NodeB/ ENodeB Telephone Conference #3. Aug 7, 2007", Motorola

[30] R4-070825, "Home BTS consideration and deployment scenarios for UMTS", Orange

[31] R4-080097, "Minutes of Home NodeB/ ENodeB Telephone Conference #7, Jan 31, 2008"

[32] R4-071618, "Home Node B HSDPA Performance Analysis", Qualcomm Europe

[33] R4-080152, "Simulation results for Home NodeB uplink performance in case of adjacent channel deployment within the block of flats scenario", Ericsson

[34] R4-080155, "Home NodeB maximum output power from the maximum UE input level point of view", Ericsson

[35] R4-082153, "Transmitter characteristics of 3G Home NodeB" CR by Alcatel-Lucent, Ericsson, Vodafone, Orange, Huawei

[36] R4-083255, "HNB adjacent channel protection requirements", CR by Nokia Siemens Networks, Vodafone Group, Ericsson, Huawei, Motorola, Alcatel-Lucent

[37] R4-081938 TP for 25.9xx: Section 6.1.2 Frequency error, Ericsson

[38] R4-081939 TP for 25.9xx: Section 6.1.3 Spectrum emission mask

[39] R4-082146 TP for 25.9xx: Section 6.1.4 Adjacent Channel Leakage power Ratio (ACLR), Ericsson

[40] R4-082664 Transmitter characteristics Tests for 3G Home NodeB, CR by Huawei.

[41] R4-082665 Receiver characteristics Tests for 3G Home NodeB, CR by Huawei

[42] R4-082666 Demodulation Requirements Tests for 3G Home NodeB, CR by Huawei

[43] R4-083193 Modified Test Models for 3G Home NodeB, CR by Alcatel-Lucent, Huawei, Qualcomm Europe, Vodafone.

[44] R4-083149 Comparison on proposals on Modified Test Models for 3G Home NodeB, Alcatel-Lucent

[45] R4-072006, “Clarification of Home eNB scenarios and issues for RAN2/3/4”, NTT DoCoMo, T-mobile

[46] R4-082994, “HNB Output power for adjacent channel protection”, Ericsson, RAN4 #49 Prague

[47] R4-082114, “Receiver Characteristics of 3G Home NodeB”, Alcatel-Lucent, Nokia Siemens Networks, Ericsson, Vodafone, Orange, RAN4 #48 Jeju, Korea

[48] R4-081886, “Home NodeB Co-existence Analysis with Adjacent-Channel Operator”, Qualcomm Europe, RAN4 #48 Jeju, Korea

[49] R4-081884, “Requirement for Co-existence of HNB with Adjacent Channel Operator”, Qualcomm Europe, Vodafone Group, ip.access, Airvana, RAN4 #48 Jeju, Korea

[50] R4-082613, “Requirement for Co-existence of HNB with Adjacent Channel Operator”, Qualcomm Europe, Airvana, AT&T, ip.access, Vodafone Group RAN4 #48bis Edinburgh, Scotland

[51] R4-081597, “Impact of uplink co-channel interference from an un-coordinated UE on the Home Node B”, Airvana, Vodafone, ip.access, RAN4 #47, Munich, Germany

[52] R4-081598, “Requirement Impact of uplink adjacent channel interference from an un-coordinated UE on the Home Node B”, ip.access, Vodafone, Airvana, RAN4 #47, Munich, Germany

[53] 3GPP TR 21.905: Vocabulary for 3GPP Specifications

[54] Broadband Forum TR-069 Amendment 2, CPE WAN Management Protocol, Broadband Forum Technical Report, 2007.

[56] R4-090172, “Home Node B control and monitoring”, BMWi, RAN4#49bis, Ljubljana, Slovenia.

[57] 3GPP TS 25.331 v8.3.0, “Radio Resource Control (RRC); Protocol specification”.

3 Definitions, symbols and abbreviations

For the purposes of the present document, the terms and definitions given in TR 21.905 [54] 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 [54].

3.1 Definitions

Void.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$No_{f\,i}$	Interference on frequency fi
G_{ant}	Gain of antenna
I_{oc}	The power spectral density (integrated in a noise bandwidth equal to the chip rate and normalized to the chip rate) of a band limited white noise source (simulating interference from cells, which are not defined in a test procedure) as measured at the UE antenna connector. For DC-HSDPA I_{oc} is defined for each of the cells individually and is assumed to be equal for both cells unless explicitly stated per cell.
$v_{UE\ max}$	Maximum speed of UE
$v_{UE\ HNB}$	UE speed

3.3 Abbreviations

ACIR	Adjacent Channel Interference Rejection, can be translated to receiver selectivity when the emission mask of the interfering signal is accounted for.
BW	Band Width
CSG	Closed Subscriber Group
DL	Downlink, the RF path from BS to UE
E-DPDCH	Enhanced Dedicated Physical Data CHannel
E-DPCCH	Enhanced Dedicated Physical Control CHannel
FRC	Fixed Reference Channel
GSM	Mobile cellular system (throughout this document, this acronym is generally to also means the services GPRS and EDGE, both enhancements to GSM, unless not applicable to the discussion.)
HENB	Home Enhanced Node B
HNB	Home NodeB
HNBAP	HNB Application Protocol
HNB-GW	HNB GateWay
HSPA	High Speed Packet Access
HS-DPCCH	High Speed Dedicated Physical Control CHannel
HUE	UE camping on HNB cell
IE	Information Element
IRAT	Inter-RAT
LAC	Location Area Code
LAU	Location Area Update
MBSFN	Multicast/Broadcast over a Single Frequency Network
MNB	Macro NodeB
MUE	UE camping on Macro cell
NB	NodeB
NLM	Network Listen Mode
NR	Noise Rise
PL	Path Loss
REM	Radio Environment Measurement
RRC	Radio Resource Control
RTWP	Receive Total Wideband Power
RX, Rx	Receive, Receiver
SIB	System Information Block
TX, Tx	Transmit, Transmitter
UE	User Equipment, also cellular terminal
UL	Uplink, the RF path from UE to BS

4 General

As agreed in the work item proposal [1]:

Within the course of increasing UMTS terminal penetration and fixed-mobile convergence, an upcoming demand for 3G Home NodeBs is observed to provide attractive services and data rates in *home environments*.

UTRAN is not optimally suited for this application as UTRAN was developed and defined under the assumption of coordinated network deployment, whereas Home NodeBs are typically associated with uncoordinated and large scale deployment.

Aim of this work item is to amend the UTRAN NodeB related RF specifications to support the Home NodeBs application. No changes to the UE RF specifications are foreseen.

The scope of this work item is limited to the UTRA FDD mode.

4.1 Task description

4.1.1 HNB class definition

The purpose of this work is to update the radio performance requirement specification TS 25.104, further work required to agree on *new parameter values will be documented in the TR and the updates required in test specification TS 25.141 will be documented.*

4.1.2 HNB measurements and adaptation

The purpose of this work item is to ensure that operators have necessary information about how to adjust the output transmission power of HNB as a function of the signal strength from the macro cell layer, and/or from other HNBs, in order to enhance overall system performance.

In order to achieve this, (at least) the following areas should be addressed:

1) Guidance on how to control HNB power
    a. The intention is to provide guidance to operators on possible strategies and expected performance in typical exemplary deployment scenarios.
    b. Is it possible to have the same mechanism to control HNB output power with respect to the macro cell layer, other surrounding HNBs, and in the case of HNB coverage control for open access HNB.
    c. It is not the intention to mandate HNB behaviour.
2) Measurements of surrounding environment (i.e. macro and other HNBs signal strength)
    a. Issues to address include factors that govern accuracy and timeliness of the suggested measurements, and the ability to identify the macro neighbour cell list.
    b. It is not the intention to restrict the vendor’s scope about how to perform measurements.
    c. It is envisaged that measurements will be performed directly by the HNB or by employing the UEs attached to the HNB, using existing UE defined measurements.
3) Mechanism to set maximum power
    a. Issues to address include accuracy and timeliness of HNB maximum power setting.
    b. It is not the intention to restrict the vendor’s scope about how to process measurements.
    c. It is not the intention to restrict the vendor’s scope about which network element the measurements may be processed in.
    d. It is not the intention to restrict to which network entities measurements are reported. However, it is not envisaged that new signalling will be standardised to support this.
4) Mechanism to adjust HNB uplink.
    a. Issues to address include possibility to adjust uplink noise rise target.

b. It is not the intention to restrict the vendor's scope about what actions may be taken regarding HNB uplink.

5 Radio scenarios

5.1 Deployment configurations

A number of different deployment configurations have been considered for Home (e)NodeB. The aspects which define these are as follows:

- Open access or CSG (Closed Subscriber Group)
  - Open access HNBs can serve any UE in the same way as a normal NodeB
  - CSG HNBs only serve UEs which are a member of a particular Closed Subscriber Group
- Dedicated channel or co-channel
  - Whether HNBs operate in their own separate channel, or whether they share a channel with an existing (e)UTRAN network
- Fixed or adaptive (DL) maximum transmit power
  - Fixed: HNBs have a set fixed maximum transmit power
  - Adaptive: HNB's sense interference to existing networks, and adjust maximum transmit power accordingly

The following configurations are considered and are described in more detail in the following sections.

A. CSG, Dedicated channel, Fixed Power

B. CSG, Dedicated channel, Adaptive Power

C. CSG, Co-channel, Adaptive Power

D. Partial Co-Channel

E. Open Access, dedicated or co-channel

5.1.1 Configuration A. CSG, dedicated channel, fixed power

HNB is configured as a Closed Subscriber Group. Access to HNB is controlled through an arrangement between the HNB owner and by the network operator. Access is restricted to a very limited number of UE; the majority of UE do not have access to the HNB. Therefore, a CSG covers the partially open system, as discussed in [46].

The HNB is deployed on a dedicated channel; i.e. a channel that is not used within the macro layer. The worst case dedicated channel deployment is the adjacent channel. The worst case adjacent channel deployment is when the adjacent channel is owned by a different operator.

Although the HNB is deployed on the dedicated frequency with respect to the macro network, a co-channel interference scenario remains between HNB's. HNB's must share the same frequency, hence co-channel coexistence must be analysed within a dense population of HNB.

In this configuration, the Home NodeB's maximum transmit power could potentially be fixed by the operator to be lower than the Maximum Transmit power capability. As analysed in detail in [13], the reduced power limit ensures the dominance of the HNB with respect to a macro cell is appropriately bounded. Therefore, the HNB cell size is limited with respect to a weak macro signal. Consequently, the HNB can operate with a fixed maximum power level even at the edge of a macro cell.

5.1.2 Configuration B. CSG, dedicated channel, adaptive power

HNB is configured as a Closed Subscriber Group.

The HNB is deployed on a dedicated channel.

Maximum transmit power may be set as high as the maximum capability of the HNB class of base stations. However, higher maximum power level than the acceptable “fixed” maximum power for dedicated channel deployment, Section 5.1.1 shall only be used when appropriate for the deployed environment, and when the resulting interference is acceptable.

5.1.3 Configuration C. CSG co-channel, adaptive power

HNB is configured as a Closed Subscriber Group.

The HNB is deployed on the same channel as the macro network. This is considered the worst case interference scenario; consequently this is the highest risk deployment. Power levels used by the Home Node B and all attached UE’s must be set as appropriate for the deployed environment.

The fixed maximum transmit power limit is not considered feasible for co-channel deployment and has been removed from further analysis.

5.1.4 Configuration D. Partial co-channel

Partial co-channel is proposed for CSG operation for HNBs. This works by limiting frequencies which are shared by the “macro layer” and the HNB, as shown in Figure 5.1.4-1. The macro layer uses the all available frequencies, whereas the home NodeB only uses a subset – the shared part. Macro UEs can operate on any frequency. Macro UEs in the shared part experiencing “pathological” interference from home NodeBs can move to the clear part.

Whilst this configuration is indented as a solution for CSG operation, it may also be applicable to Open Access in order to limit the influence of the HNB in the overall network and allow more control over mobility.

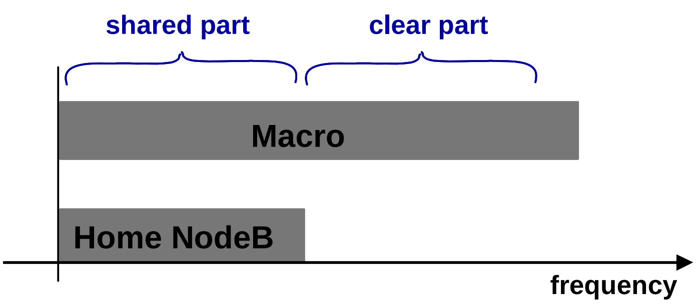


Figure 5.1.4-1 Spectrum arrangement for macro and home node Bs

Figure 5.1.4-2 shows how this could be implemented in UTRAN. Two channels are needed, one for Macro+HNB, the other for Macro only. Macro-only UEs experiencing HNB interference in channel 1 would handover to channel 2.

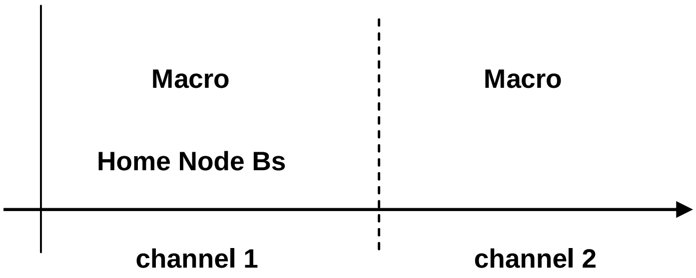


Figure 5.1.4-2 Spectrum arrangement for UTRAN

Figure 5.1.4-3 shows how this could be implemented for EUTRAN. Since it has scalable bandwidth, it does not necessarily require two channels as with UTRAN. Provided the HENB sub-band does not overlap the central 6 RBs of the macro's channel, then it will not prevent UEs receiving the BCH and SCH and connecting to the macro layer. Frequency hopping and Frequency dependent scheduling will ensure UEs experiencing HNB interference on part of the band will still be able to function.

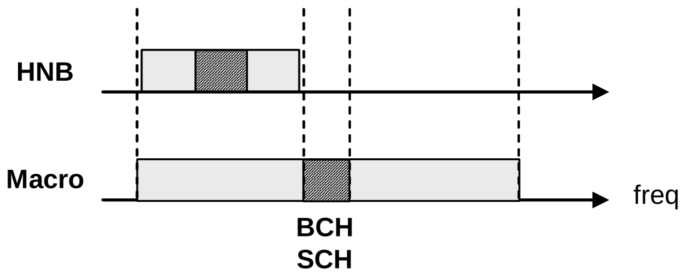


Figure 5.1.4-3 Spectrum arrangement for EUTRAN

Providing UEs hand over to the clear channel when experiencing HNB interference , the performance of this configuration should be similar to that of configuration A (dedicated channel, fixed power)

5.1.5 Configuration E. Open Access, dedicated or co-channel

Open access Home NodeBs serve all UEs, in the same way as other NodeBs do [6-8] . The results referenced in Section 5.2 explain the level of openness supported by a HNB deployment when explaining the model and assumptions used. A completely open system is already covered by the existing classes of Node B.

5.2 Interference scenarios

Home Node B's are intended to enhance the coverage of a UMTS Radio Access Network in the *home environment*. However, it is not feasible to completely control the deployment of the HNB layer within the UMTS RAN. Therefore, interference due to the HNB is a concern and interference mitigation techniques are required. Interference mitigation techniques will impact the HNB performance, which will present the HNB with challenges in managing its radio resources and maintaining Quality of Service to its attached users. In the following sections the interference scenarios that exist between a HNB and the macro layer, and among HNBs, are discussed in more detail.

Priority of the interference scenario investigations has been established as shown in Table 5.1.5-1.

Table 5.2-1 Interference scenarios

Number	Aggressor	Victim	Priority
1	UE attached to Home Node B	Macro Node B Uplink	yes
2	Home Node B	Macro Node B Downlink	yes
3	UE attached to Macro Node B	Home Node B Uplink	yes
4	Macro Node B	Home Node B Downlink	
5	UE attached to Home Node B	Home Node B Uplink	yes
6	Home Node B	Home Node B Downlink	yes
7	UE attached to Home Node B and/or Home Node B	Other System	
8	Other System	UE attached to Home Node B and/or Home Node B	

In addition to the above scenarios, we also addressed the scenario of a HNB mobile operating very close to its serving HNB, simulation results are referred to in Section 5.2.9.

Additionally, possible methods for assessing HNB performance in the different interference scenarios were proposed in [9].

5.2.1 Coexistence simulation parameters

Simulation results assuming a wide range of parameters were performed to ensure a robust and diverse analysis of the problem. The results in this section were generated over a range of simulation assumptions. Simulation models are described for different HNB deployment scenarios in [10-14]. Models for the dense urban apartment building, HNB-Macro are provided in [12,16].

5.2.2 Interference scenario 1 UL HNB UE → Macro

Noise rise on the macro layer will significantly reduce macro performance; consequently, the transmit power of the UE should be controlled. The following mechanisms are investigated to limit the interference cause by an HNB attached UE:

- HNB receiver performance will have an impact on UE transmit power; therefore any relaxation of the BS receiver required must be carefully investigated.
- UE power limitations such as maximum transmit power limits, and strict scheduling limits and noise rise limitation for HSUPA
- Open access; UEs are permitted to move easily between the macro and HNB layers, thereby ensuring each uplink connection requires the least amount of UE transmit power and generates the least amount of interference [11].

Table 5.2-2. Directory of results for interference scenario 1 UL HNB UE → Macro

Requirements Affected	Refer-ences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[14,17,18]	CSG Performance analysis	
	[11,19]	Performance analysis of open system	
	[20,21]	Need to address trade-off between macro and HNB performance. Adaptive uplink attenuation can improve performance.	
Base station Requirements			
Receiver Sensitivity (for CSG HNB)	[17,21]	As per Local Area BS class spec. Acknowledgement that desensitisation of the CSG HNB receiver will potentially increase HNB UE interference on Macro	RAN4
Receiver Performance (for HNB)	[17]	As per Local Area BS class spec. Acknowledgement that poor performance of the HNB receiver will potentially increase HNB UE interference on Macro. However, testing for high speed mobile may no longer be required, if lower maximum UE speed is adopted	RAN4
In band blocking tests	[18,22]	As per Local Area BS class spec, (but may change if a different Minimum Coupling Loss is chosen)	RAN4
HNB system Requirements			
UE power limits	[11]	No protocol changes required. A limit is required to protect macro performance. Note: this is operator implementation specific; no need to standardise.	
		Deployment Scenario B will see highest UE power levels; hence most likely to require a limit.	

5.2.3 Interference scenario 2 DL HNB → Macro UE

In a CSG, downlink interference from an HNB will result in coverage holes in the macro network. In co-channel deployment the coverage holes are considerably more significant than when the HNB is deployed on a separate carrier. Several mechanisms are considered to reduce the impact on the macro coverage:

- fixed HNB transmit power. (this is only applicable to dedicated channel deployment)
- control of HNB behaviour with respect to setting its maximum transmit power
- moving macro UE to another carrier. (this is only applicable to the areas deploying overlay carriers)
- open access systems.

Deployment scenario C reduces the impact on the macro layer by automatically adjusting the HNB transmit power. The algorithm used to control the HNB transmission power will be left as an implementation detail; consequently a variety of models are explored when setting the HNB transmission power. Some options are as follows:

- In [13], the maximum output power for each HNB is set based on a fixed limit in the “dead zone” (out-of-coverage area) that would be caused by any adjacent channel macro UE.
- In [10], the transmit power for each HNB is set based on the inverted power control scheme used for macro/macro coexistence simulation (power control set 1, power control set 2)
- In [11], the average transmit power for both the HNB and the macro are balanced at the HNB cell edge.

Deployment scenario B, where the HNB output power is controlled and the HNB’s are deployed on an adjacent carrier to the macro layer, is shown to be of limited use [15], since the reduced power limit of Deployment Scenario A is adequate for coverage of the majority of homes. An increase in power may be desirable when a large coverage area is desired, or when coverage within the home is difficult. However, when the density of HNB is very high, inter-HNB interference dominates, and an increase in HNB power beyond Deployment scenario A does not result in performance gains.

Open access provides an alternative solution, as illustrated in [11] and [19].

When specifying HNB behaviour, it is the goal of this study item to avoid any RAN1 impact if possible. If possible, RAN4 will determine the framework to allow a range of implementation to set the maximum transmit power. For example, a framework may consist of requirements and tests for a suitable target power level, but will not specify the algorithm.

It is acknowledge that no single mechanism alone provides a definitive solution. Any solution will likely involve a combination of methods, and will certainly have to reach a suitable compromise between macro layer and HNB layer performance.

Table 5.2-3. Directory of results for interference scenario 2 DL HNB → Macro UE

Requirements Affected	Refer-ences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[13,14,23]	CSG Performance analysis, Deployment Configuration A	
	[10,14,15,21, 23]	CSG Performance analysis, Deployment Configuration B,C	
	[11,19]	Performance analysis of open system, Deployment Configuration E	
	[13,21,23,24]	CSG deployment of HNB's using fixed HNB transmit power results in unacceptable performance for co-channel deployments	
	[21]	CSG deployment of HNB's using fixed HNB transmit power results in unacceptable performance both for co-channel and dedicated channel deployments	
Base station Requirements			
Maximum transmit power	[21,25]	**Deployment Configuration A:** agreement that Adjacent Channel interference still exists without some control or reduction of power.	RAN4, RAN2
Maximum transmit power dynamic range	[23,26,27,28]	General agreement that CSG HNB performance may benefit from the ability to set the maximum transmit power to lower values. This will require a change to Primary CPICH Tx Power in TS 25.331, Section 10.3.6.61 and is currently under discussion with RAN2 via LS, [77].	RAN4, RAN2,
Electromagnetic Field protection. Need for Radiated Power Tests	[29]	Raised in [30], no recorded objections	
HNB system Requirements			
Need for BS to set transmit power appropriate for macro environment.	[21,25]	**Deployment Configuration B,C:** Acknowledged that interference in closed system is too high, **interference management mechanism required.**	RAN4, RAN2,
Definition of transmit power level	[30]	**Deployment Configuration B,C:** Multiple possibilities exist to define HNB power level: - Relative to macro CPICH RSCP - Relative to macro CPICH Ec/Io - Relative to total RSSI Could be defined as: - HNB dominance level - Size of dead zone caused.	RAN4, RAN2,
Hand In requirement for Interference mitigation	[30]	**Deployment Configuration A,B,C:** General consensus that aspects of open system help in managing HNB interference scenarios. interference mitigation is required in a closed system; hand in should be permitted as an option.	RAN2, RAN4

5.2.4 Interference scenario 3 UL Macro UE → HNB

As described in interference scenario 1, the HNB attached UE is constrained in its transmit power. Consequently, the HNB attached UE is especially susceptible to interference from the macro UE. The HNB receiver must reach a compromise between protecting itself against uncoordinated interference from the macro UEs, while controlling the interference caused by its own UE's towards the macro layer.

Table 5.2-4. Directory of results for interference scenario 3 UL Macro UE → HNB

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[20,21]	Need to address trade-off between macro and CSG HNB performance. Adaptive uplink attenuation can improve performance.	RAN2, RAN4
	[14]	CSG performance analysis	
Base station Requirements			
Receiver Sensitivity	[17]	In general can be the same as local area BS	RAN4
	[17,31]	**Deployment Scenario B,C:** In a CSG, co-channel deployment, HNB must manage noise rise of other UE's. It is noted that HNB desensitisation has an impact of system performance, eg. a reduction on UE battery life.	RAN4
Receiver Dynamic Range		In general can be the same as local area BS	RAN4
	[31]	**Deployment Scenario B,C:** In a CSG, co-channel deployment, HNB must manage noise rise of other UE's. Local Area BS class spec is sufficient.	RAN4
Adjacent Channel Selectivity		As per Local Area BS class spec.	RAN4
Receiver Performance (fading)	[32]	general consensus on max user speed < 30 km/h;	RAN4
Receiver Performance (delay spread)		50 m cell radius	RAN4
In band blocking tests		As per Local Area BS class spec (dependent on MCL).	RAN4

5.2.5 Interference scenario 4 DL Macro → HNB UE

A trade off exists between the HNB coverage and the impact on the macro network coverage (discussed in Section 5.2.3). The HNB downlink transmit power can be adjusted to maintain coverage if the dynamic range of the HNB power is large enough [16]. Additional performance analysis in a closed system is provided in [14].

No changes to UE. This is expected to hold for LTE as well. The Wide Area Base Station defines the UE RF performance. The UE will then be expected to work with all other classes of eNodeB.

5.2.6 Interference scenario 5 HNB ←→ HNB (UL)

With respect to other HNB, co-channel interference must be considered. This is especially important to deployment option A, where a strong macro presence is not available on the same frequency to act as a reference level to determine UE power limits.

It is difficult to avoid co-channel interference between CSG HNB's, which limits the interference reductions achieved by deploying a CSG HNB on an separate carrier from the macro network, as shown in [15,18,33]. Interference management techniques are required to manage HNB to HNB interference.

Table 5.2-5. Directory of results for interference scenario 5 HNB ←→ HNB (UL)

Requirements Affected	References	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[21,33]	The performance of CSG HNBs is degraded unless interference mitigation techniques are used.	RAN4
	[34]	Without interference mitigation techniques, there is a clear impact on CSG HNB performance. However, the significant of the impact must be judged by the operator in the context of the desired system performance.	
Base station Requirements			
Receiver Sensitivity	[21,33]	Acknowledgement that a large number of HNB could be located very close together	RAN4
Receiver Dynamic Range	[21,33]	Acknowledgement that a large number of HNB could be located very close together	RAN4
Adjacent Channel Selectivity		Acknowledgement that a large number of HNB could be located very close together	RAN4
In band blocking tests		Acknowledgement that a large number of HNB could be located very close together	RAN4
HNB system Requirements			
UE power limits		No protocol changes required	RAN4

5.2.7 Interference scenario 6 HNB ←→ HNB (DL)

With respect to other HNB, co-channel interference must be considered. This is especially important to deployment option A where a strong macro presence is not available on the same frequency to act as a reference to determine HNB transmit power settings.

Table 5.2-6. Directory of results for interference scenario 6 HNB ←→ HNB (DL)

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[21,33]	The performance of CSG HNBs is significantly degraded unless interference mitigation techniques are used.	
	[16,25]	CSG DL performance analysis including apartment blocks and macro layer.	
HNB system Requirements			
Need for HNB to set transmit power based on neighbouring HNB power.		**Deployment Scenario B,C:** Acknowledged that interference in closed system is too high, **interference management mechanism required.**	RAN4, RAN2,

5.2.8 Interference scenarios 7,8 HNB ←→ Other systems

Table 5.2-7. Directory of results for interference scenarios 7 and 8

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
Base station Requirements			
Out of band blocking	[31]	Need for new out of band blocking requirements due to different transceivers on top of each other in the home. [30][31] recommends a 15 dB MCL, 20 cm minimum spacing should be considered for investigations in RAN4 Status: An LS reply [73] was sent to ETSI TC DECT, stating that inter-operation studies are best done in ECC PT1	RAN4
Spurious Emissions	[31]	As above.	

5.2.9 HNB mobile operating very close to serving HNB

Table 5.2-8. Directory of results for HNB mobile operating very close to serving HNB

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
Base station Requirements			
Maximum output power	[35]	Possible impact on a HNB mobile operating very close its serving HNB is addressed. Indicates that power levels lower than 20dBm may be recommended to ensure correct mobile operation.	RAN4

6 HNB class definition

6.1 Changes in 3GPP TS 25.104

This section describes the changes to BS RF requirements specifications TS 25.104

6.1.1 Changes on receiver characteristics

The changes on receiver characteristics are summarized in Table 6.1-1 and were approved in [48].

Table 6.1-1 Summary of changes on receiver characteristics in TS 25.104

Section	Requirement	Discussion / Required Changes
7.2.1	Reference Sensitivity Level	Same requirements l as for Local Area BS
7.3.1	Dynamic Range	Introduced new requirements for Home BS
7.4.1	ACS	Introduced new requirements for Home BS
7.5	Blocking Characteristics	Same requirements as for Local Area BS. The minimum requirements for Home BS when co-located with DECT and WiFi/WLAN are FFS.
7.6.1	Intermodulation characteristics	Same requirements as for Local Area BS.
8.1.	General	Only Static and Multipath Case 1 for Home BS
8.4	Demodulation of DCH…	This requirement shall not be applied to Home BS.
8.5	Demodulation of DCH…	This requirement shall not be applied to Home BS.
8.7	Perf. Req for RACH	Requirements in Tables 8.10, 8.10A, 8.12, 8.12A shall not be applied for Home BS.
8.10	Perf. Of ACK/NACK	Not applicable for Home BS
8.12	Performance of signaling detection for E-DPCCH in multipath fading condition	Requirements in Tables 8.21 and 8.22 are not applicable for Home BS.

6.1.1.1 Receiver dynamic range

The impact of co-channel uplink interference on the Home NodeB has been investigated in [51] for a scenario where the receiver can be exposed to strong blocking signals from un-coordinated UEs. It was shown that the HNB dynamic range requirement needs to be extended by 20dB to protect the HNB from the strong blocking signal of an un-coordinated UE.

6.1.1.2 Adjacent channel selectivity (ACS)

The impact of adjacent channel uplink interference on the Home NodeB has been investigated in [52] for a scenario where the receiver can be exposed to strong blocking signals from un-coordinated UEs. It was shown that the HNB ACS requirement needs to be extended by 10dB to protect the HNB from the strong blocking signal of an un-coordinated UE.

6.1.2 Changes on transmitter characteristics

The main changes on transmitter characteristics were agreed and approved in [36] and [37].

6.1.2.1 Base station maximum output power

Maximum output power, Pmax, of the base station is the mean power level per carrier measured at the antenna connector in specified reference condition. The rated output power, PRAT, of the BS shall be as specified in Table 6.0A in the TS 25.104. In summary:

- the output power of the HNB is limited to 20 dBm (17 dBm for MIMO)
- a power level of 8 dBm is always accepted
- an upper limit on the output power of HNB is introduced to protect an adjacent-channel operator [37]

A minimum requirements was also introduced: In normal conditions, the Base station maximum output power shall remain within +2 dB of the manufacturer's rated output power. In extreme conditions, the Base station maximum output power shall remain within +2.5 dB of the manufacturer's rated output power. In certain regions, the minimum requirement for normal conditions may apply also for some conditions outside the range of conditions defined as normal.

6.1.2.2 Frequency error

During the Home NodeB study item a consensus was reached that the Home NodeB is expected to support UE speeds up to 30 kmph, see the RAN4 conclusions in TR 25.820. Since the UEs are anyhow required to operate with speeds up to 250 kmph within a macro cell, the approach here is to keep the same total frequency error tolerance but allow a larger BS frequency error as a result of the smaller Doppler.

Considering the maximum UE speed of 30 kmph (8.3 m/s), and following the same approach as in TR 25.951 and R4-070687, the corresponding frequency reference error can be calculated as

$$\Delta_{freq,ppm} = \frac{10^6}{f_c} \cdot \left(\frac{v_{UE,max} \cdot f_c}{c} + \frac{0.05 \cdot f_c}{10^6} - \frac{v_{UE,HNB} \cdot f_c}{c} \right) = \frac{v_{UE,max}}{300} + 0.05 - \frac{v_{UE,HNB}}{300}$$

Assuming $v_{UE,max}$ = 69.4 m/s (250 kmph), $\Delta_{freq,ppm}$ becomes equal to 0.254 ppm. It is therefore proposed to relax the frequency error requirement for Home BS class to 0.25 ppm.

The corrsponding text proposal [38] was approved in [36] during RAN 4 #48.

6.1.2.3 Spectrum emission mask

The BS spectrum emission mask specifies the maximum allowed BS emission level in the frequency range from Δf = 2.5 MHz to Δf_{max} from the carrier frequency. In between 2.5 MHz and 12.5 MHz frequency offsets the BS emissions are also limited by the ACLR requirements. However, for scenarios where the frequency offset to the UMTS Tx band edge is larger than 12.5 MHz, the emissions beyond 12.5 MHz offset, e.g. "ACLR3", are limited only by the spectrum emission mask.

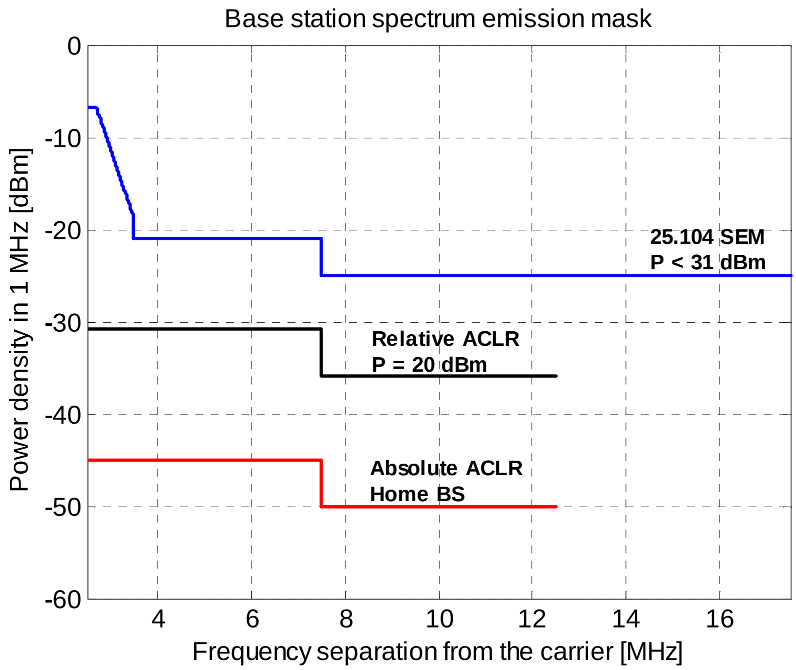


Figure 6.1. Base station spectrum emission limits within the UMTS tx band.

Considering now the current requirements for the Home BS, it is quite straightforward to notice that the ACLR results in considerably stringent emission requirements compared to the spectrum emission mask currently applicable for HNB (P < 31 dBm), see Figure 6.1. Hence, as a result the required ACLR3 becomes considerably smaller than the required ACLR2 as highlighted also in Tdoc R4-080942.

As a solution to avoid this kind of "jumping" ACLR, it is proposed to introduce an additional requirement, valid only for the Home BS and for frequency offset 12.5 MHz < Δf < Δf_{max}. Based on the results in Tdoc R4-080942, and assuming that the maximum output power of the Home BS is less than 20 dBm, it is proposed that the emissions within 12.5 MHz < $\Delta f < \Delta f_{max}$ shall not exceed:

P - 56 dBm/MHz, for 6 dBm ≤ P < 20 dBm

and

-50 dBm/MHz for P < 6 dBm.

The corresponding text proposal [39] was included and approved in [36]

6.1.2.4 Adjacent channel leakage power ratio (ACLR)

Based on the findings in Tdoc R4-080939 and R4-080941 the current (relative) ACLR requirements of 45 dBc (5 MHz offset) and 50 dBc (10 MHz offset) are sufficient also for Home BS. However, as proposed by the results in Tdoc R4-081378 and R4-081379, an absolute emission requirement can be introduced for Home BS in addition to the existing relative requirement. System simulation results for this were presented in [49]. The value for the absolute requirement is proposed to be equal to -50 dBm/MHz for both 5 MHz and 10 MHz frequency offsets. The minimum requirement is calculated from the relative requirement or the absolute requirement, whichever is less stringent.

The corresponding text proposal [40] was included and approved in [36].

6.2 Changes in 3GPP TS 25.141

This section describes the considered changes to base station conformance testing.

The changes in TS 25.141 are summarised in the following tables.. Requirements which are not shown are applicable to Home BS without any modifications from the existing specifications.

The necessary modifications to TS 25.141 were approved in [41-43]. The modifications for test models were approved in [44], based on the comparison of different proposals described in [45].

Table 6.2-1 Changes on transmitter characteristics to TS 25.141

Section	Requirement	Discussion / Required Changes
4.3A	Base station classes	Added a new BS class - Home Base Station. Home Base Stations are characterized by requirements derived from Femto Cell scenarios.
6.2.1	Base station maximum output power	Added rated output power requirement for Home BS. It was agreed on 20 dBm (without MIMO) or 17 dBm (with MIMO).
6.3	Frequency error	Added frequency error requirement for Home BS It was agreed on a minimum frequency error of -0.25ppm-12Hz and maximum frequency error of +0.25ppm+12 Hz.
6.5.2.1	Spectrum emission mask	Added additional requirements for Home BS. Introduction of tabled 6.21D and 6.21E. See [41].
6.5.2.2	ACLR	Added additional ACLR absolute limit requirement for Home BS. It was agreed that for Home BS, the adjacent channel power (the RRC filtered mean power centered on an adjacent channel frequency) shall be less than or equal to -49.2 dBm/MHz or as specified by the ACLR limit, whichever is the higher.
6.5.3	TX Spurious emissions	Added Home BS spurious emissions limits for protection of the BS receiver and coexistence with Home BS operating in other bands. Added Tables 6.37C and 6.47. See [41].

Table 6.2-2 Changes on receiver characteristics to TS 25.141

Section	Requirement	Discussion / Required Changes
7.2	Reference sensitivity level	Added requirement for Home BS. See [42].
7.3	Dynamic range	Added general and additional requirement for Home BS. See [42].
7.4	ACS	Added general and additional requirement for Home BS. See [42].
7.5	Blocking characteristics	Added minimum and narrowband requirements for Home BS. See [42].
7.6	Intermodulation characteristics	Added minimum and narrowband requirements for Home BS. See [42].

Table 6.2-3 Changes on demodulation requirements to TS 25.141

Section	Requirement	Discussion / Required Changes
8.2	Demodulation of DCH in static propagation conditions	The requirement is applied to Home BS. See [43].
8.3.1	Demodulation of multipath fading case 1	The requirement is applied to Home BS. See [43].
8.3.2	Demodulation of multipath fading case 2	The requirements shall not be applied to Home BS. See [43].
8.3.3	Demodulation of multipath fading case 3	
8.4	Demodulation of DCH in moving propagation conditions	
8.5	Demodulation of DCH in birth/death propagation conditions	
8.5A	Demodulation of DCH in high speed train conditions	
8.8	RACH performance	Only requirements in static propagation conditions or multipath fading case 1 are applied to Home BS. See [43].
8.11	Performance of signaling detection for HS-DPCCH	Only requirements in static propagation conditions or multipath fading case 1 are applied to Home BS. See [43].
8.12	Demodulation of E-DPDCH in multipath fading conditions	Only requirements in Pedestrian A are applied to Home BS. See [43].
8.13.1	E-DPCCH false alarm in multipath fading conditions	Only requirements in Pedestrian A are applied to Home BS. See [43].
8.13.2	E-DPCCH missed detection in multipath fading conditions	

Table 6.2-4 Modifications of the transmitter test models in TS 25.141

Section	Requirement	Discussion / Required Changes
6.1.1.1	Test Model 1	For Home base station, additional options of this test model containing 8 and 4 DPCH are also specified. See [44].
6.1.1.3	Test Model 3	For Home base station, additional options of this test model containing 8 and 4 DPCH are also specified.
6.1.1.4A	Test Model 5	For Home base station, an additional option of this test model containing 4 HS-PDSCH + 4 DPCH is also specified.
6.1.1.4B	Test Model 6	For Home base station, an additional option of this test model containing 4 HS-PDSCH + 4 DPCH is also specified.

7 Guidance on how to control HNB interference

7.1 HNB measurements

Several types of measurements that HNB can perform are listed in the following subsections. The objectives of the HNB measurements are

- to provide sufficient information to the HNB for the purpose of interference mitigation
- to provide sufficient information to the HNB such that the HNB coverage can be maintained.

According to the measurement type, some of these measurements can be collected through Connected Mode UEs attached to the HNB or via a DL Receiver function within the HNB itself. Such DL receiver function is also called Network Listen Mode (NLM), Radio Environment Measurement (REM) or "HNB Sniffer".

These measurements can also be used during the HNB self-configuration process.

7.1.1 Measurements from all cells

This section identifies the potential measurements performed by HNB during self-configuration and normal operation. Based on the measurements in Table 7.1.1-1, the HNB can obtain useful information from its surrounding cells for purposes such as interference management.

Table 7.1.1-1: HNB measurements from surrounding cells

Measurement Type	Purpose	Measurement Source(s)
Co-channel carrier RSSI	Calculation of co-channel DL interference towards HUEs from neighbouring cells	HNB DL Receiver HUE
Adjacent channel carrier RSSI	Calculation of adjacent channel DL interference towards HUEs from neighbouring cells	HNB DL Receiver HUE
CPICH Ec/No	Calculation of DL interference towards HNB	HNB DL Receiver HUE
RTWP	Calculation of UL interference towards HNB	HNB Physical Layer

The CPICH Ec/No measurement could be used in the scenario where the HNB is installed near a macro NodeB such that the HNB coverage is sufficient to meet the user requirements.

The HNB downlink interference level depends on the HNB location and coverage area. It can be indicated whether the interference at the coverage edge is larger than the interference at the location of HNB by a pre-defined value. Therefore, HNB's coverage performance can be improved by changing the location of HNB if needed. The downlink interference at the coverage edge can be obtained by UE measurement reports.

The interference level can be indicated to the HNB's owner. With this indication, the owner can make a decision as to where the proper place is to install HNB.

HNB could use the RTWP measurement to monitor the uplink interference. For example, a RTWP measurement value larger than a pre-defined threshold (where an interfering MUE is close to HNB) would mean that the MUE's Tx power would cause significant interference towards the HNB.

7.1.2 Measurements to identify macro cells

This section identifies the potential measurements performed by HNB during self-configuration and normal operation. Based on the measurements in Table 7.1.2-1, the HNB can obtain useful information to identify its surrounding macrocells and indirectly identifies other HNBs nearby for purposes such as mobility handling.

Table 7.1.2-1: HNB measurements to identify macro cells

Measurement Type	Purpose	Measurement Source(s)
PLMN ID	Identification of operator Distinction between macrocell and HNB	HNB DL Receiver
Cell ID	Identification of surrounding macrocells	HNB DL Receiver
LAC	Distinction between macrocell and HNB	HNB DL Receiver
RAC	Distinction between macrocell and HNB	HNB DL Receiver

Note: These measurements are all made as decoded System Information IEs.

7.1.3 Measurements from macro cell layer

This section identifies the potential measurements performed by HNB during self-configuration and normal operation. Based on the measurements in Table 7.1.2-1, the HNB can obtain useful information from its surrounding macrocells for purposes such as interference management.

Table 7.1.3-1: HNB measurements from surrounding macro cells

Measurement Type	Purpose	Measurement Source(s)
Co-channel CPICH RSCP	Calculation of co-channel DL interference towards macro UEs (from HNB) Calculation of co-channel UL interference towards macro layer (from HUEs)	HNB DL Receiver HUE
Adjacent channel CPICH RSCP	Calculation of adjacent channel DL interference towards macro UEs (from HNB) Calculation of adjacent channel UL interference towards macro layer (from HUEs)	HNB DL Receiver HUE
P-CPICH Tx Power [1]	Calculation of pathloss to MNB	HNB DL Receiver

Note 1: “P-CPICH Tx Power” is a decoded System Information IE, rather than a direct physical layer measurement

7.1.4 Measurements of other HNB cells

This section identifies the potential measurements performed by HNB during self-configuration and normal operation. Based on the measurements in Table 7.1.4-1, the HNB can obtain useful information from its adjacent HNBs for purposes such as interference management.

Table 7.1.4-1: HNB measurements from adjacent HNBs

Measurement Type	Purpose	Measurement Source(s)
Co-channel CPICH RSCP	Calculation of co-channel DL interference towards neighbour HUEs (from HNB) Calculation of co-channel UL interference towards neighbour HNBs (from HUEs)	HNB DL Receiver HUE
Adjacent channel CPICH RSCP	Calculation of adjacent channel DL interference towards neighbour HUEs (from HNB) Calculation of adjacent channel UL interference towards neighbour HNBs (from HUEs)	HNB DL Receiver HUE

7.2 Control of HNB downlink interference

7.2.1 Control of HNB power

The following subsections provide some guidance on the control of HNB power relative to its surrounding macro cells and/or other HNBs, as part of interference mitigation techniques used by the HNB. The control mechanisms can be either used during HNB normal operation or during self-configuration process.

7.2.1.1 Control of HNB power with respect to macro layer

This section provides guidelines on setting the HNB total DL transmit power (data and control channel power) based on the following deployment scenarios:

- HNB and MNB operate in either co-channel or adjacent channel
- HNB situated far away from the MNB (i.e. cell edge scenario)
- HNB situated close to the MNB (i.e. cell site scenario)

Based on these deployment scenarios, it is therefore expected that there will be trade-off between the HUE performance and MUE performance when the HNB transmit power is varied.

First the co-channel deployment of HNB and MNB is analyzed for both cell site and cell edge cases. The analysis setup assumes a MNB and a HNB. A MUE is connected to the MNB and a HUE is connected to the HNB as shown in Figure 7.2.1.1-1.

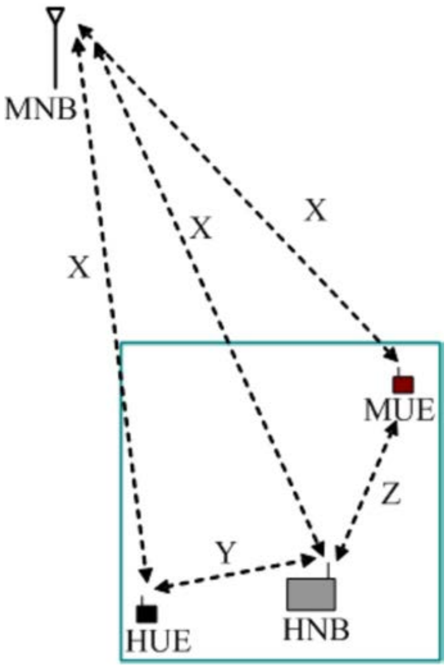


Figure 7.2.1.1-1: DL Interference Setup

7.2.1.1.1 Co-channel deployment

In this section, the performance of HNB when deployed co-channel with MNB is analysed, for both cell site and cell edge cases. For the analysis, some simplified assumptions have been made in an effort to show the basic bottlenecks that arise from such deployment scenarios.

The system model is also simplified (compared to a real situation) as shown in Figure 7.2.1.1-1, which consists of one MNB and one HNB. Only one MUE is connected to the MNB and only one HUE is connected to the HNB. We assume the pathloss from the MUE, HUE, HNB to the MNB are all equal to PL_MNB, i.e., X=PL_MNB. The parameters for the setup are given in Table 7.2.1.1.1-1. The total received signal level (i.e., RSSI) in the table includes the signals received from all NBs (MNBs and HNBs) other than the HNB under consideration. The RSSI is assumed to be the same at the HNB, HUE and MUE. Both the MUE and the HUE are placed at PL_HNB from the HNB, i.e., Y=Z=PL_HNB.

Table 7.2.1.1.1-1: Parameters for co-channel deployment: cell edge versus cell site

Parameters	Cell Edge	Cell Site
PL to MNB [dB]	140	100
RSSI [dBm]	-95	-60
MNB RSCP [dBm]	-107	-67
MNB maximum Tx Power [dBm]	43	43
MNB Tx CPICH Ec [dBm]	33	33
HNB CPICH Ec/Ior [dB]	-10	-10
MNB load factor [%]	50	50
HNB load factor [%]	100	100

In the analysis, the HNB Tx power is varied and the corresponding CPICH Ec/No of both the MUE and the HUE are calculated for different values of PL_HNB.

For the Cell Edge case the trade-off results are shown in Figure 7.2.1.1.1-2.

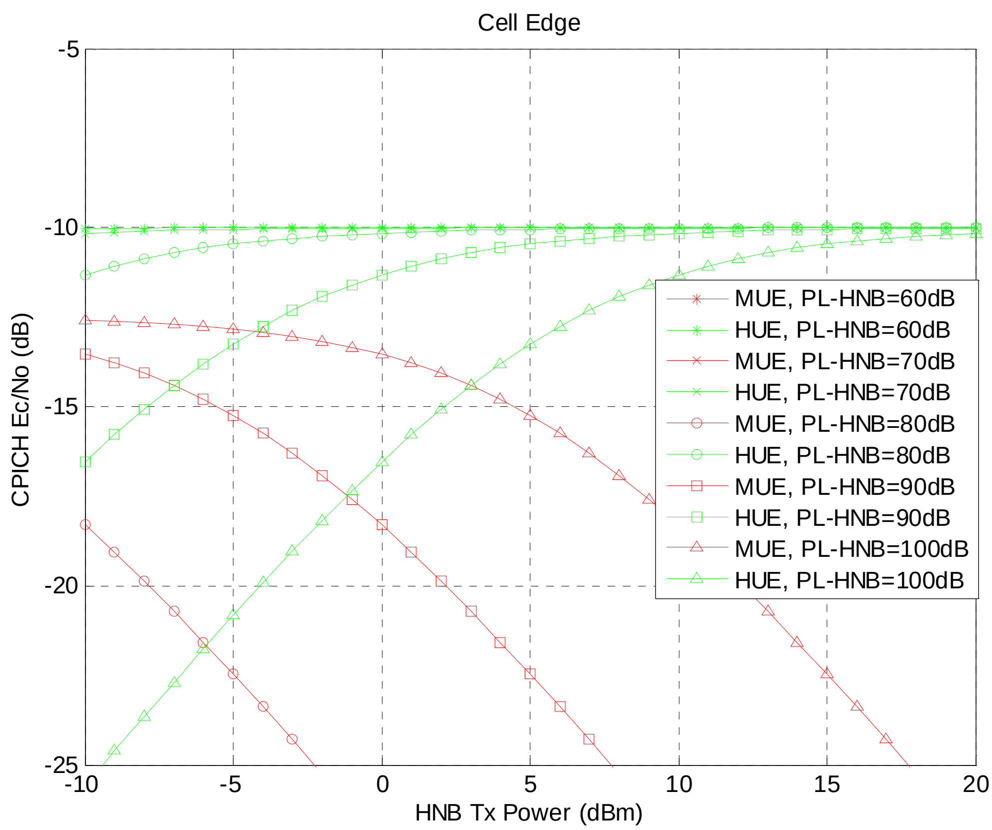


Figure 7.2.1.1.1-2: Trade-off between HUE and MUE performance as a function of HNB tx power at cell edge

It is observed that the at the cell edge, *the HNB needs to transmit at low power to maintain the required coverage for the MUE*. Also, as the desired coverage radius reduces, the HNB power has to be lower to maintain the MUE performance.

For the Cell Site case the tradeoff results are shown in Figure 7.2.1.1.1-3. *At the cell site the HNB has to increase its power to maintain good coverage for the HUE while not creating "much" interference for the MUE*. More power is required to maintain the same coverage for the HUE compared to the cell-edge case, due to larger interference from the MNB.

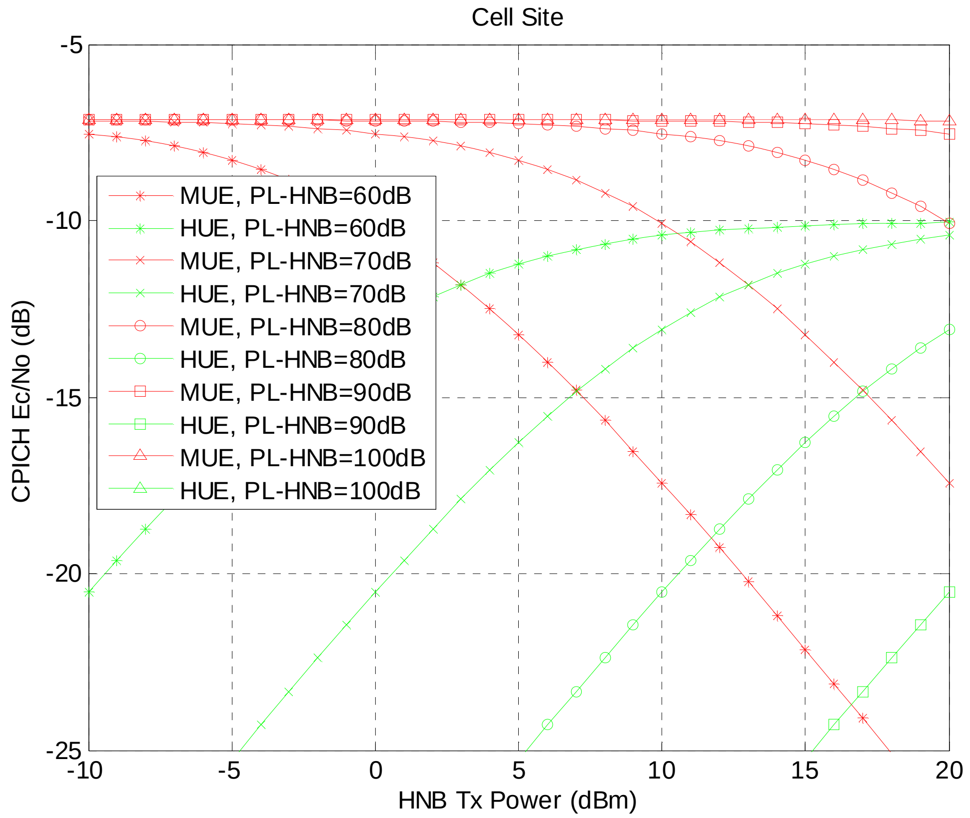


Figure 7.2.1.1.1-3: Trade-off between HUE and MUE performance as a function of HNB tx power at cell site

In these figures, different PL_HNB values correspond to different HNB deployment scenarios. Depending on the particular deployment scenario (e.g., suburban, urban, dense-urban), the HNB can have different coverage radius (i.e., link budget). For example, in a suburban scenario, the HNB coverage can be 100dB whereas a lower HNB coverage radius (e.g., 70dB) may be more suitable for dense-urban deployments. It is seen that in the cell edge scenario, using high HNB Tx power results in poor CPICH Ec/No for the MUE. On the other hand, when HNB is close to the macrocell site, a low HNB Tx power results in poor CPICH Ec/No for the HUE. As the HNB Tx power increases, the MUE CPICH Ec/No degrades. Therefore, the HNB transmit power needs to be adjusted properly to maintain an acceptable performance for both the HNB and the MNB.

In order to exemplify how to adjust the HNB DL transmit power, we employ the following algorithm, where the transmit power of HNB is determined based on the results of a few measurements. Each HNB measures the total signal strength (No) from all the other NodeBs (including MNBs and HNBs). It also measures the pilot strength from the best co-channel and adjacent-channel MNBs. Based on these measurements, the HNB can calculate its transmit power:

1. To maintain an CPICH Ec/No of -18dB for a MUE located X1 dB away from the HNB on the same channel (i.e., protect the co-channel macro user)
2. To maintain an CPICH Ec/No of -18dB for a MUE located X2 dB away from the HNB on the adjacent channel (i.e., protect the adjacent channel macro user)
3. To make sure that HNB is not causing unnecessary interference to others by enforcing a cap on CPICH Ec/No of the HUE of -15 dB at X3 dB away from the HNB.

Using the algorithm above with X1=X3=PL_HNB, the calibrated HNB transmit powers for the co-channel case for different PL_HNB values are shown in the following table.

Table 7.2.1.1.1-2: Calibrated HNB transmit power for cell-edge and cell-site scenarios

PL_HNB (dB)	60	70	80	90	100
Cell Edge: HNB Transmit Power in dBm	-10	-10	-10	-7.9	2.1
Cell Site: HNB Transmit Power in dBm	-3.2	6.8	16.8	20	20

The performance of the HUE and the MUE at the specified coverage radius and specified HNB output power is given in Table 7.2.1.1.1-3 and 7.2.1.1.1-4 for cell edge and cell site cases, respectively.

Table 7.2.1.1.1-3: Performance for cell-edge scenario based on the HNB tx powers in Table 7.2.1.1.1-2

PL_HNB (dB)	60	70	80	90	100
MUE CPICH Ec/No (dB)	-37	-27	-18	-14	-14
HUE CPICH Ec/No (dB)	-10	-10	-11.3	-15	-15

Table 7.2.1.1.1-.4: Performance for cell-site scenario based on the HNB tx powers in Table 7.2.1.1.1-2

PL_HNB (dB)	60	70	80	90	100
MUE CPICH Ec/No (dB)	-8.8	-8.8	-8.8	-7.5	-7
HUE CPICH Ec/No (dB)	-15	-15	-15	-20.5	-30

In general, we observe that at the cell edge deployment, the HNB should transmit at lower power compared to the cell site deployment. This is to maintain the minimum level of performance requirements for the MUE at the coverage radius. In some cases, the HNB will end up hitting the minimum transmit power level (e.g., -10dBm) in an attempt to satisfy the requirement for the MUE. For the cell-site, in some cases the HNB will end up hitting the maximum transmit power level (e.g., +20dBm) in an attempt to provide coverage for the HUE at the HNB coverage radius.

7.2.1.1.2 Adjacent channel deployment

For the adjacent channel scenario, we consider the case when the two operators have macrocell Node Bs that are *not collocated*. The simulation parameters for the adjacent operator deployment are shown in Table 7.2.1.1.2-1.

Table 7.2.1.1.2-1: Parameters for adjacent channel non-collocated operator deployment.

Parameters	Operator 1	Adjacent Operator
PL to MNB	100 dB	120 dB
RSSI	-60 dBm	-80 dBm
MNB RSCP	-67 dBm	-87 dBm

The other simulation parameters are the same as for the co-channel deployment. A NodeB ACLR of 45dB and UE ACS of 33 dB are assumed, which result in an ACIR of 33 dB. The MUE and the HUE will have the same pathloss to the HNB (after taking the ACIR into account), as this is the worst case envisioned in this study.

The trade-off between the performance of the MUE and the HUE as a result of varying the HNB transmit power is shown in Figure 7.2.1.1.2-1.

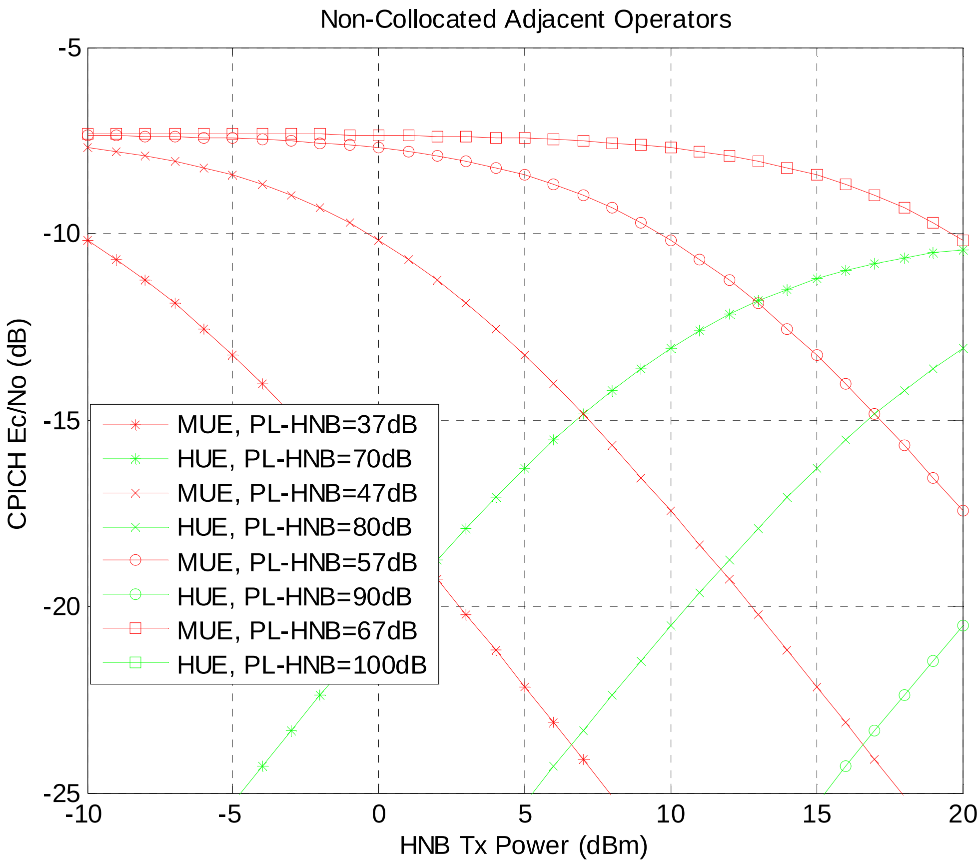


Figure 7.2.1.1.2-1: Trade-off between HUE and MUE (on adjacent channel) performance as a function of HNB tx power for non-collocated operators

The calculated HNB transmit powers as obtained from the example algorithm described above with X1=X3=PL_HNB and X2=47dB are in the following table.

Table 7.2.1.1.2-2: Calibrated HNB transmit power for adjacent channel non-collocated operator deployment.

PL_HNB (dB)	70	80	90	100
HNB Transmit Power in dBm	6.8	10.6	10.6	10.6

The CPICH Ec/No performance of the HUE and the MUE at the specified coverage radius and specified HNB output power is given in Table 7.2.1.1.2-3.

Table 7.2.1.1.2-3: Performance for adjacent-channel scenario based on the HNB tx powers in Table 8.6

PL_HNB (dB)	70	80	90	100
MUE CPICH Ec/No (dB)	-14.7	-18	-18	-18
HUE CPICH Ec/No (dB)	-15	-20	-29.6	-39.5

It is observed that the although the HNB is close to the adjacent-channel cell site, the calibrated powers for the HNB are lower than those in Table 7.2.1.1.1-2 for the co-channel cell site case. This is because the HNB has to lower its power to maintain the coverage for the adjacent operator's MUE. The case is of interest when the MNBs of the two operators are not collocated.

7.2.1.2 Centralized HNB power control

From the previous studies we noticed that when HNB tries to self calibrate the transmission power it sometime faces an important bottleneck: the power necessary for guaranteed coverage in higher that a level which would also insure the co- and adjacent channels protection. In the scenarios we assumed, there are cases when either one of them has to be compromised in the favour of the other. One of the problems is that HNB measurements on the surrounding environment are not precise enough (i.e. we refer at the tolerance of the measurements, how often the HNB can perform these measurement, etc.), to allow the presented algorithm to calculate the ideal transmission power for the respective moment in time.

In this section, we explore an alternative approach, when the HNB power control algorithm is implemented in a *"centralized"* manner. The HNBs may be initially configured with default thresholds for one or more parameters: HNB data rate, macro cell dead-zone, CIR of HUEs, detection of a nearby macro UE etc. The individual HNB then locally calibrates the transmission power to meet these thresholds by monitoring the relevant parameters using the algorithm above. As traffic conditions vary, the HNB gateway, which is an element owned by the operator deploying HNBs,, may compute the desired thresholds for these parameters and communicate to the HNBs at a slower or faster time-scale. This network command is not time-critical and does not rely on all HNBs being able to "hear" the network. It is meant to simply optimize system performance.

Three options for enhancing the power adjustment of HNBs are proposed below. Note that these techniques are not mutually exclusive, and may co-exist with each other.

- **Usage of macro network specific information.** The desired thresholds for the relevant system parameters (data rate, macro cell dead-zone coverage etc) are computed by the network for all HNBs. To do this, the network may take into account macro NodeB load, number of active HNBs, distance of the HNB to the macro cell, fading environment, time-of-day etc. The network command with threshold is communicated to the HNB either through the Broadcast Control Channel (BCCH) or the backhaul such as DSL or cable connection. By sharing information between HNB and macro NodeBs using the backhaul, it is possible for HNB to get more information than otherwise could obtain by listening the broadcast channels. For example, the close-by macro UE's target signal to noise ratio (SNR), measured SNR, and received power are information that can be utilized for HNB power adjustment in a more proper way with respect to the interference caused to the surrounding macro networks However, it is required to modify the signalling at the macro layer to support this functionality and carefully design the backhaul information exchange by controlling the overhead.

- **Pseudo-static power assignment for HNB.** In addition to dynamic power calibration, it may be desirable to have a pseudo-static power assignment to the HNB. The transmit power of the HNB is a simple function of the HNB's geographical location. The default value for transmit power and a geographical zone can be pre-configured at the time of buying a HNB or when there is a change in the location of the HNB. Any changes to the zone-wise power setting of HNB can be communicated at a slower time-scale over BCCH or the backhaul such as DSL or cable connection. However, it is again required to modify the signalling at the macro layer to support this functionality.

- **Control channel – data channel power ratio.** The proposal is to manipulate the ratio between HNB control channels power and HNB data channels power. For example, depending on the expected throughput, we can fix the control channel power, while reducing the maximum data channel power. This will ensure that the coverage area (for the assumed expected throughput) for HUE does not diminish, but the allowed total transmit power of HNBs reduces. This will result in improved macro cell coverage and reduced HNB maximum power requirement, at the same time. Note that the HNBs can support relatively high data rates even at low data channel power settings.

7.2.1.3 Control of HNB power with respect to other HNB

Similar principles as in Section 7.2.1.1 and Section 7.2.1.2 can be applied to set the Tx power of the HNB in a dedicated deployment. One difference is that the co-channel macro condition does not apply in this case. For example, the transmit power of HNB may be determined as follows.

Each HNB measures the total signal strength (No) from all the other NodeBs (including MNBs and HNBs). It also measures the pilot strength from the best MNB on the adjacent channel. Based on these measurements, the HNB determines its transmit power:

i. To maintain an CPICH Ec/No of -18dB for a MUE located X2 dB away from the HNB on the adjacent channel (i.e., protect the adjacent channel macro user)

ii. To make sure that HNB is not causing unnecessary interference to others by enforcing a cap on CPICH Ec/No of the HUE of -15 dB at X3 dB away from the HNB.

7.2.1.4 Control of HNB power or macro UE based on network control

When the HNBs are deployed on the same channel as the macro network, macro UEs can experience interference from HNB DL when the macro UE is nearby a HNB or gets close to the HNB. One potential solution for mitigating this interference is to control HNB DL or macro UE adaptively through enhanced interference coordination.

Potential methods for controlling HNB transmission power adaptively according to the macro UE behavior are as follows;

i. To reduce the interference to macro UE from HNB, it is useful to reduce the HNB CPICH power temporarily (this is only applicable when no HUEs exist on the HNB)

ii. To avoid the interference to macro UE from HNB, it is useful to halt the HNB CPICH power temporarily (this is only applicable when no HUEs exist on the HNB)

A potential method for controlling macro UE adaptively according to the macro UE behavior is as follows;

i. To avoid the interference to macro UE from HNB, the macro UE is driven out to another carrier by the network. (this is only applicable to the areas deploying overlay carriers)

These solutions may need trigger from macro UEs. AS and NAS procedures may be utilized for this purpose.

7.2.1.5 Enhancements for Control of HNB Tx Power

7.2.1.5.1 UE-Assisted Power Calibration

To deal with scenarios where there is a significant mismatch between the RF conditions measured by the HNB and those experienced by the MUEs and HUEs, it is useful to use UE measurements (or measurement statistics) to optimize the calibrated HNB Tx power. This is particularly useful in co-channel deployments and can provide better protection for MUEs while maintaining good HNB coverage for the HUEs.

For example, if the HNB is placed near a window, HNB may see a stronger signal from MNB than the indoor HUE. In this case, HNB power calibration algorithm responding to the higher level of signal from the MNB, may set the transmit power of the HNB to a higher value than needed for the coverage of the home. This higher power may create a coverage hole for the MUEs that may be walking on the street close to the HNB premise. Therefore, if both the measurements from MUEs and HUEs (e.g. path loss to HNB), are made available to the HNB, then HNB can fine-tune its HNB Tx power.

7.2.1.5.2 Minimum HNB Tx power

According to [57], the RRC signalling limits the lowest value for Primary CPICH Tx Power to -10 dBm. For CPICH Ec/Ior of -10 dB, this limits the lowest power transmit by a HNB to 0 dBm. However, in certain cases such as when the HNB is located at macro cell edge, the effectiveness of HNB power calibration algorithms is reduced because of 0 dBm limit imposed by the CPICH signalling. Since the HNB Tx power calibration algorithm may indicate a value less than 0 dBm as the desired value, it is useful to reduce the lower limit that can be signalled for CPICH Tx Power. This should be done in a manner that ensures backward compatibility with legacy UEs.

7.3 Control of HNB uplink interference

The guidance in this section addresses issues related to UL interference. The specific cases considered are:

a) how to minimise UL interference from HUEs towards the macro layer and other neighbour HNBs

b) how to accommodate UL interference from uncontrolled (e.g. macro) UEs towards the HNB

7.3.1 Control of HUE allowable transmit power

This is to address UL interference from HUEs towards the macro layer and other neighbour HNBs. This is especially significant when a HUE is at the edge of its coverage, for example outside the property, but has good visibility of a neighbouring cell. Under such extreme conditions the UL power transmitted by the HUE could cause a considerable noise rise at the macro NodeB impacting its UL capacity.

Such conditions are extreme and potentially unlikely in practice; HUE transmit levels will not typically cause a significant noise rise at neighbour cells. However to cover these extreme cases a maximum limit for the allowed transmit power of HUEs can be defined.

In order to evaluate the potential level of UL interference that can be caused by a HUE, it is necessary to estimate the pathloss from the vicinity of the HNB to the neighbouring NodeBs. The pathloss from the vicinity of the HNB to the neighbouring NodeBs can be derived from measurements of CPICH RSCP of the neighbouring cells – potentially made by UEs attached to the HNB or by the HNB itself using a Downlink Receive mode of operation. Details of these measurements can be found in Section 7.1.

Based on the pathloss and other related parameters, the HNB can then determine a maximum allowed HUE transmit power, such that the noise rise experienced at the neighbour cells is constrained to be within an acceptable limit. This maximum power level would be signalled to the HUE as part of its normal RRC connection setup procedure. Further, periodic and/or event-triggered pathloss measurements made by the UEs can be used by the HNB to update the maximum allowable UE transmit power or a correction factor that used to offset the initial maximum allowable UE transmit power determined during the HNB self-configuration. The updated value can be signalled to the UE using e.g., Radio Bearer Reconfiguration message.

Alternatively, a fixed “cap” on the HUE transmit power could be defined irrespective of the proximity of the macro NodeB. Such approach offers simpler HNB implementation. However, due to no adaptation in the HUE transmit power level, if the cap is set too high, then this will create high UL interference. On the other hand, if the cap is set too low, then the UL interference is reduced at the expense of a potential reduction in the HUE UL throughput. Therefore, this limit would need to be selected such that the noise rise generated at the macro layer was acceptable in the worst case co-channel deployment scenario. A suggested value for this limit is 21dBm.

The pros and cons of these mitigation techniques can be summarised in Table 7.3.1-1.

Table 7.3.1-1: HUE Allowable transmit power control techniques - pros and cons

HUE Allowable Transmit Power Control techniques	Pros	Cons
Fixed “cap”	simple HNB implementation no additional signalling requirements	potential high UL interference created by HUE(s) if cap is not set optimally high UL interference created by HUE(s) transmitting at consistently high Tx power (e.g. cell edge scenarios)
Dynamic	reduced UL interference created by HUE(s) transmitting at high Tx power improved HNB performance	additional signalling required to adjust the allowable HUE Tx power additional HNB RRM implementation

The noise rise at the MNB due to the HUE UL transmission can be determined from the estimated pathloss, as shown in the following link budget example. Table 7.3.1-2 shows the parameters used on the link budget analysis.

Note that "estimated pathloss" is the difference between the MNB "CPICH Tx Power" as indicated in its System Information and the CPICH RSCP as received at the HNB. Therefore "estimated pathloss" is equivalent to actual pathloss minus the MNB and HNB antenna gains.

Table 7.3.1-2: Link Budget example parameters

Parameter	Value	Formula
Thermal noise density	-174 dBm/Hz	ND_t
Bandwidth	3.84 MHz	BW
Thermal noise power	-108.16 dBm	N_t = ND_t + 10log(BW*10^6)
MNB Noise Figure	5 dB	NF
MNB receiver noise floor	-103.16 dBm	N_rx = N_t + NF
MNB antenna gain	14 dBi	Gant_m
HNB antenna gain	0 dBi	Gant_h
Actual Pathloss	100 dB (for example)	PL
Pathloss estimate	86 dB	PL_Est = PL – Gant_m – Gant_h
HUE tx power	-30 dBm (for example)	H_tx
HUE antenna gain	0 dBi	Gant_ue
ACLR	0 dB (co-channel)	ACLR
HUE rx power at MNB	-116 dBm	H_rx = H_tx + Gant_ue - PL - ACLR + Gant_m
Noise rise due to HUE	0.22 dB	NR = 10log(1 + log2lin(H_rx – N_rx))

Figure 7.3.1-1 and Figure 7.3.2-2 show the noise rise at the MNB vs HUE transmit power, for a range of pathloss values.

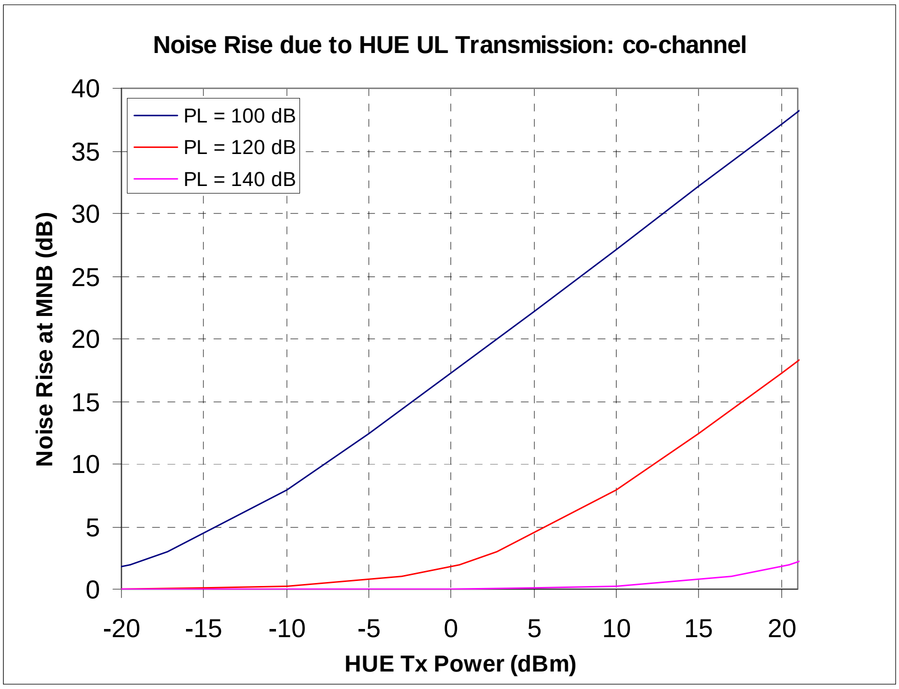


Figure 7.3.1-1: Noise rise at co-channel MNB

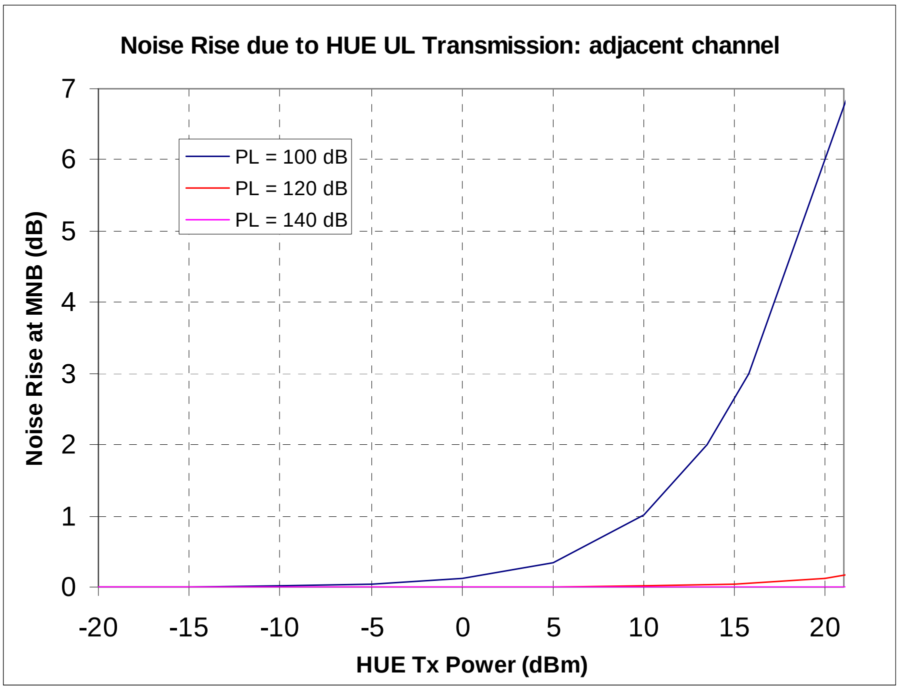


Figure 7.3.2-2: Noise rise at adjacent channel MNB

From these characterisations, the HNB can select a maximum allowable HUE transmit power based on the estimated pathloss, the desired limit to the noise rise at the MNB and the RSCP and/or RSSI levels of other neighbour NodeBs.

7.3.2 Control of HNB noise rise threshold

This is a mitigation technique to address UL interference from uncontrolled macro or other HNB UEs towards the HNB. This is especially significant for CSG deployments, as illustrated by the following scenarios:

1. Uncontrolled UEs may be located within the premises where the HNB is installed while still being attached to an external macro network. In such cases the macro UE's transmit power will be high while the pathloss to the HNB will be small.

2. A HUE can generate a large UL noise rise at the HNB if the pathloss is very small and the HUE cannot be powered down due to limited dynamic range.

This mitigation approach also applies to the use of HSUPA and is associated with the UL scheduler. Specifically the scheduler in the HNB is configured to dynamically allow a greater UL noise rise (rise over thermal) than would normally be the case for a macro NodeB. This ensures that the HNB scheduler will be able to continue to grant significant capacity on the UL, so that HUE traffic throughput can be maintained, in the presence of an interfering macro UE or when a HUE cannot be powered down.

Adjustment of the UL noise rise threshold can be made by the HNB, driven by measurements of receive total wideband power (i.e. RTWP) or other similar measurement entities on the UL (as outlined in Section 7.1). Blocking levels of UL noise rise due to out of cell interference can be detected and the noise rise threshold adjusted accordingly. This adjustment would only need to be made temporarily while the UL interference was strong and as the noise rise was seen to fall the noise rise threshold could be returned to its normal operating value. However, in the presence of such greater UL noise rise, the HNB receiver should be designed so as to ensure proper system stability for HUEs (e.g., in the presence of bursty interference from MUE or power race among multiple HUEs) and adequate demodulation performance.

Modifying the HNB scheduler in this way will increase HUE throughput but as a result will also increase the UL interference caused by the HUEs at the macro layer. As a consequence the UL throughput of macro UEs can become degraded. The application of an upper limit on the HUE transmit power, as discussed in Section 7.4.1, will ensure that this effect is constrained to an acceptable level.

Table 7.3.2-1 summarises the control of HNB noise rise threshold.

Table 7.3.2-1: Control of HNB noise rise threshold based on different deployment scenarios

Deployment Scenario	Interference source(s)	HNB noise rise threshold setting
HNB installed inside a building far from macrocell site	Macro UEs attached to macrocell and located close to HNB	High
HNB installed inside a building close to macrocell site	Macro UEs attached to macrocell and located close to HNB	Low
HNB installed inside a building far from other HNBs	HUE(s) served by other HNBs and located close to HNB	High
HNB installed inside a building close to other HNB(s)	HUE(s) served by other HNBs and located close to the HNB	Low
HNB installed inside a building	Own HUE(s) located very close to the HNB that cannot be powered down due to limited dynamic range	High

7.3.3 Control of HNB receiver gain

This is an alternative mitigation technique to address UL interference from uncontrolled UEs towards the HNB and increase in noise rise from a HUE that cannot be powered down due to limited dynamic range. Again it is especially significant for CSG deployments where uncontrolled UEs may be located within the HNB premises while still being attached to an external macro network. In such cases,

- the macro UE's transmit power could be high while the pathloss to the HNB could be small, or
- the uncontrolled UE (i.e. a HUE) associated with a neighbour HNB could be transmitting at high power, or
- own HUE located very close to the HNB could be transmitting at high power as it cannot be powered down due to limited dynamic range

This mitigation approach is based *on dynamic control of the receiver gain* or UL attenuation, also known as *adaptive noise figure adjustment*. This has the effect of moving the dynamic range of the HNB receiver such that the interfering UE is no longer blocking the UL. As a consequence the HNB receiver is temporarily desensitised during periods of reduced gain or attenuation.

Adjustment of the receiver gain or UL attenuation can be made by the HNB, driven by measurements of receive total wideband power (i.e. RTWP) or other similar measurement entities on the UL. Blocking levels of UL noise rise due to out of cell interference can be detected and the receiver gain reduced accordingly. This adjustment would only need to be made temporarily while the UL interference was strong and as soon as the noise rise was seen to fall the receiver gain could be returned to its normal operating value.

This adjustment would also need to react fast when the UL interference is strong or noise rise from a HUE is high and slowly decay with time, e.g., to accommodate variations in interference due to bursty traffic. The effect of such desensitisation would be to temporarily cause HUEs to increase their own UL transmit power and thereby increase interference to the macro layer. Therefore, it is crucial to determine the correct amount of attenuation that will improve the HUE's performance without degrading the MUEs. The application of an upper limit on the HUE transmit power, as discussed in Section 7.4.1, will ensure that a runaway positive feedback condition is avoided.

7.3.3.1 Performance analysis

The performance of using dynamic control of the receiver gain or UL attenuation can be obtained using the following analysis setup. The general set up for the uplink analysis is given in Figure 7.3.3.1-1. The cell edge case is considered first, where a HNB is deployed at the edge of a macro cell and it has an active HUE associated with it. There is also a MUE which is located close to the HNB. The HNB, HUE and the MUE are assumed to have 140dB PL with the MNB (X=140dB). The HUE and the MUE are assumed to be separated from the HNB by Y and Z dB PL, respectively.

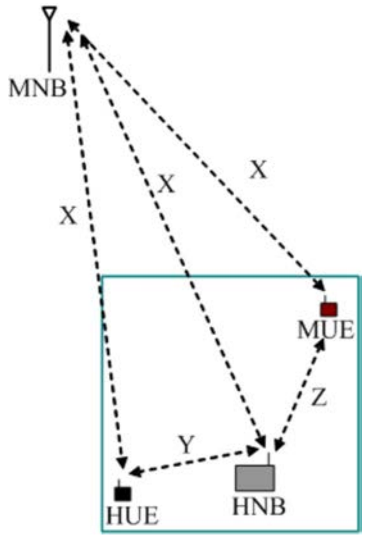


Figure 7.3.3.1-1: UL Interference Analysis Setup

The PL values of interest (i.e., Y and Z) depend on the HNB coverage determined by the tx power chosen. Three deployment scenarios are considered: a) HNB with 70dB coverage radius, b) HNB with 80dB coverage radius, and c) HNB with 90dB coverage radius. Both cell edge and cell site scenarios are analyzed. The performance analysis for the cell edge and cell site scenarios demonstrate the need for an adaptive algorithm that adjusts the UL attenuation / padding based on the out-of-cell interference experienced at the HNB.

7.3.3.1.1 Cell edge scenarios

For cell edge scenario, the following PL pairs are investigated in more detail (Table 7.3.3.1-1). When the HNB coverage of 70dB is targeted, the HNB tx power cannot go as low as required (min HNB total tx power limitation of -10dBm is assumed). Therefore, a MUE located at the edge of the targeted coverage region will be in outage. Hence, the MUE is placed 80dB away from the HNB in this case.

Table 7.3.3.1-1: Cell edge parameters

Parameters	Values		
HUE UL Ec/No at HNB	-2.4 dB		
HNB default Noise Figure	19 dB		
Maximum HUE/MUE Tx Power	21 dBm		
MNB Noise Figure	5 dB		
Additional interference at MNB	-101 dBm		
Y: PL (HUE to HNB)	70 dB	80 dB	90 dB
Z: PL (MUE to HNB)	80 dB	80 dB	90 dB

Being at the cell edge, the MUE is assumed to be transmitting at 21dBm (e.g., the maximum UE total tx power). The MUE transmitting at high power close to the HNB can significantly increases the noise rise at the HNB. This noise rise contribution is denoted by Ec/No', where Ec is received signal strength of the MUE at the HNB and No' corresponds to the received signal strength in the absence of HUE or MUE. The goal of the UL interference management is to keep the MUE contribution on the HNB noise rise below the noise rise threshold by adding attenuation or increasing the noise figure, such that the HUEs can get scheduled.

In Figure 7.3.3.1-2, the solid curves correspond to the noise rise contribution of the MUEs at the HNB as a function of the additional padding / UL attenuation applied at the HNB. The HUE transmit power is determined based on a -2.4dB Ec/No requirement. The dashed curves correspond to the noise rise contribution of HUE at the MNB. Although the transmit power of the HUE is increased with the additional attenuation applied at the HNB, the HUE is still located very close to the HNB while being on the edge of the MNB coverage. Therefore, the HUE's contribution to the MNB noise rise is minimal.

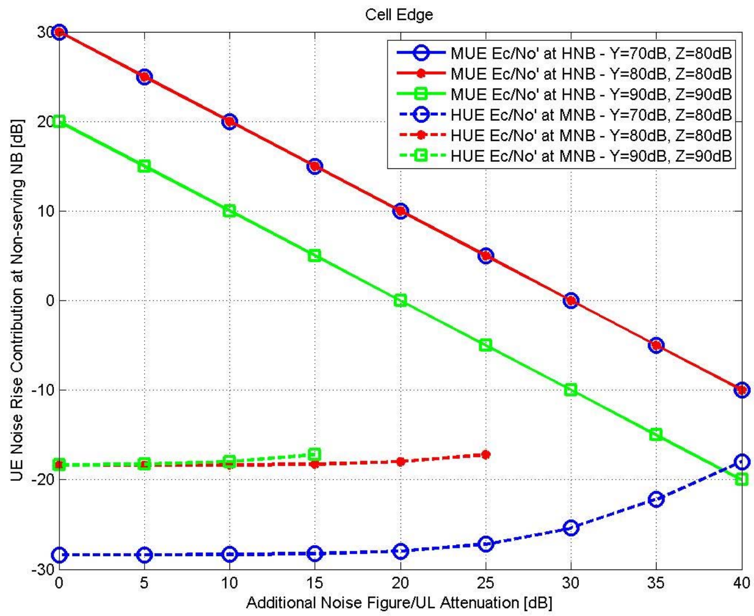


Figure 7.3.3.1-2: UL cell edge scenario: noise rise contribution of non-associated UEs

The HUE and MUE Ec/No values at their corresponding serving NBs are provided in Figure 7.3.3.1-3. Although the effect of HUE on the macro network is minimal, using more than the required amount of attenuation is not desired. For the cases where HUE to HNB PL is 80dB and 90dB, it is observed that beyond 10dB and 20dB additional noise figure respectively, the HUE starts running out of headroom and is unable to maintain the Ec/No requirement.

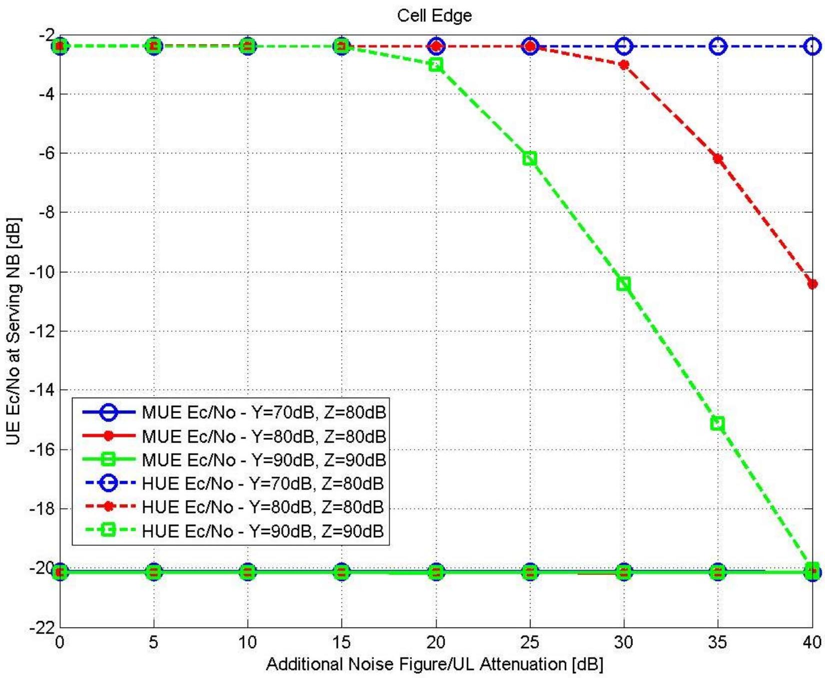


Figure 7.3.3.1-3: UL cell edge scenario: Ec/No at serving NB

A reference algorithm trying to maintain the out-of-cell contribution to the HNB noise rise at 3dB would choose the following UL attenuation values (Table 7.3.3.1-2):

Table 7.3.3.1-2: Cell edge analysis: suggested UL attenuation at HNB

Y: PL (HUE to HNB)	70 dB	80 dB	90 dB
Z: PL (MUE to HNB)	80 dB	80 dB	90 dB
UL Attenuation (Additional Noise Figure)	27dB	27dB	17dB

7.3.3.1.2 Cell site scenarios

For cell site scenarios, the HNB is deployed close to the macro cell site. In this case the HNB, HUE and the MUE are assumed to have 100dB PL to the MNB (X=100dB). The PL values of interest (i.e., Y and Z) again depend on the HNB coverage determined by the tx power chosen. For the cell site case, the following PL pairs are investigated in more detail (Table 7.3.3.1-3). When a HNB coverage of 90 or 100dB is targeted, the HNB tx power becomes insufficient due to the max HNB total tx power limitation of 20dBm. Therefore, a HUE located at the edge of targeted coverage region is unable to maintain -20dB CPICH Ec/No with the HNB.

Table 7.3.3.1-3: Cell site parameters

Parameters	Values		
HUE UL Ec/No at HNB	-2.4 dB		
HNB default Noise Figure	19 dB		
HUE maximum Tx Power	21 dBm		
MUE Tx Power	-15 dBm		
HNB maximum Tx Power	20 dBm		
MNB Noise Figure	5 dB		
Additional interference at MNB	-101 dBm		
Y: PL (HUE to HNB)	70 dB	80 dB	80 dB
Z: PL (MUE to HNB)	70 dB	80 dB	90 dB

Being at the cell site, the MUE is assumed to be transmitting at -15dBm. In Figure 7.3.3.1-4, the noise rise contributions of the MUE and HUE at the HNB and MNB, respectively are presented. Here again, the HUE transmit power is determined based on a -2.4 dB Ec/No requirement.

As seen in Figure 7.3.3.1-4, unlike the cell edge case, there is no need for large additional UL attenuation values to control the noise rise at the HNB. In fact, if unnecessary attenuation is applied, then the HUE tx power increases considerably, creating significant noise rise at the MNB.

In Figure 7.3.3.1-5, the UE Ec/No values at their serving NB are presented. It is clearly seen that the MNB Ec/No goes down if more than necessary UL attenuation is used. For certain cases, the HUE could also run out of headroom and not be able to maintain the required Ec/No.

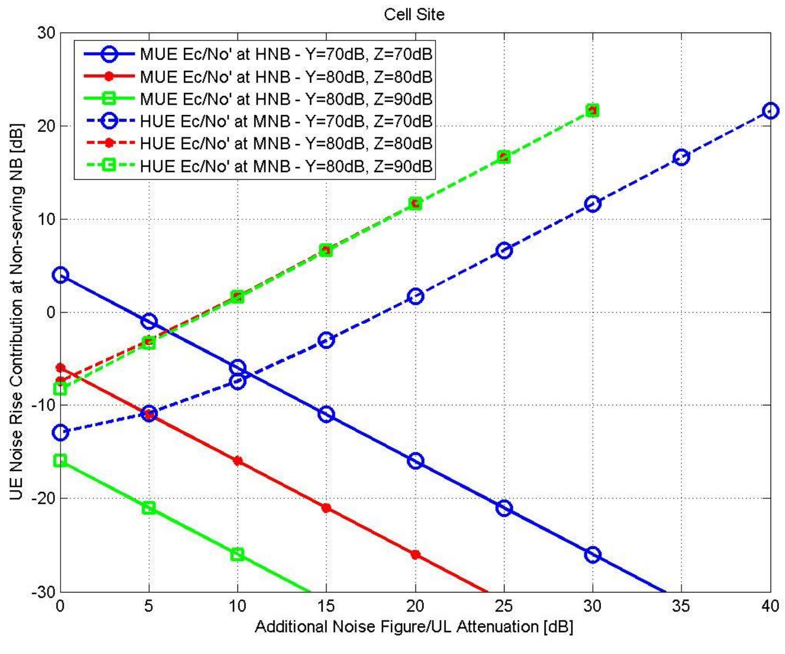


Figure 7.3.3.1-4: UL cell site scenario: noise rise contribution of non-associated UEs

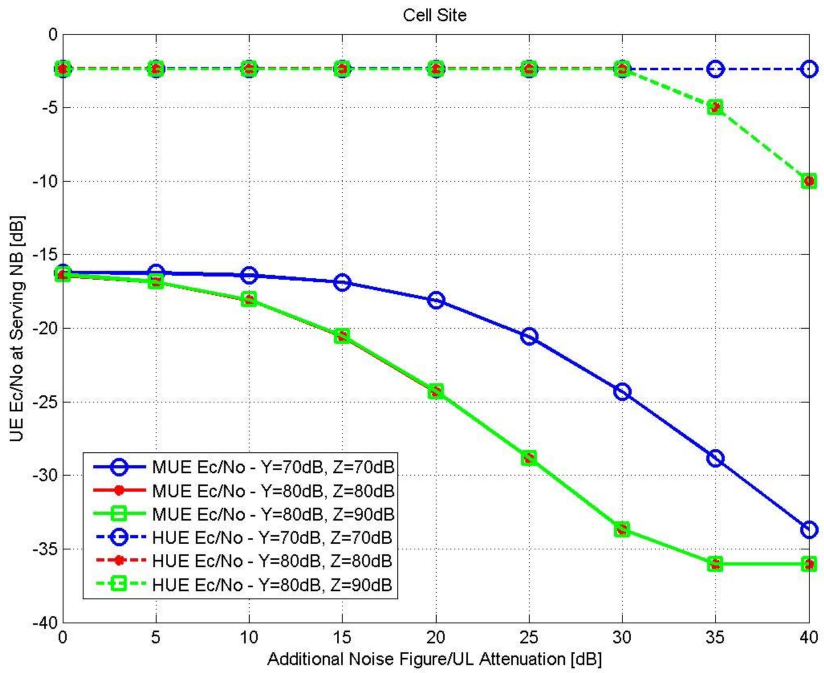


Figure 7.3.3.1-5: UL cell site scenario: Ec/No at serving NB

A reference algorithm trying to maintain the out-of-cell contribution to the HNB noise rise at 3dB would choose the following UL attenuation values (Table 7.3.3.1-4):

Table 7.3.3.1-4: Cell site analysis: suggested UL attenuation at HNB

Y: PL (HUE to HNB)	70 dB	80 dB	80 dB
Z: PL (HUE to HNB)	70 dB	80 dB	90 dB
UL Attenuation (Additional Noise Figure)	1dB	0dB	0dB

7.4 HNB self-configuration

HNB should perform self-configuration at power up and on a regular basis during normal operation. Depending on the implementation, the HNB should be able to relay its measurements to, and receive its RF configuration from, an external configuration element such as network planning server, O&M server and HNB-GW. Such configuration elements can also optimize the RF parameters of a set of HNBs in a joint manner. However, this section does not describe the operation of these configuration elements and is limited to the self-configuration of a HNB based on the self-obtained information..

The HNB self-configuration can also be activated on a regular basis provided that no UE is RRC connected to the HNB or all UEs attached to the HNB are in idle mode. The self-configuration capability of HNB should not impact the existing UE behaviour. If any UE served by the HNB has on-going voice/data transmission, the HNB should wait until the corresponding UE to complete its voice/data transmission, release the RRC connection and then activate the self-configuration mode.

The self-configuration activation period can be set to long, medium or short (exact value FFS). For example, activation period can be set to 24 hours in order to activate HNB self-configuration mode once a day. Performing self-configuration on a regular basis (self-configuration interval FFS) or event triggered self-configuration will help to reduce excessive interference generated by the HNB to the surrounding macrocells and HNBs.

Self-configuration of HNB consists of setting a number of RF parameters to a value which is optimized for achieving the proposed objectives. The most important parameters are:

- Choosing the right carrier frequency,
- Selecting the optimum DL scrambling code
- Selecting suitable LAC and/or RAC.
- Setting the optimum maximum allowable Tx power level in downlink and uplink,
- Building a set of cell lists, and,
- Processing the UE measurement reports (if available)

The HNB self-configuration requirements are listed in Table 7.4-1. Detailed fulfilment of HNB self-configuration requirements is vendor specific (i.e. dependent on self-configuration modes). Generally, the HNB self-configuration can be broadly divided into passive and active mode. The passive mode HNB self-configuration satisfies only the basic requirements, while the active mode HNB self-configuration is capable of handling more complex tasks such as detecting of abnormal operating conditions, decoding UE measurement reports, neighbour cell list construction, etc.

Table 7.4-1: HNB self-configuration modes and requirements

Requirement No	Requirements	
	Passive	**Active**
1	Conduct measurements in section 7.1.1, 7.1.2, 7.1.3, 7.1.4	Conduct measurements in section 7.1.1, 7.1.2, 7.1.3 and 7.1.4
2	Select DL scrambling code or UARFCN	Select DL scrambling code or UARFCN
3	Select DL Tx Power level of the HNB and max UL Tx power level of the HUE	Select DL Tx Power level of the HNB and max UL Tx power level of the HUE
4	Decode broadcast channel (e.g. BCH)	Decode broadcast channel (e.g. BCH)
5	N/A	Use UE measurement reports as input to self-configuration algorithm
6	N/A	Perform additional RRM (e.g. handover handling, coverage control) based on a set of measurement inputs
7	N/A	Detection of abnormal operating conditions
8	Construct a set of neighbour cell lists	Construct a set of neighbour cell lists
9	Synchronise local clock/RF oscillator with e.g., macrocells, IP network	Synchronise local data clock/RF oscillator with e.g., macrocells, IP network
10	Select suitable LAC, RAC	Select suitable LAC, RAC

7.4.1 Scrambling code selection

In general, HNB should have abilities to detect interference and scrambling code. Using the information detected, HNB selects a spare scrambling code which is not used by neighboring HNBs. For example, HNB can monitor the radio signal in its downlink bands before setting up its own cell. Then, the HNB selects a scrambling code as its operating scrambling code which is not used by the neighboring HNBs or macro cells.

Therefore, each HNB would require to be configured for a particular scrambling code on the downlink. If neighbouring HNBs use the same scrambling code, significant problems can arise since HUEs may not be able to associate with the correct HNB. In macrocell networks, scrambling codes for base stations are carefully managed so that base stations in a certain region use different scrambling codes. This, however, is not very practical for HNBs and a more autonomous method to select the scrambling codes would be useful for HNBs. The goal of such a mechanism is to minimize the number of scrambling code collisions for a given number of total scrambling codes.

For instance, depending on the HNB deployment strategy, a certain set of scrambling codes can be reserved for HNBs, denoted as $S_{HNB}=\{S_1, S_2, \ldots, S_{N_{sc}}\}$. If the HNBs operate on a dedicated carrier, the HNB can scan all the available scrambling codes (i.e., N_{sc}=512) and the total number of scrambling codes that can be reserved for HNBs is configurable. If HNBs operate on a shared carrier (co-channel) with macrocell, a certain subset of available scrambling codes should be reserved for HNBs and these codes should not be used by any macrocell base station.

During HNB self-configuration, HNB scans for all scrambling codes and construct a set of scrambling codes which have pilot energy above detection threshold: $S_{DETECTED}=\{S_i, S_j, \ldots, S_k\}$. Note that some of the scrambling codes in the set $S_{DETECTED}$ can be part of the set S_{HNB} (i.e., PSCs used by neighbouring HNBs) and rest of the set can be part of "macrocell only" scrambling codes. Then, HNB can select the "best" scrambling code based on certain criteria, for example:

- If all HNB-reserved scrambling codes are being used by neighbour HNBs
    - HNB picks a scrambling code in S_{HNB} with smallest amount of detected energy (i.e., smallest CPICH Ec/No and CPICH RSCP)
- Else
    - HNB picks a scrambling code randomly from set of scrambling codes that are member of S_{HNB} but not member of $S_{DETECTED}$

Upon failure to pick the "best" scrambling code, an alarm or some form of error indication shall be send to the network controller (e.g. Core Network, HNB-GW, O&M server). The details of alarm triggering threshold is FFS.

7.4.2 Carrier or UARFCN selection

In general, HNB should have abilities to select a carrier frequency using information such as interference level. For example, HNB can monitor the radio signal in its downlink bands before setting up its own cell. Once the HNB gets the inference level (RSSI) on each of its available frequencies, it selects a carrier frequency as its operating frequency which has the smallest interference.

Therefore, each HNB needs to be configured for a certain carrier frequency (channel or UARFCN) to operate on. Such a mechanism depends on the particular deployment configuration listed in section 5.1. If there is only one available carrier for all HNBs, there could be certain amount of inter-HNB interference. One solution for addressing this issue would be to use multiple carriers for HNBs. For example, HNBs in neighboring apartments can be assigned to different frequency carriers to mitigate the potential interference problems.

If macrocells operate on the same carrier as HNBs, then HNB-macrocell interference can result in a certain amount of outage and performance degradation both for HUEs and MUEs. One solution for mitigating the HNB-macro interference would be to make sure the carriers used by HNBs are not used by macrocells. Although this method reduces HNB-macro interference noticeably, it is not efficient in terms of spectrum utilization especially if HNB deployment density is not high. Also, the total number of available carriers for an operator needs to be considered in this decision. For most operators with limited carriers (e.g., two or three carriers), sharing the carriers between HNBs and macrocells could be preferable. In this case, if a MUE goes into coverage hole of a HNB, it could perform inter-frequency handoff to another carrier frequency[1]. In order to minimize the number of inter-frequency hand-off events for MUEs, HNBs may prefer a certain frequency and use other frequencies only in the homes where there is noticeable interference from neighboring HNBs.

In general if an operator has N carrier frequencies: $F=\{f_1,f_2,\ldots,f_N\}$, then HNBs are allowed to use a certain subset (F_{HNB}) of these frequencies while macrocells can use a certain subset (F_{macro}). Without loss of generality, in the following, we will assume $F_{HNB}=\{f_1,f_2,\ldots,f_K\}$ and $F_{macro}=\{f_M,f_{M+1},\ldots,f_N\}$ where $1 \leq K \leq N$ and $1 \leq M \leq N$.

As a possible method for carrier selection, during self configuration, the HNB will measure the RSS values for all K carrier frequencies and find the carriers with least interference, denoted as No_{min}. The accuracy of RSS measurement is [FFS]. In order to find the carrier suitable for operation, the HNB can scan all the available UARFCN or carrier frequencies and, starting from f_1, choose f_i if $No_{f\_i} \leq No_{min} + HNB\_Frequency\_RSS\_margin$. The usage of the parameter

[1] Note that macrocell legacy UEs are designed to choose the best macrocell frequency to operate given that system parameters are chosen appropriately.

HNB_Frequency_RSS_margin is to adjust the tradeoff between selecting least interference carrier and concentrating the HNBs on certain carriers such that coverage hole created by macrocell is minimized.

7.4.3 Neighbour cell list configuration and handover

During the HNB self-configuration mode, HNB should be able to use the macrocells information detected on a set of UARFCNs to build the following cell lists:

- Intra-frequency cell list
- Inter-frequency cell list
- Inter-RAT list

In addition to the standard cell lists above, the HNB may also construct the following cell lists:

- Preferred cell camping list. This list can be a subset of the normal cell camping list and can be operator configurable (via O&M server). The purpose of the preferred cell camping list is to prioritise certain cells for HUE to camp on for load balancing, traffic and QoS control.
- Preferred RAT handover list. This is can be a subset of the normal IRAT list and can be operator configurable (via O&M server). The purpose of the preferred RAT handover list is to prioritise the handover preference of certain RAT cells (e.g. prefer handover to EDGE over GSM/GPRS).

Upon constructed the cell lists, the HNB can broadcast some of the cell list information (in e.g. SIB11) to the UEs served by the HNB.

When an HUE leaves the coverage area of HNB it can be handed over to macro network. In order to support the handover from HNB to macro network, HNBs should detect macro neighboring cells and add them to their neighbour cell list automatically.

In addition, when a number of HNBs may be required to be deployed as a small network, the HNB neighbour cell list can be configured automatically by the HNB or a HNB controller (e.g. HNB-GW) in order to facilitate the handover between HNBs.

To enable MNBs and network aware of the cell list information, the cell lists constructed by the HNB during self-configuration mode and/or subsequent cell list updates can be fed back to the network controller (i.e. Core Network, HNB-GW) via either HNBAP or TR-069 [55] signalling.

7.4.4 HNB DL power setting

HNBs with large transmit power may cause significant interference to macro network and neighboring HNBs, leading for example to dropped calls for the connected UEs on same and adjacent channels. Therefore the transmit power of HNBs should be controlled. Coverage range and interference level in different HNB deployment environments are different and varied. For this reason the HNBs should have the ability to adjust its power autonomously and/or based on the report from UEs about interference and signal quality detected by the UEs.

HNB DL power setting is a function of HNB cell coverage, macrocell interference and other-HNB interference. Given a suitable DL operating power range, the HNB should be able to set its output Tx power by taking into account a number of criterions such as:

- The CPICH Ec/No at the expected edge of coverage of the HNB is of sufficient quality to provide adequate coverage/performance for the HNB
- The macro layer CPICH Ec/No at the expected edge of coverage of the HNB is not severely degraded
- The adjacent-channel macro layer CPICH Ec/No at certain distance/pathloss from the HNB is not severely degraded

Out of all these three objectives, the last one is of special importance when the adjacent channel belongs to another operator, as it refers to the impact of HNB activity on the surrounding networks on adjacent channels.

7.4.5 HUE UL power setting

During HNB self-configuration, the HNB should set a maximum allowed transmit power for its UEs based on the pathloss to the neighbour NodeBs and the expected received power at neighbour NodeBs such that if its UEs were transmitting at this maximum power level they will not cause a significant UL noise rise to the neighbour NodeBs, and thus compromise the coverage or capacity significantly. The pathloss to the neighbour NodeBs can be estimated via measurements outlined in subclause 7.1. The received power at the neighbour NodeBs can be obtained either from measurements outlined in subclause 7.1 or from network (e.g. Core Network, HNB-GW).

Note that the process to set HUE maximum allowed transmit power should not alter the existing UE behaviour. Also, the HUE transmit power will mainly affect the macro NodeBs operating on the same frequency channels as the Home NodeB.

As the HUE transmit power does not significantly affect the surrounding macro NodeBs operating on adjacent channels (i.e. other operator's network), the HUE power adjustment remains an operator choice.

7.4.6 LAC/RAC selection

In a CSG deployment, in order to perform user authentication for the UEs, one technique is to utilize Location Area Update/Routing Area Update procedure. This technique assumes that each HNB is configured with a LAC that is different from the surrounding macro cells and nearby HNBs, so that a UE always performs location area update when it tries to camp on the HNB. Therefore, during the HNB self-configuration mode, the HNB should be capable of selecting a suitable LAC (or RAC) from a list of available LACs/RACs.

However, the drawback of user authentication via LAU/RAU procedure is that there may be potentially a large number of LAU/RAU update reject messages generated when a HUE is not allowed to camp on to a consecutive number of HNBs under certain mobility scenarios, particularly for CSG type deployment.

The solution to avoid generating a large number of LAU/RAU update reject messages is [FFS].

7.4.7 Extreme/Abnormal operating conditions

There are certain conditions whereby the HNB might not be able to provide optimal RF performance to its HUEs, such as not having an accurate picture of the surrounding RF environment or the RF self-configuration algorithms not being able to select parameters within supplied bounds. In the event of detecting an error condition the HNB may use a set of RF parameters defined by the operator which will provide restricted HNB coverage or could disable radio transmission [56] until the situation has been rectified.

Table 7.4.7-1 provides a list of such conditions, their implications on HNB operation and suggested actions to take on detecting such conditions.

Table 7.4.7-1: Extreme/Abnormal operating conditions

	Condition	Implication	Possible consequent Actions
1	Lack of suitable DL scrambling Code	HNB could degrade performance of other HNBs	-Select alternative UARFCN if available. -HNB could be relocated within building
2	Failure to detect BCH on downlink UARFCN	HNB power setting & DL primary scrambling code might not be optimal Neighbour cell list will not be generated	-Alert operator -HNB could be relocated within building -Other possible actions [FFS]
3	No suitable LAC/RAC available	If a HNB reuses a LAC within the same geographical area it is possible that a UE can camp on to neighbour's HNB without being on its access control list. Under this scenario the UE will not be able to receive paging messages.	- Alert operator - HNB could transmit with low power to eliminate the overlap in coverage areas between HNBs that have the same LAC.

4	Location Change e.g. as indicated by different macro cell IDs on UARFCN or PLMN	HNB is potentially in a location outside the one it was provisioned for. HNB can potentially transmit on a UARFCN that is not allocated to the operator.	- Alert operator - HNB could disable radio transmission until new location has been verified[1] - Other possible actions [FFS]
5	Failure to detect a suitable frequency reference	The RF oscillator of the HNB could potentially be out-of-synch.	- Alert operator - HNB could disable radio transmission[1]

Note 1: For regulatory reasons (e.g., intended by Japan and Germany), HNB should be able to stop radio transmission [56].

7.5 Control of HNB coverage

In principle, the HNB transmit power could be used to ensure HNB coverage. This is because the HNB coverage range and interference level in different HNB deployment environment are different and variable. With HNB adjusting its Tx power either autonomously and/or based on interference and signal quality detected and reported by surrounding UEs, the HNB coverage can be controlled.

The HNB coverage is determined by HNB output power, the data rate provided to the HUEs, and the external interference that HNB system received from macrocells and surrounding HNBs. There is no simple formula to define the HNB coverage as a function of all the parameters involved. However, the HNB coverage can be used as a trade-off in order to reduce the interference caused to the macrocells or other surrounding HNBs. Some interference control mechanisms in Section 7.2 and Section 7.3 can also be used to control the HNB coverage.

The HNB can be uplink and downlink coverage limited depending on the link budgets. The coverage of the HNB can also be controlled via dynamic switching of service-level date rates.

7.5.1 CSG

[Editor notes: detail of HNB coverage control for CSG type deployment]

7.5.2 Open access

[Editor notes: detail of HNB coverage control for open access HNB deployment]

8 Interference tests

//Editors note: this section is to test the ability of HNB maximum allowable transmit power dependant of co-channel interference conditions.

The following subsections describe example test procedure and parameters which can be used to evaluate HNB self-configuration and performance in both uplink and downlink scenarios.

8.1 Downlink

8.1.1 Co-channel tests

In order to ensure reasonable behaviour of HNB on the DL, two scenarios are considered for HNB deployments: a) cell edge and b) cell site. The DL scenario under consideration is shown in Figure 8.1-1. Cell edge refers to the case where the HNB and UEs are at the macro cell edge and cell site refers to the case where the HNB and UEs are close to the macro cell edge.

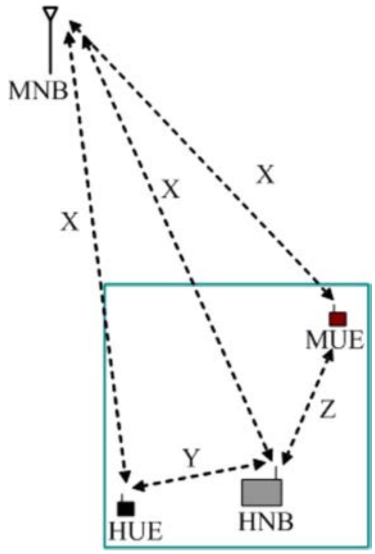


Figure 8.1-1: DL interference scenario

Since a HNB can have different coverage radius (i.e., link budget) depending on the particular deployment scenario (e.g., suburban, urban, dense-urban), three categories of HNBs are considered: a) HNB with 70dB coverage radius, b) HNB with 80dB coverage radius, and c) HNB with 90dB coverage radius. A HNB with a particular coverage radius shall adjust its transmit power within the minimum and maximum power limits such that the MUE at the coverage radius can maintain a minimum quality of the CPICH Ec/No and the HUE can maintain an acceptable quality of CPICH Ec/No at the coverage radius. HNB DL tests are given below for the three HNB categories. The purpose of these tests is to ensure the HNB Tx power is adjusted properly to provide good HNB coverage and limit the coverage hole on macro.

Test Set-up:

The test set-up is as follows. The HNB under test is on frequency F1. A noise generator on F1 generates Ioc as specified in Table 8.1.1-1. A NB on frequency F1 is set up such that the RSSI (including Ioc) and the RSCP at the HNB are as specified in Table 8.1-1.

Table 8.1.1-1: Parameters for HNB DL co-channel tests

Test Parameters	Cell Edge	Cell Site
PL to MNB	140 dB	100 dB
RSSI at HNB MNB RSCP Ioc at HNB	-95 dBm -107 dBm -96dBm	-60 dBm -67 dBm -75dBm

In the following tests, the requirements are in terms of lower and upper limits for HNB Tx power. The lower limits are specified such that a HUE at the HNB coverage radius is able to maintain -18dB CPICH Ec/No. For the upper limits, a margin of a few dBs (~3dB) is included to allow for variations in the algorithm used for HNB Tx powers. CPICH Ec/Ior of -10dB for HNB and MNB are assumed. The tests assume +20dBm as the maximum power for the HNB.

8.1.1.1 DL test for HNB with 70dB coverage radius

For the test scenario described in Table 8.1.1-1, the total output power of the HNB with a designed coverage radius of 70dB shall be as specified in Table 8.1.1-2.

Table 8.1.1-2: HNB total output power

Reference Condition	MNB RSCP at HNB	RSSI at HNB	Ioc at HNB	HNB Transmit Power Range
A	- 107 dBm	- 95 dBm	- 96 dBm	-34 dBm ≤ HNB Total Tx Power ≤ -10 dBm
B	- 67 dBm	- 60 dBm	- 75 dBm	2 dBm ≤ HNB Total Tx Power ≤ 10 dBm

8.1.1.2 DL test for HNB with 80dB coverage radius

For the test scenario described in Table 8.1.1-1, the total output power of the HNB with a designed coverage radius of 80dB shall be as specified in Table 8.1.1-3.

Table 8.1-3: HNB total output power

Reference Condition	MNB RSCP at HNB	RSSI at HNB	Ioc at HNB	HNB Transmit Power Range
A	- 107 dBm	- 95 dBm	- 96 dBm	-24 dBm ≤ HNB Total Tx Power ≤ -10 dBm
B	- 67 dBm	- 60 dBm	- 75 dBm	12 dBm ≤ HNB Total Tx Power ≤ 20 dBm

8.1.1.3 DL test for HNB with 90dB coverage radius

For the test scenario described in Table 8.1.1-1, the total output power of the HNB with a designed coverage radius of 90dB shall be as specified in Table 8.1.1-4.

Table 8.1-4: HNB total output power

Reference Condition	MNB RSCP at HNB	RSSI at HNB	Ioc at HNB	HNB Transmit Power Range
A	- 107 dBm	- 95 dBm	- 96 dBm	-14 dBm ≤ HNB Total Tx Power ≤ -5 dBm

8.1.2 Adjacent channel tests

The purpose of the test is to ensure that a HNB does not cause unacceptable interference to the adjacent channel operator. The HNB can use measurements such as RSSI and RSCP to adjust its transmit power such that it does not cause interference for the adjacent channel operator. The test set-up and requirements are specified in [25.104/25.141].

8.2 Uplink

8.2.1 Basic tests

Uplink interference between HNBs and the macro layer comprises three components, identified in the figure below as (a) (b) and (c):

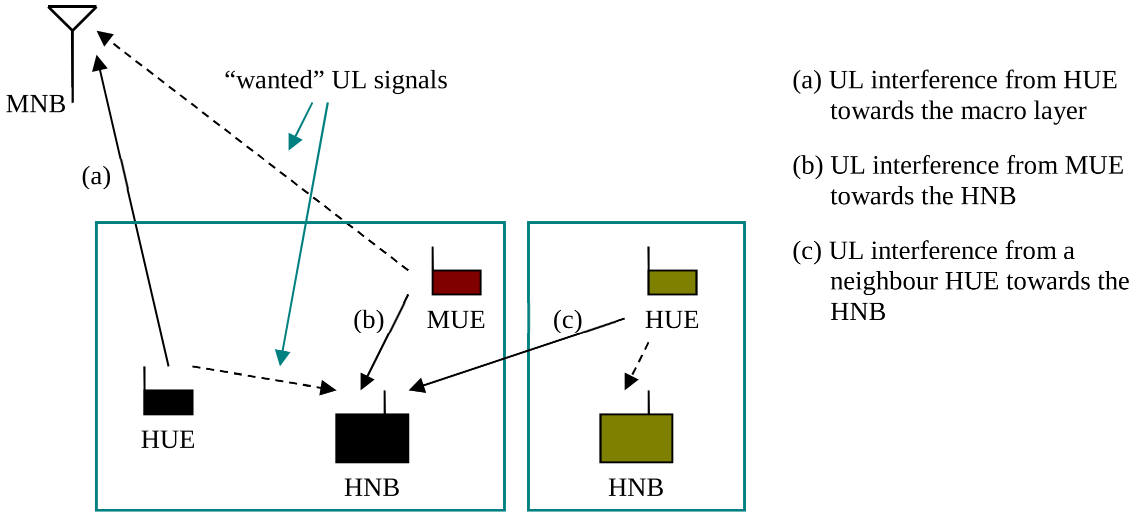


Figure 8.2-1: UL interference paths

The interference mitigation approaches presented in Section 7.4 above have addressed all of these interference components, but the key requirement being tested here is that the UL interference from the HUE towards the macro layer (component (a) in the figure above) is controlled to be within an acceptable limit.

The additional Dynamic Range and ACS tests for the Home BS class in 25.104, as specified in [3], have ensured that the HNB receiver can accommodate increased levels of interference (b) and (c) from nearby uncontrolled UEs. Guidance on how to make this accommodation has been provided in Sections 7.4.2 and 7.4.3 above. It has further been noted that as a result of this mitigation the transmit power of the HUE will increase, potentially causing additional noise rise at the macro layer – so interference paths (b), (c) and (a) are inextricably linked. The way in which this positive feedback cycle is broken is through the application of a limit on the HUE allowable transmit power as discussed in Section 7.4.1 above.

Therefore, given that mitigation techniques to accommodate UL interference (b) and (c) towards the HNB have already been tested by the new Dynamic Range and ACS requirements in 25.104, it is sufficient from a "closed loop" system perspective to ensure that the maximum UL interference (a) towards the macro layer is controlled. This can be tested as follows.

8.2.1.1 Test setup

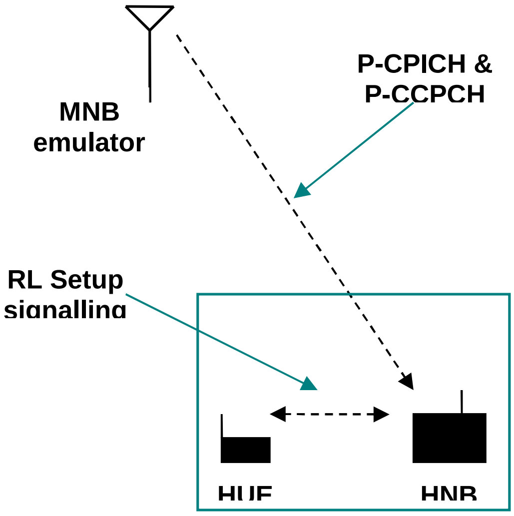


Figure 8.2-2: UL interference test setup

The MNB emulator is configured to transmit a P-CPICH and a P-CCPCH. The latter physical channel carries the BCH on which SIB5 is transmitted, providing an indication of the P-CPICH Tx Power. Note that the actual transmit power of the P-CPICH does not need to align with this signalled value. Sufficient other SIBs must also be present to allow for identification of the NodeB as part of the macro layer, rather than another HNB. The cabled connection to the HNB receiver passes through a variable attenuator (not shown in the figure above) such that the pilot power (RSCP) arriving at the HNB can be controlled.

The HNB makes measurements, as defined in Section 7.1 above, of the macro P-CPICH RSCP and the decoded P-CPICH Tx Power IE in order to estimate the pathloss to the MNB. From this estimate it can derive a value for the maximum HUE allowable transmit power such that the noise rise at the macro layer is constrained. This value will be signalled to the HUE as part of a subsequent RL Setup procedure for AMR 12.2 kbps service and can be logged at the HUE for verification.

8.2.1.2 Test parameters

Based on the analysis in subclause 7.4.1 above, the following test parameters are specified for the co-channel and adjacent channel cases. The maximum allowable HUE transmit power is defined such that it causes no more than [1dB] noise rise at the MNB:

Table 8.2-1: Co-channel UL test parameters

Signalled P-CPICH Tx Power (on MNB BCH)	Pathloss [1]	P-CPICH RSCP at HNB	Maximum allowable HUE Tx power [2]
33 dBm	100 dB	-67 dB	≤ [-9 dBm]
33 dBm	140 dB	-107 dB	≤ [21 dBm]

Table 8.2-2: Adjacent channel UL test parameters

Signalled P-CPICH Tx Power (on MNB BCH)	Pathloss [1]	P-CPICH RSCP at HNB	Maximum allowable HUE Tx power [2]
33 dBm	100 dB	-67 dB	≤ [21 dBm]
33 dBm	140 dB	-107 dB	≤ [21 dBm]

Notes:

1. The Pathloss of 100dB and 140dB represent typical “cell-site” and “cell-edge” scenarios respectively.

2. The maximum allowable HUE Tx power is capped at a maximum level of [21 dBm] as per Section 7.4.1 above.

8.2.2 HSUPA tests

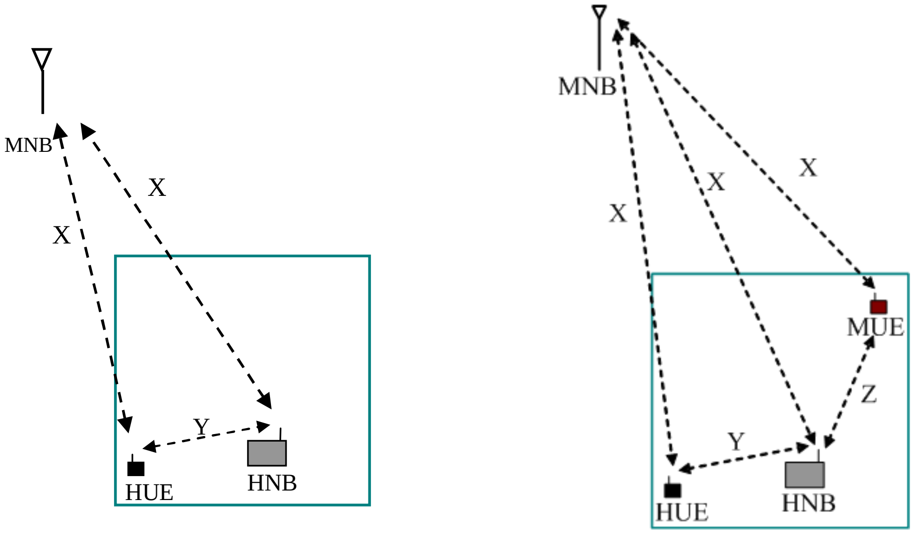
8.2.2.1 HNB-Macro tests

For the uplink tests, we again consider three deployment scenarios: a) HNB with 70dB coverage radius, b) HNB with 80dB coverage radius, and c) HNB with 90dB coverage radius. Separate cell edge and cell site tests are specified. The uplink tests are to be carried out in a cabled-up lab setup. The HNB and MNB in these tests are on the same carrier frequency (i.e., co-channel). All the path loss values specified here include antenna gains.

For the cell edge tests, the test setup is as displayed in Figure 8.2.2.1-1(i). The HUE, HNB and MUE path loss to the MNB is assumed to be 140dB. The MNB is assumed to experience interference at -101dBm from users other than the HUE, which is modelled through an AWGN noise source (not shown in the picture). Two BS testers are used as the HUE and the MUE, which are connected to the HNB and the MNB through channel emulators. AWGN channel is assumed and path loss values of the links are set as specified in the test description. The MUE is set to transmit at 21dBm max Tx power, with power control disabled. The HNB is run with the regular UL scheduler and power control enabled with full queue traffic. The UL throughput and the transmit power at the BS tester (HUE) is measured. The MNB does not play any role in the test requirements.

For the cell site tests, a HNB, a MNB and a single BS tester (HUE) are used (Figure 8.2.2.1-1(ii)). The HUE and HNB path loss to the MNB is assumed to be 100dB. A channel emulator is used to adjust the path loss between the HUE and the HNB. The HNB is operated with the regular UL scheduler with full queue traffic. The UL throughput and the transmit power at the BS tester (HUE) is measured. It should be noted that since there is no MUE present in this test, the only purpose of having a MNB is for path loss estimation in case it is used by the HNB.

The E-DPDCH demodulation tests for FRC1 and FRC2 for Ped A channel with no Rx diversity have been used as reference to show that the transmit power and throughput requirements for the cell-edge and cell-site tests are indeed achievable. However, since the power control is enabled for these tests, AWGN channel is used instead of PedA to minimize the fluctuations in HUE tx power and throughput (due to fading).



(i) (ii)

Figure 8.2.2.1-1: UL test setup

The test requirements for the different HNB coverage scenarios are given below.

8.2.2.1.1 Uplink test for HNB with 70dB coverage radius

The purpose of the test is for the HUE to achieve a minimum UL throughput while its average total transmit power does not exceed the requirement given in Table 8.2.2.1.1-1.

For the cell edge test, the HUE transmit power can go as high as the maximum limit of 21 dBm. The test requirement is in terms of an upper limit for the HUE average transmit power while the HUE average throughput is above a certain value. The throughput and transmit power requirements are chosen based on an Ec/No target of 0.8 dB (corresponding to the FRC2 E-DPDCH demodulation test).

For the cell site test, the maximum Tx power is specified such that the HUE interference at the MNB which is 100dB away is limited to 5dB below the noise floor of the MNB which is -103dBm. Here again, an Ec/No target of 0.8 dB is used.

Table 8.2.2.1.1-1: UL test specifications - 70dB HNB coverage

Parameter	Cell Edge	Cell Site
PL to MNB	140dB	100dB
PL MUE to HNB	80dB	-
HUE Throughput	≥ 811kbps	≥ 811kbps
HUE Tx Power	≤ 21dBm	≤ -8dBm

8.2.2.1.2 Uplink test for HNB with 80dB coverage radius

The purpose of the test is for the HUE to achieve a minimum uplink throughput at the HNB for cell site case while its average total transmit power does not exceed the requirement given in Table 8.2.2.1.1-2.

For the cell edge test, the HUE transmit power can go as high as the maximum limit of 21 dBm. The test requirement is specified in terms of an upper limit for the HUE average transmit power while the HUE average throughput is above a certain value. The throughput and transmit power requirements are chosen based on an Ec/No target of -2.4 dB (corresponding to the FRC1 E-DPDCH demodulation test).

For the cell site test, the maximum tx power is specified such that the HUE interference at the MNB which is 100dB away is limited to 5dB below the noise floor of the MNB which is -103dBm. Here, an Ec/No target of 0.8 dB is used (corresponding to the FRC2 E-DPDCH demodulation test).

Table 8.2.2.1.1-2: UL test specifications - 80dB HNB coverage

Parameter	Cell Edge	Cell Site
PL to MNB	140dB	100dB
PL MUE to HNB	80dB	-
HUE Throughput	≥ 405kbps	≥ 811kbps
HUE Tx Power	≤ 21dBm	≤ -8dBm

8.2.2.1.3 Uplink test for HNB with 90dB coverage radius

The purpose of the test is for the HUE to achieve a minimum uplink throughput at the HNB for the cell edge case while its average total transmit power does not exceed the requirement given in Table 8.2.2.1.1-3. A cell site test is not specified for this particular HNB coverage case due to the fact that the max Tx power limit of 20dBm on the HNB does not allow the coverage to be 90dB.

For the cell edge test, the HUE transmit power can go as high as the maximum limit of 21 dBm. The test requirement is specified in terms of an upper limit for the HUE average transmit power while the HUE average throughput is above a certain value. The throughput and transmit power requirements are chosen based on an Ec/No target of -2.4 dB (corresponding to the FRC1 E-DPDCH demodulation test).

Table 8.2.2.1.1-3: UL test specifications - 90dB HNB coverage

Parameter	Cell Edge
PL to MNB	140dB
PL MUE to HNB	90dB
HUE Throughput	≥ 405 kbps
HUE Tx Power	≤ 21dBm

8.2.2.2 Inter-HNB uplink test

The inter-HNB test corresponds to two neighbouring HNBs on the same carrier as shown in Figure 8.2.2.2-1.

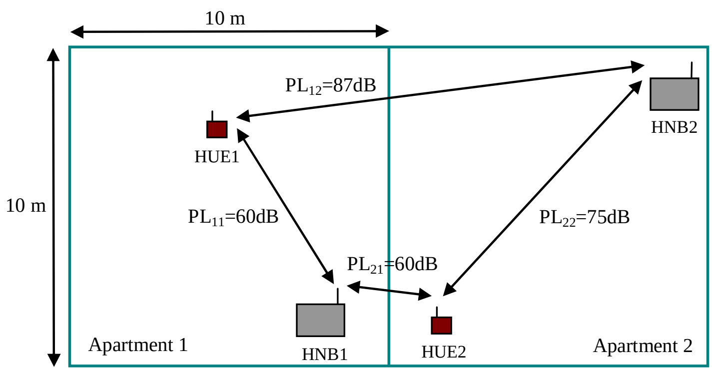


Figure 8.2.2.2-1: Inter-HNB uplink test set-up

The purpose of the test is for the HUEs to maintain a minimum uplink throughput at their own HNBs while their total transmit powers do not exceed the requirements given in Table 8.2.2.2-1.

The test requirement is specified in terms of an upper limit for the HUE average transmit power while the HUE average throughput is above a certain value. The throughput and transmit power requirements are chosen based on an Ec/No target of 0.8 dB (corresponding to the FRC2 E-DPDCH demodulation test).

Table 8.2.2.2-1: Specifications for UL inter-HNB test

Parameter	HUE1	HUE2
HUE Throughput	≥ 811kbps	≥ 811kbps
HUE Tx Power	≤ -11dBm	≤ -12dBm

9 Summary

10 Conclusions

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2008-06	RAN4#47 bis				TR created based on content in R4-081548		0.2.0
2008-08	RAN4#48	R4-082045			Agreed TPs in RAN4#47bis: R4-081380, "TP for 25.9xx: Structure of chapter 6, HNB Class definition"	0.2.0	0.3.0
2008-11	RAN4#49	R4-083250			Agreed TPs in RAN4#48bis: R4-082623, "Merged Text Proposal for HNB TR25.9xx – Home NodeB RF" R4-082624, "Merged Text Proposal for HNB TR25.9xx: DL Interference Mitigation for Home NodeB RF" R4-082316, "Text Proposal for HNB TR25.9xx: Guidance on UL interference mitigation"	0.3.0	0.4.0
2008-12	RAN#42	RP-080972			Approved TR in RAN#42: RP-080972 "TR 25.9xx v 1.0.0, FDD Home NodeB RF Requirements Work Item Technical Report"	0.4.0	1.0.0
2009-01	RAN4#49 bis	R4-090394			Approved TPs in RAN4#49bis: R4-090349," Text Proposals for TR 25.967 – Home NodeB RF, chapter 7" R4-090383," Text Proposals for TR 25.967 – Home NodeB RF, chapters 1 to 6"	1.0.0	1.1.0
2009-02	RAN4#50	R4-091032			Approved TPs in RAN4#50: R4-091026," Text Proposal for TR25.967 regarding switch off upon RF-Tx-failure in Chapters 2 and 7.4" R4-091027," Text Proposal for TR25.967 for improvement of reading in Chapters 3 and 7.3.1"	1.1.0	2.0.0
2009-03	RAN#43	RP-090284			Technical Report Approved.	2.0.0	8.0.1
2009-05	RAN#44	RP-090561	2		Enhanced interference management methods for controlling HNB transmit power	8.0.1	9.0.0
2009-05	RAN#44	RP-090561	3		Enhanced HNB interference coordination based on network control	8.0.1	9.0.0
	SA-51				Upgraded unchanged from Rel-9	9.0.0	10.0.0
2012-09	-	-	-	-	Update to Rel-11 version (MCC)	10.0.0	11.0.0
2014-09	SP-65	-	-	-	Update to Rel-12 version (MCC)	11.0.0	12.0.0
2016-01	SP-70	-	-	-	Update to Rel-13 version (MCC)	12.0.0	13.0.0
2017-03	RP-75	-	-	-	Update to Rel-14 version (MCC)	13.0.0	14.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-06	SA#80	-	-	-	-	Update to Rel-15 version (MCC)	15.0.0
2020-06	SA#88	-	-	-	-	Update to Rel-16 version (MCC)	**16.0.0**
2022-03	SA#95					Update to Rel-17 version (MCC)	**17.0.0**

History

Document history		
V17.0.0	April 2022	Publication