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TECHNICAL REPORT

**Digital cellular telecommunications system (Phase 2+) (GSM);
Optimized transmit pulse shape for downlink Enhanced
General Packet Radio Service (EGPRS2-B)
(3GPP TR 45.913 version 16.0.0 Release 16)**

A GLOBAL INITIATIVE

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

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Contents

Foreword

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Introduction

The EGPRS2-B feature has been included into GERAN Rel-7 with the legacy GMSK pulse shape. This pulse shape yields good performance and can be used without any requirements on the operator network scenario.

Initial analysis have shown that in certain network scenarios, a spectrally wider pulse shape can improve data throughput performance further.

To obtain superior data throughput performance, investigation of a wider pulse shape is needed, including the network scenarios that will benefit from a wider pulse shape. Selection of either the legacy pulse shape or the new pulse shape will be under operator control.

It is not clear to what degree the current spectral mask can be widened without causing a detrimental impact on legacy mobile stations in these networks. It is also not clear if a spectral mask relaxation is dependent on the modulation transmitted or whether it can be assumed to be applicable for all modulations. It is important to continue to improve the GERAN system performance with new features, and as such it is relevant that this topic is carefully and independently studied.

1 Scope

The present document is an output of the 3GPP study item "Optimized Transmit Pulse Shape for Downlink EGPRS2-B" ("WIDER") [2], the objective of which is to optimise pulse shapes based on optimization criteria to be agreed by TSG GERAN WG1, and provide an evaluation of the optimized pulse shapes in a similar manner as was used in the SAIC feasibility study TR 45.903 [3].

2 References

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

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

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

[2] 3GPP TDoc GP-072026: "WID Optimized Transmit Pulse Shape for Downlink EGPRS2-B".

[3] 3GPP TR 45.903: "Feasibility Study on Single Antenna Interference Cancellation (SAIC) for GSM networks".

[4] "Candidate Pulse Shapes for WIDER", Nokia Siemens Networks & Nokia Corporation, 3GPP GERAN Teleconference #3 on WIDER.

[5] 3GPP TDoc SMG2 EDGE 2E99-017: "Reference Models for Nonlinear Amplifiers and Phase Noise for Evaluation of EDGE Radio Performance", ETSI SMG2 EDGE Workshop, Toulouse (France), 2-4 March 1999.

[6] AHG1-080111: "A link to system interface methodology, Nokia Siemens Networks & Nokia Corporation".

[7] 3GPP TR 45.913 (V1.0.0): "Optimized transmit pulse shape for downlink Enhanced General Packet Radio Service (EGPRS2-B)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

3.2 Symbols

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

μ	mean of the uncoded BER
σ	variance of the uncoded BER
C/I	Carrier to Interference Ratio
C/I1	Carrier to First (Strongest) Interferer Ratio

3.3 Abbreviations

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

ACI	Adjacent Channel Interference
ACP	Adjacent Channel Protection
AFS	Adaptive Multi-Rate Full Rate Speech
AMR	Adaptive Multi-Rate
AWGN	Average White Gaussian Noise
BCCH	Broadcast Control Channel
BER	Bit Error Rate
BQC	Bad Quality Call
BSS	Base Station Subsystem
BTS	Base Tranceiver Station
CCI	Co-channel Interference
CDF	Cumulative Distribution Function
CIR, C/I	Carrier-to-Interference Ratio
CS	Circuit Switched
DARP	Downlink Advanced Receiver Performance
DL	Downlink
DTS	DARP Test Scenario
DTX	Discontinuous Transmission
EGPRS2	EDGE General Packet Radio Service 2
EGPRS2-B	EGPRS2 Level B
FER	Frame Erasure Rate
FTP	File transfer Protocol
GMSK	Gaussian Minimum Shift Keying
LGMSK	Linearised GMSK
MCL	Minimum Coupling Loss
MS	Mobile Station
MUROS	Multi-User Reusing One Slot
PA	Power Amplifier
PDTCH	Packet Data Traffic Channel
PS	Packet Switched
RRC	Root Raised Cosine
SAIC	Single Antenna Interference Cancellation
SID	Silence Indicator Description
TCH	Traffic Channel
TRX	Transceiver
TDMA	Time Division Multiple Access

UMTS	Universal Mobile Telecommunication System
UL	Uplink

4 Objectives

4.1 Performance objectives

4.1.1 Data throughput improvements

The objective is to further enhance the data throughput of EGPRS2-B on the downlink.

4.2 Compatibility objectives

4.2.1 Maintenance of voice quality

The introduction of the wide bandwidth pulse should not decrease voice quality as perceived by the user.

The criteria for minimum call quality shall be:

1st Criterion: blocked calls < 2 %

2nd Criterion: satisfied user criterion fulfilled:

- average call FER < 1 % for at least 95 % users in case of network scenarios WIDER-2 and WIDER-3 (see section 5.3);
- average call FER < 2 % for at least 95 % users in case of network scenarios WIDER-1 (see section 5.3).

4.2.2 Data throughput

The introduction of the wide bandwidth pulse shall increase overall network throughput.

4.2.3 Implementation impacts to new Mobile Stations

The introduction of the wide bandwidth pulse should change MS hardware as little as possible.

4.2.4 Implementation impacts to BSS

The introduction of the wide bandwidth pulse should change BSS hardware as little as possible.

4.2.5 Impacts to network planning

Criteria for definition of minimum call quality performance for this objective is defined in section 4.2.1.

The study shall take into consideration the usage of wide pulse shape at the band edge, at the edge of an operator's band allocation and in country border regions where no frequency coordination are in place.

The wide pulse is expected to fulfil the same adjacent channel protection requirements as the linearised GMSK pulse at the 400 kHz offset and higher (see Section 5.2.3).

When EGPRS2-B is used on a frequency which is adjacent (at a 200 kHz offset) to a frequency which is uncoordinated (see above), then the linearised GMSK pulse shall be used.

4.2.6 Compatibility with Multi-User Reusing-One-Slot (MUROS)

The feature Optimized Transmit Pulse Shape for Downlink EGPRS2-B (WIDER) and the feature Multi-User Reusing-One-Slot (MUROS) will be studied independently but that compatibility of both features will be investigated after completion of the feasibility studies and before the corresponding work items are agreed.

5 Study item pre-requisites

5.1 Introduction

Pre-requisites to the study are identified as follows:

- Preliminary boundary conditions for pulse shape optimisation, where more than one set of boundary conditions may be considered in order to derive a selection of pulse shape candidates.
- One or more network configurations for pulse shape evaluation. These shall be representative of the most likely EGPRS2 deployment strategies.
- A legacy Rx filter working assumption.

5.2 Preliminary boundary conditions for pulse shape optimisation

5.2.1 Introduction

Boundary conditions are needed to define the scope of the optimisation. The boundary conditions will also allow a pre-selection at the link level if more than one pulse shape is optimised against the same set of boundary conditions.

Only when the system evaluation is complete will it be known if the boundary conditions were realistically set, therefore it is proposed to denote these as 'preliminary' boundary conditions. If they were set too loose or too tight, then a further iteration of the study might be necessary.

In general, the same procedure will be used for the optimisation of the EGPRS2-B wide pulse shape on the DL as for the EGPRS2-B wide pulse shape on the UL.

5.2.2 Time domain

The length of the optimised pulse shape shall not be longer than 6 reduced symbol periods. This is to avoid an increase in delay spread which the MS equaliser needs to cope with.

5.2.3 Frequency domain

The adjacent channel protection of the optimised pulse shape (including Tx impairments) shall be:

- 50 dB at the 400 kHz offset
- 58 dB at the 600 kHz offset

Measurements performed by network vendors will verify that these criteria can be met for each candidate pulse shape.

For the 200 kHz offset, any criterion may be considered in the pulse shape optimisation given that this criterion will be verified by the System level studies (Section 9).

If an adjacent channel at the 200 kHz offset is used by a different operator (i.e. no guard band exists), then the linearised GMSK pulse would be the default on the allocation's edge channels.

5.3 Network configurations for pulse shape evaluation

The network configurations that shall be used to evaluate the optimised pulse shapes are given in Table 5.1 and 5.2.

Table 5.1: Configuration specific assumptions

Parameter		WIDER-1	WIDER-2	WIDER-3
Frequency band		900 MHz	900 MHz	900 MHz
Cell radius		500 m	500 m	500 m
Bandwidth		4.4 MHz	11.6 MHz	8.0 MHz
Guard band		0.2 MHz	0.2 MHz	0.2 MHz
Number of channels (excl guard band)		21	57	39
Number of TRX		3	6	4
BCCH frequency reuse		4/12	4/12	4/12
TCH frequency reuse		1/1	3/9	3/9
Frequency hopping		synthesized	baseband	baseband
Length of MA		9	5	4 (includes BCCH carrier)
BCCH or TCH under interest		BCCH and TCH	BCCH and TCH	BCCH and TCH
Resource allocation on BCCH	Voice	3	3	3
	Data	4	4	4
Network sync mode		sync[1]	sync[1]	sync[1]
[1]timeslots are assumed to be aligned; TDMA frames are assumed to be aligned on intra-site level and randomly aligned on inter-site level.				

The MS is 4-PDCH capable on the downlink. The number of MSs multiplexed on the same radio resource is FFS.

Table 5.2: Common assumptions

Parameter		Value	Unit	Comment
Sectors per site		3		
Sector antenna pattern		UMTS 30.03, 90º H-plane, max TX gain 13 dBi		Applies to network scenarios WIDER-2 and WIDER-3
		65º deg H-plane, max TX gain 18dBi		Applies to network scenarios WIDER-1
Propagation model		UMTS 30.03		Path loss exponent, MCL Per 30.03
Log-normal fading	Standard deviation	6	dB	
	Correlation distance	110	m	
Handover margin		3	dB	
Channel profile and mobile speed		TU50	Km/h	HT100 will also be investigated at least at link level
Mean call length Minimum Call Length		50 5	s s	
Voice activity		60 %		Includes SID signalling
DTX		enabled		
Voice codec		AFS12.2, AFS7.4 and AFS4.75		
AMR link adaptation		enabled		
Channel rate adaptation		disabled		
Channel allocation		Random		
BTS output power		20	W	
Power control Dynamic range Step size		RxQual/RxLev 20 2	 dB dB	
Noise figure		10	dB	Reference temperature 25ºC
Inter-site log-normal correlation coefficient		0		
Traffic data model		FTP with 1 MByte file size		
Link adaptation		enabled		
Incremental redundancy		disabled		
Back off	8PSK / QPSK			The maximum back-off on the BCCH carrier shall be vendor specific
	16QAM / 32QAM			
Penetration of the optimised pulse shape		50 % and 100 %		

5.4 Legacy MS Rx filter working assumption

This shall be used to calculate the Adjacent Channel Protection (ACP) of the pulse shape candidates.

One proposal is to take the same assumption as for the EGPRS2-B wide pulse shape for the UL i.e. the linearised GMSK filter truncated to ±160 kHz.

5.5 Legacy MS type

DARP mobiles are only able to cancel GMSK modulated interference, and the wide pulse shape does not apply to GMSK modulation. When exposed to an interferer using the wide pulse shape, it therefore follows that a DARP mobile and a non-DARP mobile can be assumed to behave in the same way.

6 Network level analysis

6.1 Introduction

Network level analysis will be performed using the network configurations defined in 4.2. This will be done for different penetrations of optimised pulse shape being operated in downlink. The purpose of network level analysis is to define different interferer profiles for a certain penetration of the wider Tx pulse shape and a given network configuration.

It is proposed to follow the same approach as the SAIC FS, whereby network traces from system simulator generated for each of the agreed network configurations are used to identify the median power level of each interferer type.

6.2 Network scenarios and simulation assumptions

The network scenarios that were considered are described in detail in Section 5.3:

- Scenario A: 4/12 BCCH from WIDER-1
- Scenario B: 1/1 TCH from WIDER-1
- Scenario C: 3/9 TCH from WIDER-2
- Scenario D: 4/12 BCCH+3/9 TCH from WIDER-3

System simulation assumptions are in Table 2.

Additional assumptions were:

- The wide pulse shape was the Candidate #2 (see Section 7).
- The back-off on BCCH for each of the EGPRS2-B modulation was assumed to be 2 dB for QPSK and 4 dB for 16QAM and 32QAM.
- Penetration of the wide pulse shape was set to 100 %.
- The EGPRS2 FTP service load for the reference pulse shape was set to saturation (the rate of newly arriving PS calls equalled the rate of ending PS calls). For the wide pulse shape, the load was set to be equal the reference load. Note that when equal traffic loads are assumed, a lower activity time can be expected with the wide pulse.
- Statistics are collected only from 18 cells around the centre of the network to avoid border effects

6.2.1 Resource allocation

The PS and CS resources in Scenario A, B, C and D were allocated as shown in Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4. Note that the PS and CS resources in Figure 6.3 and Figure 6.4 should be assumed to hop over each TRX (BB hopping is used for scenario C and D).

BCCH TRX:	B	P	P	P	P	C	C	C

B blocked slot (BCCH) P PS slot C CS slot

Figure 6.1/ Resource allocation for Scenario A

P	P	P	P	C	C	C	C	hopping	1
C	C	C	C	C	C	C	C	hopping	2

P PS slot C CS slot

Figure 6.2/ Resource allocation for Scenario B

C	P	P	P	P	C	C	C	hopping	1
C	C	C	C	C	C	C	C	hopping	2
C	C	C	C	C	C	C	C	hopping	3
C	C	C	C	C	C	C	C	hopping	4
C	C	C	C	C	C	C	C	hopping	5

B blocked slot (BCCH) P PS slot C CS slot

Figure 6.3/ Resource allocation for Scenario C

B	P	P	P	P	C	C	C	BCCH	1
C	C	C	C	C	C	C	C	TCH	2
C	C	C	C	C	C	C	C	TCH	3
C	C	C	C	C	C	C	C	TCH	4

B blocked slot (BCCH) P PS slot C CS slot

Figure 6.4/ Resource allocation for Scenario D

6.3 Link to system interface

The link to system interface is described in detail in Section 8.2.

6.4 Interference statistics

In each burst, every interferer was classified into the following categories:

- IcX – dominant co-channel narrow (X=N), wide (X=W) interference.
- IaX – dominant 1st adjacent channel narrow (X=N), wide (X=W) interference.
- restIcX – sum of all co-channel interference powers excluding the dominant interferer.
- restIaX – sum of all adjacent channel interference powers excluding the dominant interferer.

The carrier to interferer ratio in each burst for each interferer was then expressed as a CDF for each of the categories. The results are shown in Annex B. All interferer levels were measured after slow fading but before fast fading. This is to avoid duplicating the affects of fast fading in the link level simulator.

The initial interference profile was DTS-2 from 3GPP TS 45.005 Annex L (with the noise component excluded) with the interferers substituted with wide pulse interferers in the case of wide pulse simulations (candidate #2 and candidate #3).

6.5 Interference profile for link level analysis

The interference statistics were used to construct the interferer models using the following assumptions:

- The median level (50th percentile in the CDF) was used to characterise the power of each interferer type.
- Interference ratios are specified relative to carrier-to-dominant co-channel interference ratio (C/IcX). This makes it easier to sweep over a range of C/I values in the link simulator. For example, to populate the link to system mappings.

In addition, information is given about the probability of each type of interferer.

6.5.1 Results

This section summarises the interference profiles for each network scenarios and pulse shape (reference LGMSK pulse, candidate pulse #2 and candidate pulse #3). All levels have been given relative to the dominant co-channel narrow interferer.Table 6.1

Interfering signal	Rel. power level							
	WIDER-1 BCCH NB		WIDER-1 TCH NB		WIDER-2 NB		WIDER-3 NB	
IcN	0		0		0		0	
IaN	8		5		13		11	
restIcN	-3		-6		-8		-7	
restIaN	6		2		4		5	
Noise	-28		-28		-15		-22	
	WIDER-1 BCCH WB		WIDER-1 TCH WB		WIDER-2 WB		WIDER-3 WB	
	pulse #2	pulse #3	pulse #2	pulse #3	pulse #2	pulse #3	pulse #2	pulse #3
IcN	0	0	0	0	0	0	0	0
IcW	-13	-12	-3	-4	0	0	-9	-9
IaN	8	8	7	7	12	12	11	11
IaW	-4	-2	2	1	3	4	-5	-5
restIcN	-5	-5	-9	-9	-8	-8	-7	-7
restIcW	-22	-21	-12	-13	-7	-7	-16	-16
restIaN	5	5	1	1	3	4	4	4
restIaW	-12	-11	-6	-8	-6	-6	-14	-14
Noise	-27	-26	-22	-22	-12	-12	-20	-20

Table 6.2

Interfering signal	Probability of presence							
	WIDER-1 BCCH NB		WIDER-1 TCH NB		WIDER-2 NB		WIDER-3 NB	
IcN	100%		100%		99%		99%	
IaN	100%		100%		100%		100%	
restIcN	100%		99%		92%		93%	
restIaN	100%		100%		100%		99%	
	WIDER-1 BCCH WB		WIDER-1 TCH WB		WIDER-2 WB		WIDER-3 WB	
	pulse #2	pulse #3	pulse #2	pulse #3	pulse #2	pulse #3	pulse #2	pulse #3
IcN	100%	100%	98%	99%	98%	98%	97%	97%
IcW	80%	81%	85%	83%	32%	33%	33%	34%
IaN	100%	100%	100%	100%	100%	100%	100%	100%
IaW	85%	90%	95%	94%	49%	49%	55%	57%
restIcN	100%	100%	91%	92%	87%	87%	87%	87%
restIcW	43%	47%	54%	51%	5%	6%	6%	6%
restIaN	100%	100%	98%	98%	99%	99%	99%	98%
restIaW	58%	67%	82%	79%	18%	19%	22%	24%

7 Pulse shape optimisation

7.1 Introduction

Pulse shape optimisation will be performed based on the preliminary boundary conditions identified in 5.2. One or more candidate pulse shapes may be proposed for each set of boundary conditions.

7.2 Candidate pulse shapes from [4]

7.2.1 Optimisation assumptions

It is specified in 5.2.3 that pulse shape optimisation shall include Tx impairments - in particular, the ACP requirements shall be met while taking into account the spectrum re-growth from the PA.

In the study, a memory-less parametric PA model was derived using gain and phase measurements of a typical base station PA. Initial verification of the PA model indicated that the spectrum re-growth was pessimistic.

Note that while models exist in the public domain (e.g. [5]), these were not felt to be sufficiently representative of a base station PA.

Numeric optimisation of the EGPRS2-B pulse shape was then performed while taking into account the following factors:

- Adjacent channel protection at the 1st and 2nd adjacent channel
- Throughput maximization for EGPRS2-B
- Spectrum re-growth after the PA, based on a PA model for BTS
- Limited length in time domain (6 reduced symbol periods = 5 normal symbol periods)

7.2.2 Results

7.2.2.1 Spectrum

The spectrum of the 1st, 2nd and 3rd optimised pulse shapes with 16-QAM are depicted in Figure 7.1, Figure 7.2 and Figure 7.3.

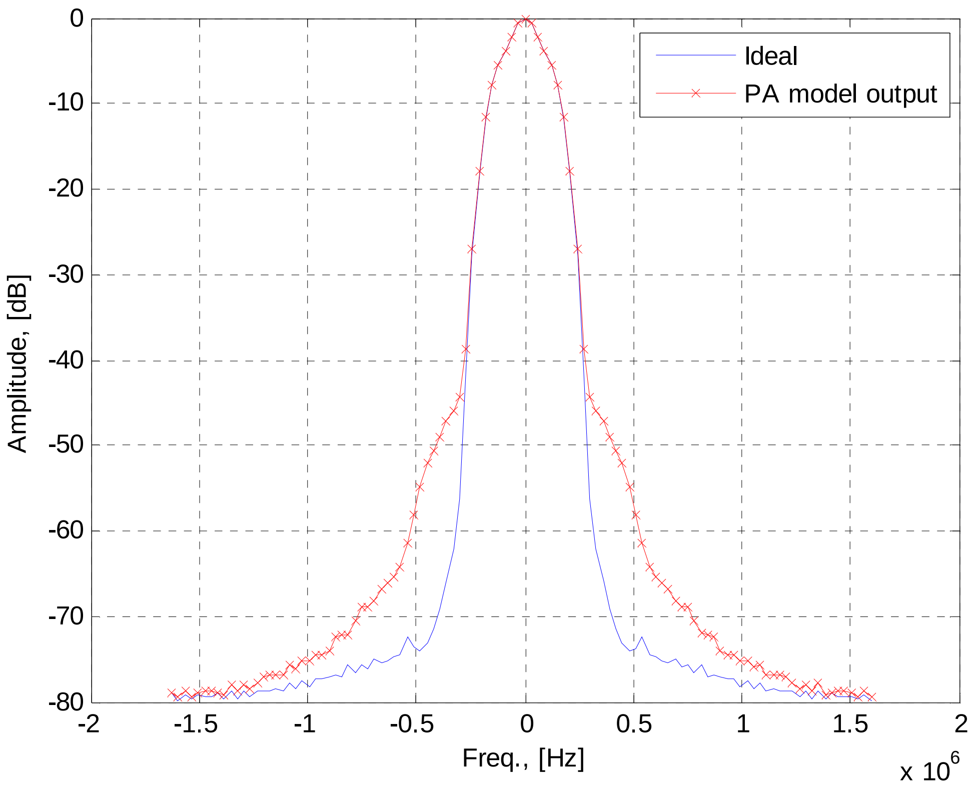


Figure 7.1: 1st optimised pulse measured before and after the PA (30 kHz filter bandwidth)

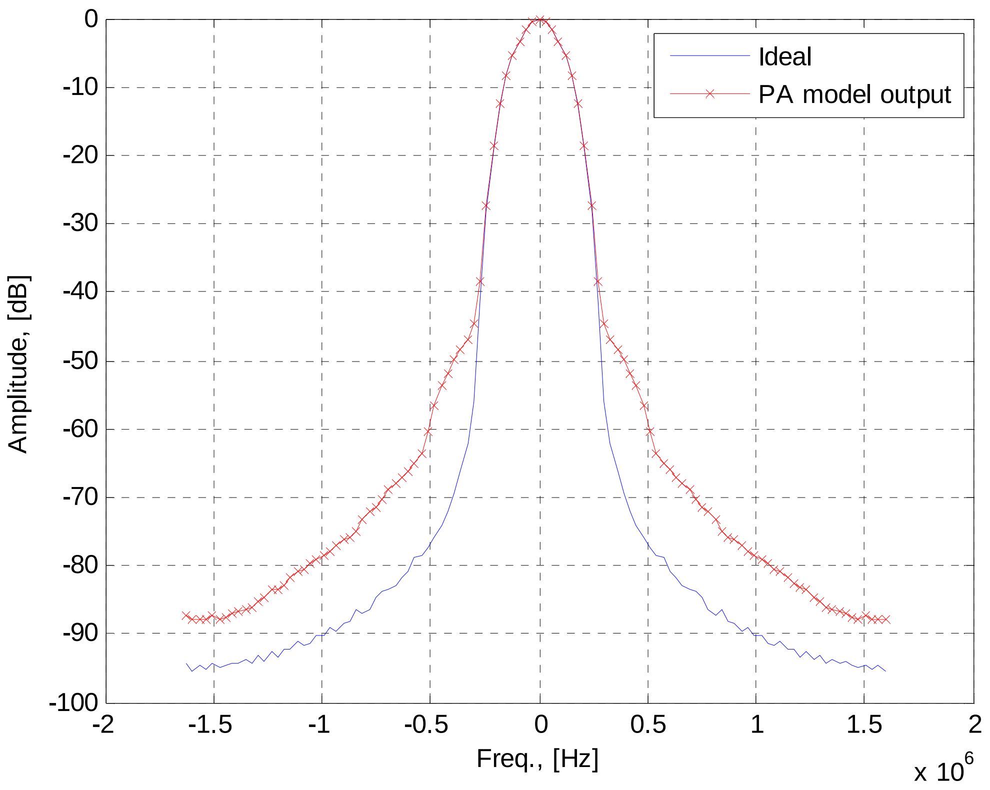


Figure 7.2: 2nd optimised pulse measured before and after the PA (30 kHz filter bandwidth)

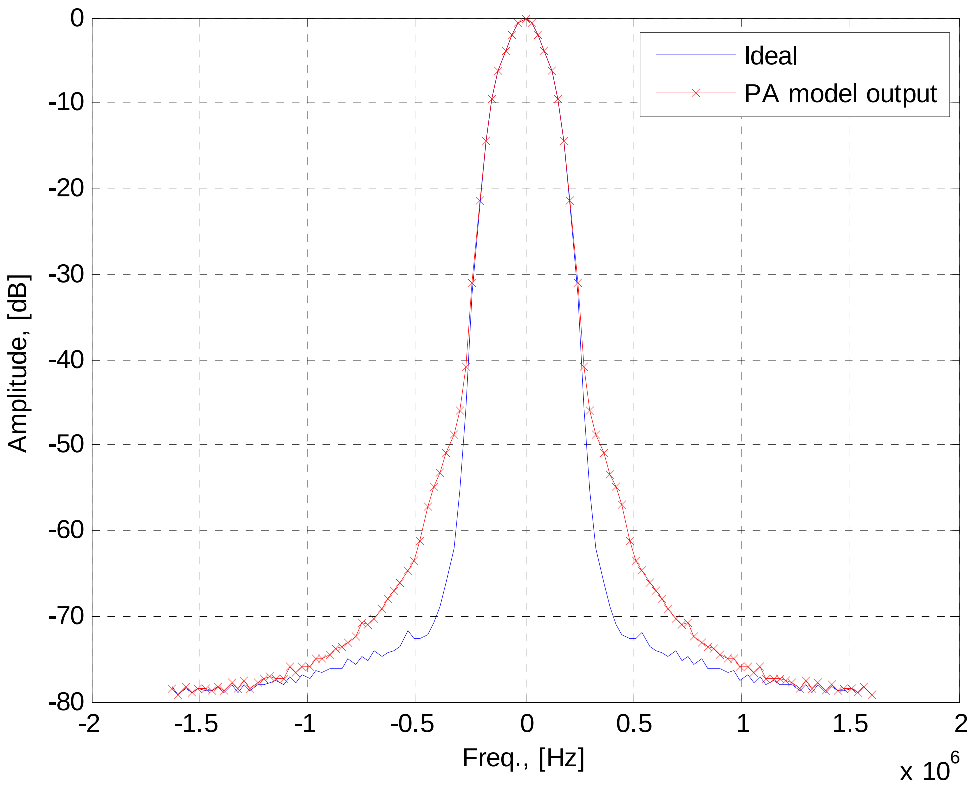


Figure 7.3: 3rd optimised pulse measured before and after the PA (30 kHz filter bandwidth)

7.2.2.2 Adjacent channel protection

The suppression of the candidate pulse shape when measured after the PA with a linearised GMSK filter truncated to ±160 kHz is shown below for the different frequency offsets:

Table 7.1

Suppression (after PA)	0 kHz	200 kHz	400 kHz	600 kHz
Candidate #1	1.0	11.6 dB	48.8 dB (*)	63.8 dB
Candidate #2	1.0	12.1 dB	50.1 dB	65.5 dB
Candidate #3	0.7	13.0 dB	52.3 dB	66.5 dB

Note. (*) 50 dB requirement is only just not met in this case. However, as verification of the 50 dB requirement should be with an actual PA rather than a PA model, this could still be kept as a candidate.

8 Link level studies

8.1 Introduction

Link level studies will be performed using the interferer profiles that are obtained from the network level analysis. The purpose of the link level studies is to: i) verify the legacy Rx model working assumption. When there are no reports from MS vendors about legacy performance being worse than the legacy Rx model working assumption, then the model will be assumed to be valid; ii) evaluate the performance of candidate pulse shapes using the MS vendors own Rx implementations for EGPRS2. The best pulse shape in terms of throughput will be selected if there are more than one candidate pulse shape for a given set of boundary conditions; iii) derive the link to system interface that will be used in the system level studies. This interface needs to consider the various MS Rx implementations and the different services.

8.2 Link to system interface

8.2.1 Introduction

When considering a new pulse shape for EGPRS2-B, it is imperative that both the throughput performance and the spectral characteristics of both the new and the legacy pulse shape are captured sufficiently in the system evaluation.

In this section, the link to system interface that is used in the Nokia Siemens Networks system simulator to model the EGPRS2-B receiver is described.

The interface design followed the methodology for deriving a model for single antenna receivers described in [6]. One exception is the factors used to determine the contribution of a type of interferer to the total C/I, which have been computed from the raw BER performance of the respective interferer type (rather than attenuation provided by the front-end filter).

For the PS resources, the load for the reference case (data using the LGMSK pulse shape), was set to saturation i.e. the rate of newly arriving equalled the rate of ending PS calls. This corresponds to the maximum offered load the network can support without being overloaded and provided the reference load with which to compare the performance of the LGMSK and the optimised pulse shape. When equal traffic loads are used with the LGMSK and the optimised pulse shape, the activity time of the optimised pulse shape can be expected to be lower.

8.2.2 Simulation assumptions

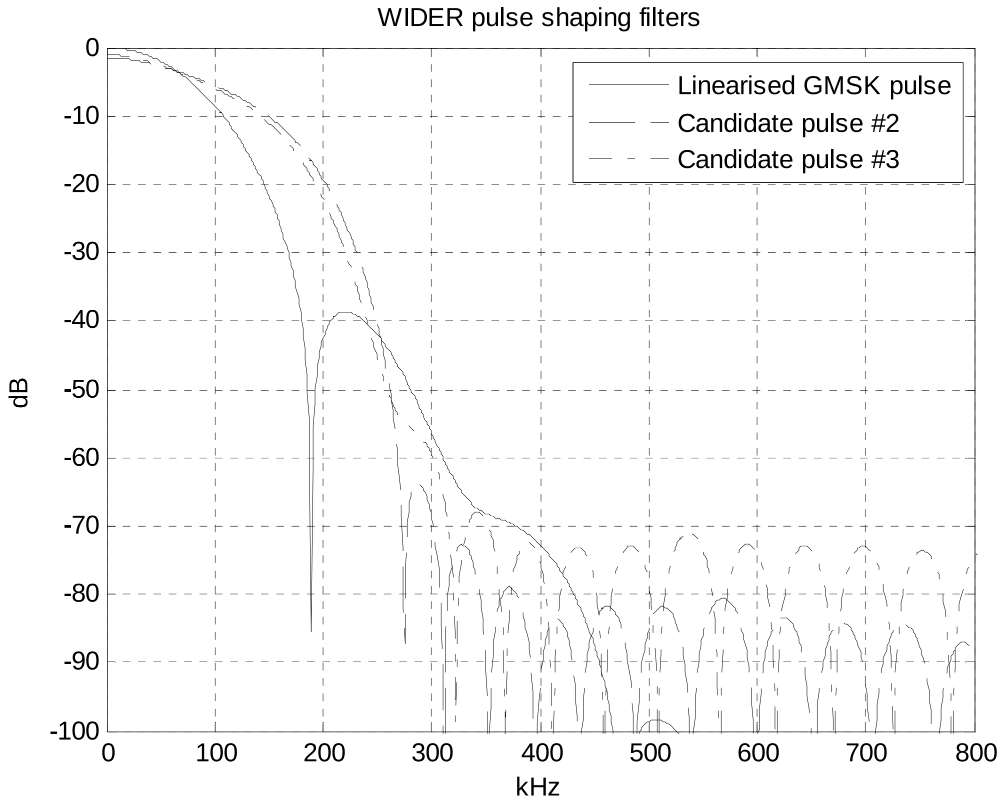
The link level simulator was configured using the assumptions in Table 8.1. Receiver impairments were enabled in the simulator.

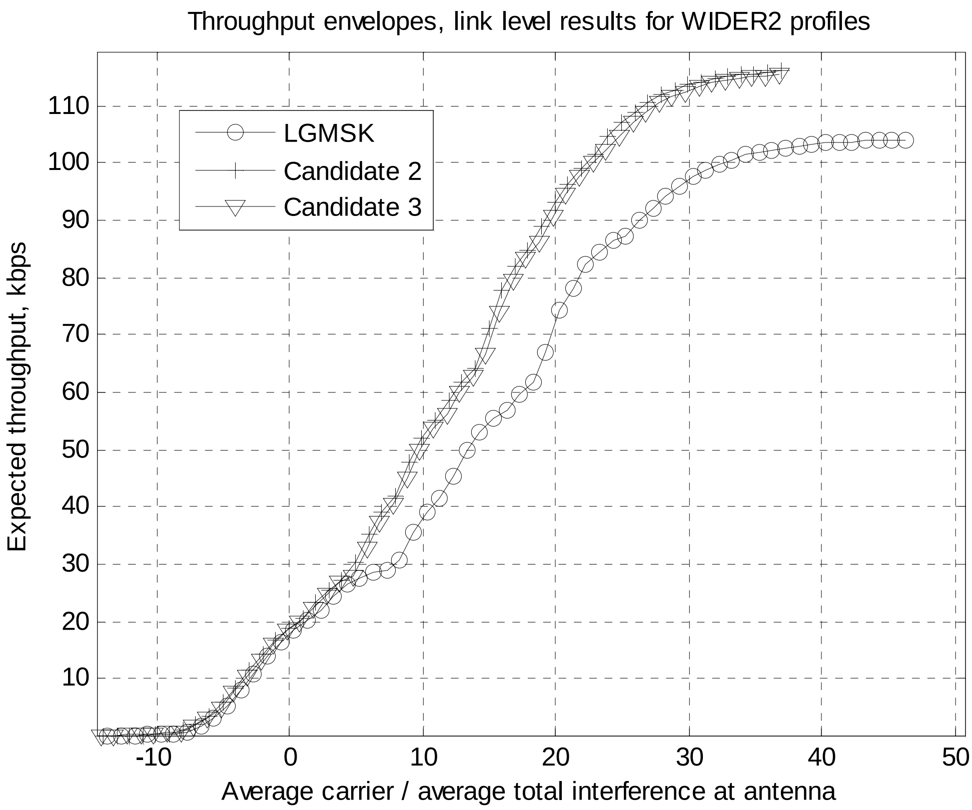
Table 8.1. Link level simulator assumptions.

Parameter	Value
Channel profile	Typical Urban (TU)
Terminal speed	3 km/h
Frequency band	900 MHz
Frequency hopping	Ideal
Interference/noise	WIDER-2 profile (see Section 6.5.1)
Modulation backoff	None
Antenna diversity	No
Equalizer	Trellis based equaliser
Tx pulse shape	LGMSK, candidate #2 and candidate #3
Rx filter	RRC 325 kHz before windowing, roll-off 0.3
Rx impairments	enabled
Simulation length	20000 bursts per simulation point

8.2.3 Link level performance

The spectra and throughput envelopes of each pulse shape (LGMSK pulse, candidate pulse #2 and candidate pulse #3) are given below


WIDER pulse shaping filters
dB
kHz
Linearised GMSK pulse
Candidate pulse #2
Candidate pulse #3
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
100
200
300
400
500
600
700
800


Throughput envelopes, link level results for WIDER2 profiles
Expected throughput, kbps
Average carrier / average total interference at antenna
LGMSK
Candidate 2
Candidate 3
110
100
90
80
70
60
50
40
30
20
10
-10
0
10
20
30
40
50

8.2.4. Legacy voice receiver

8.2.4.1 Front-end filter

For the legacy voice receiver, the contribution of each interferer type (in this case: CCI narrow, CCI wide, ACI narrow & ACI wide) to the total interference has been characterised by its residual interference at the output of the front-end filter (its in-band interference).

The calculation of in-band CIR was obtained by applying the relevant attenuation of factors for each interferer type that is present in the system before taking the sum. In Table 8.2, the attenuation factors are given for each interferer type when assuming a LGMSK front-end filter truncated to -160...+160 kHz.

Table 8.2. Attenuation factors for a legacy voice receiver.

Interferer	**ACI**	**CCI**
Ref (LGMSK)	18.3 dB	0.0 dB
Wide (cand. #2)	12.1 dB	1.0 dB
Wide (cand. #3)	13.0 dB	0.7 dB

The mappings used to model the legacy voice receiver were generated from data collected from a link level simulator which closely resembled the conventional receiver of a mobile vendor.

8.2.5 EGPRS2 receiver

8.2.5.1 Introduction

A state-of-the-art receiver could be expected to perform some kind of interference processing that is in addition to the front-end filter.

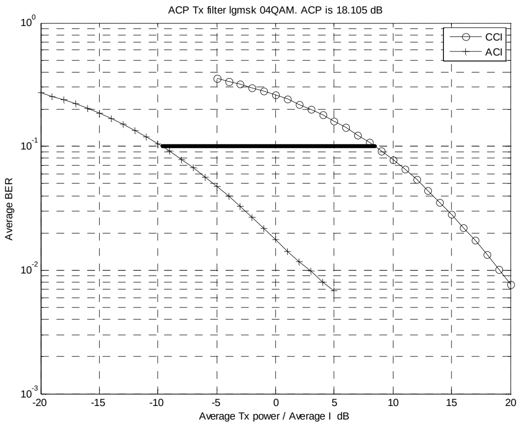
To take into account the contribution of an interferer type to the overall interference as seen by the EGPRS2 receiver, the attenuation factors were obtained using simulated raw BER curves for each of the respective interferer types rather than from the attenuation provided by the front-end filter alone.

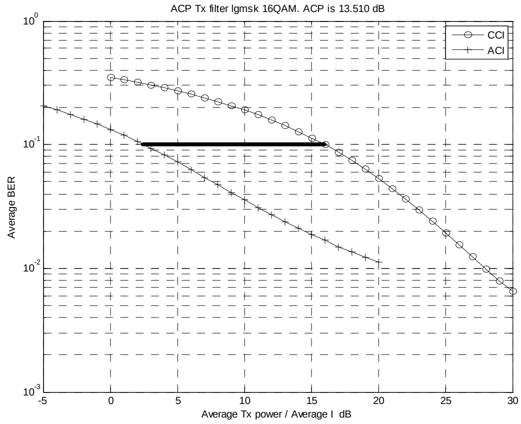
This is expected to lead to a link to system interface that better reflects the properties of the different types of interferer.

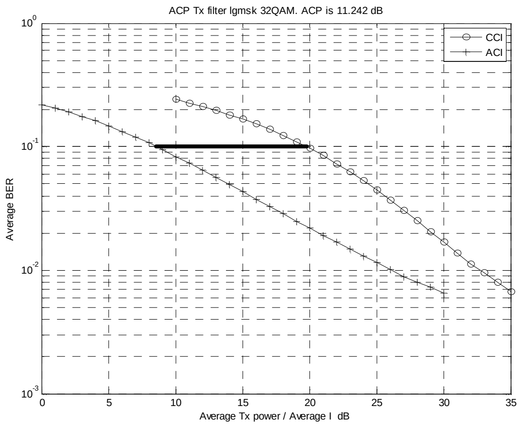
This section gives the ACP factors for the reference LGMSK pulse, candidate pulse #2 and candidate pulse #3 which were calculated from raw BER curves obtained with the updated link level simulator.

8.2.5.2 Reference pulse

	Updated Rx
C=NB	**ACI NB**
QPSK	-18.1
16QAM	-13.5
32QAM	-11.2

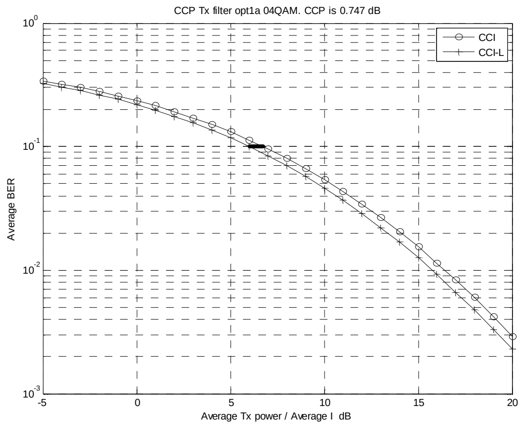


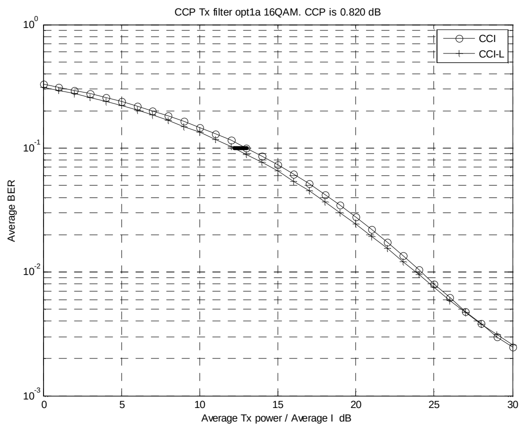


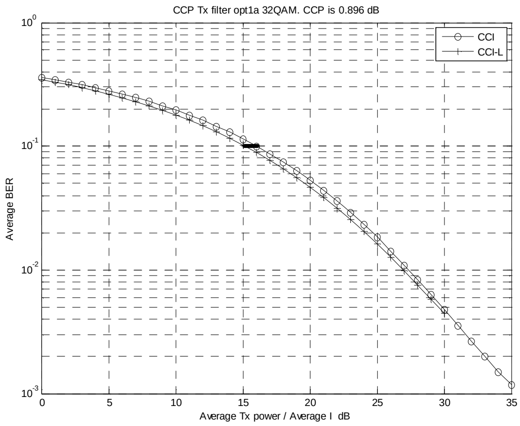


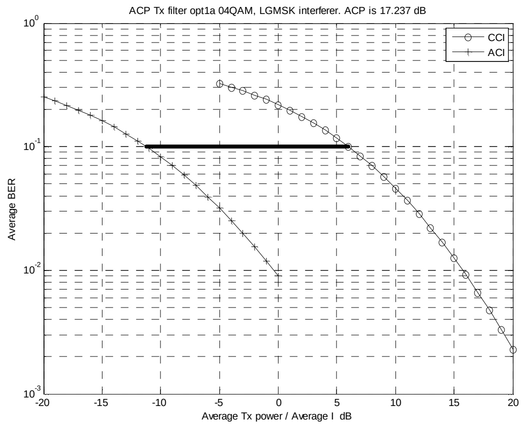
8.2.5.3 Candidate pulse #2

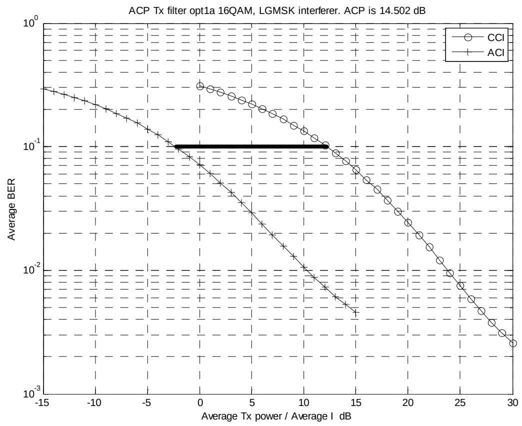
C=WB	**CCI NB**	**ACI WB**	**ACI NB**
QPSK	-0.75	-11.74	-17.24
16QAM	-0.82	-9.75	-14.5
32QAM	-0.9	-8.63	-12.97

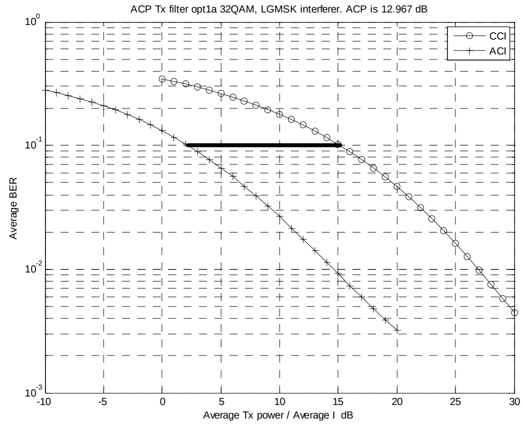

CCP Tx filter opt1a 04QAM. CCP is 0.747 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

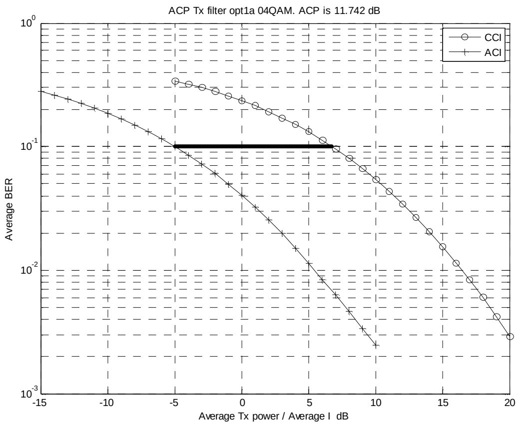

CCP Tx filter opt1a 16QAM. CCP is 0.820 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

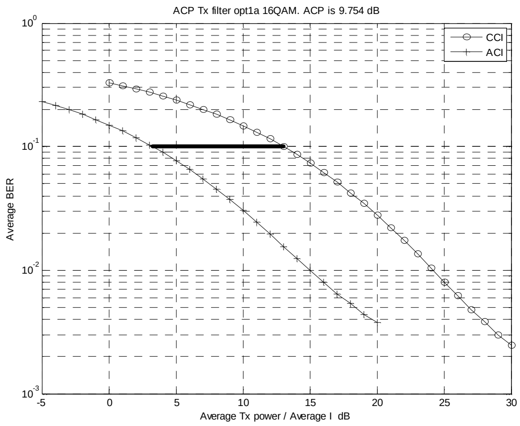

CCP Tx filter opt1a 32QAM. CCP is 0.896 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

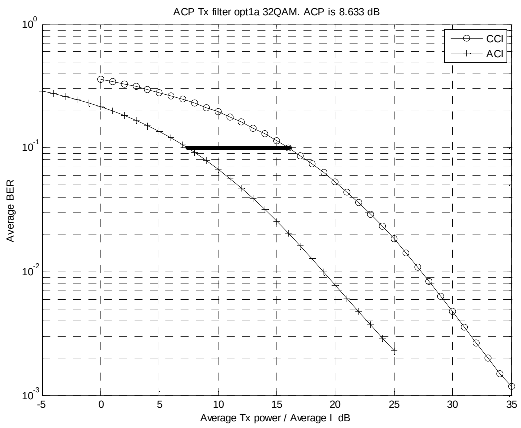

ACP Tx filter opt1a 04QAM, LGMSK interferer. ACP is 17.237 dB
CCI
ACI
Average BER
Average Tx power / Average I dB


ACP Tx filter opt1a 16QAM, LGMSK interferer. ACP is 14.502 dB
CCI
ACI
Average BER
Average Tx power / Average I dB


ACP Tx filter opt1a 32QAM, LGMSK interferer. ACP is 12.967 dB
CCI
ACI
Average BER
Average Tx power / Average I dB

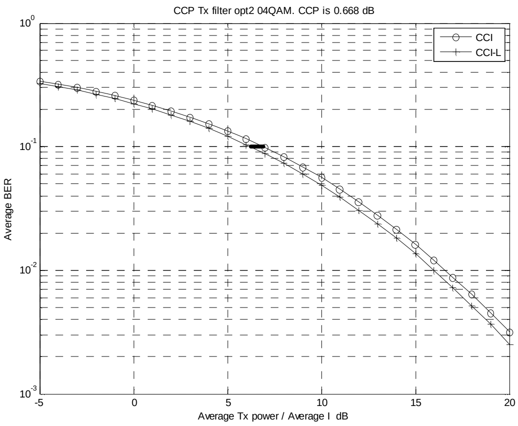


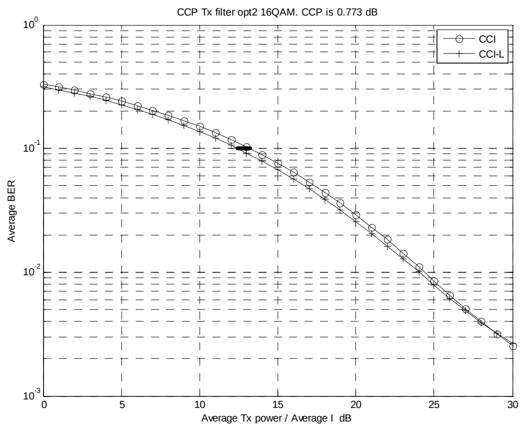


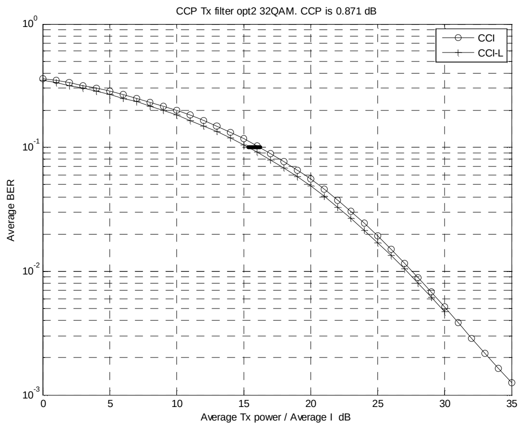


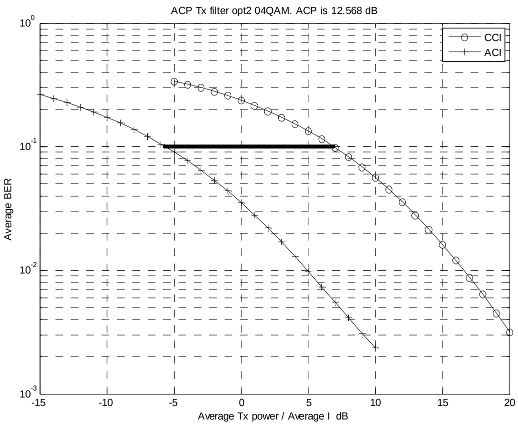
8.2.5.4 Candidate pulse #3

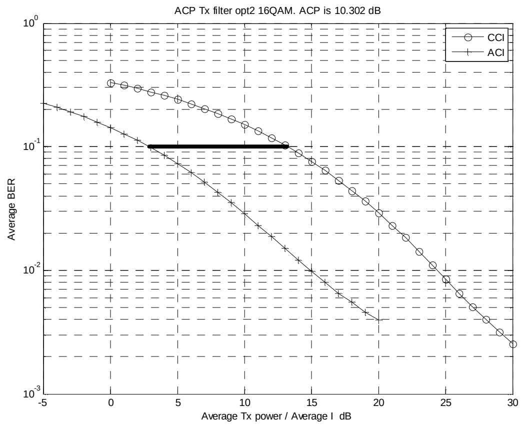
C=WB	**CCI NB**	**ACI WB**	**ACI NB**
QPSK	-0.67	-12.57	-17.29
16QAM	-0.77	-10.3	-14.35
32QAM	-0.87	-9.05	-12.72

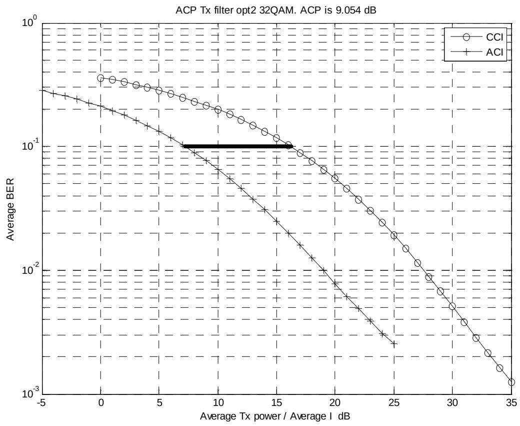

CCP Tx filter opt2 04QAM. CCP is 0.668 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

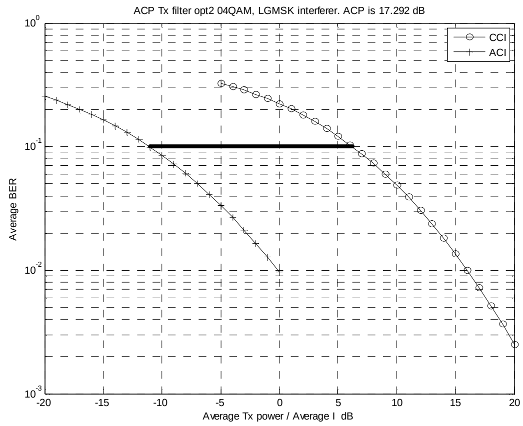

CCP Tx filter opt2 16QAM. CCP is 0.773 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

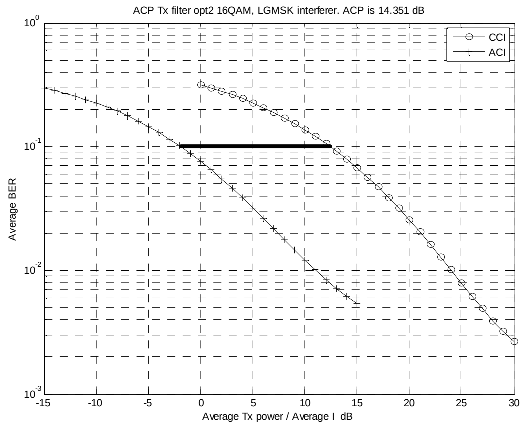

CCP Tx filter opt2 32QAM. CCP is 0.871 dB
CCI
CCI-L
Average BER
Average Tx power / Average I dB

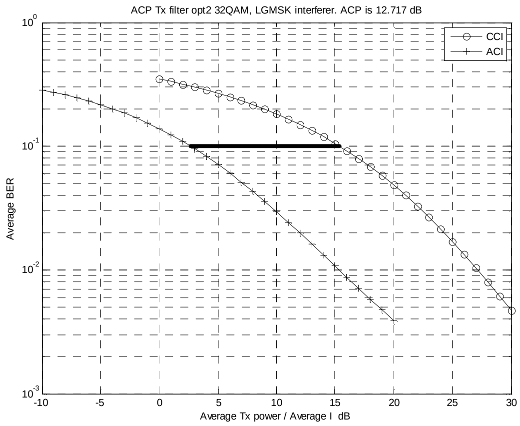

ACP Tx filter opt2 04QAM. ACP is 12.568 dB
CCI
ACI
Average BER
Average Tx power / Average I dB


ACP Tx filter opt2 16QAM. ACP is 10.302 dB
CCI
ACI
Average BER
Average Tx power / Average I dB


ACP Tx filter opt2 32QAM. ACP is 9.054 dB
CCI
ACI
Average BER
Average Tx power / Average I dB







8.2.5.5 Receiver noise

The receiver thermal noise was calculated as follows:

N (dBm) = 10log(kTB*1000) + NF where k=1.3804e-23 J/K, T=298K, B=325000 or 270833 Hz, NF = 10

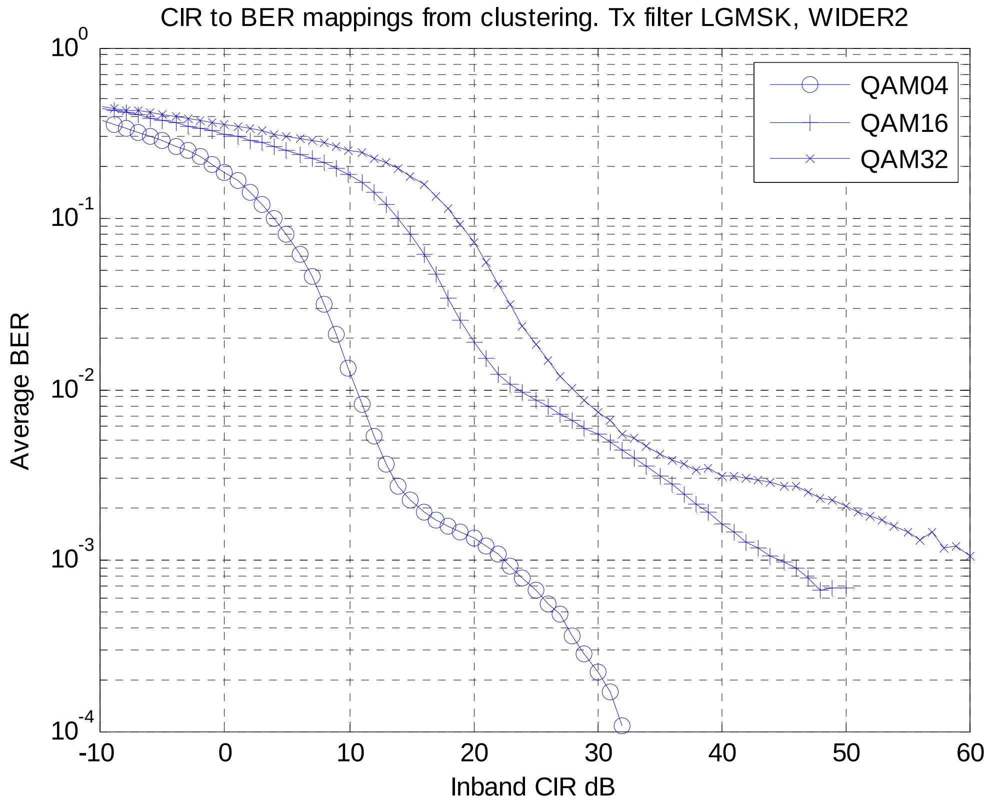
N (dBm) = -119.5 + NF for normal symbol rate

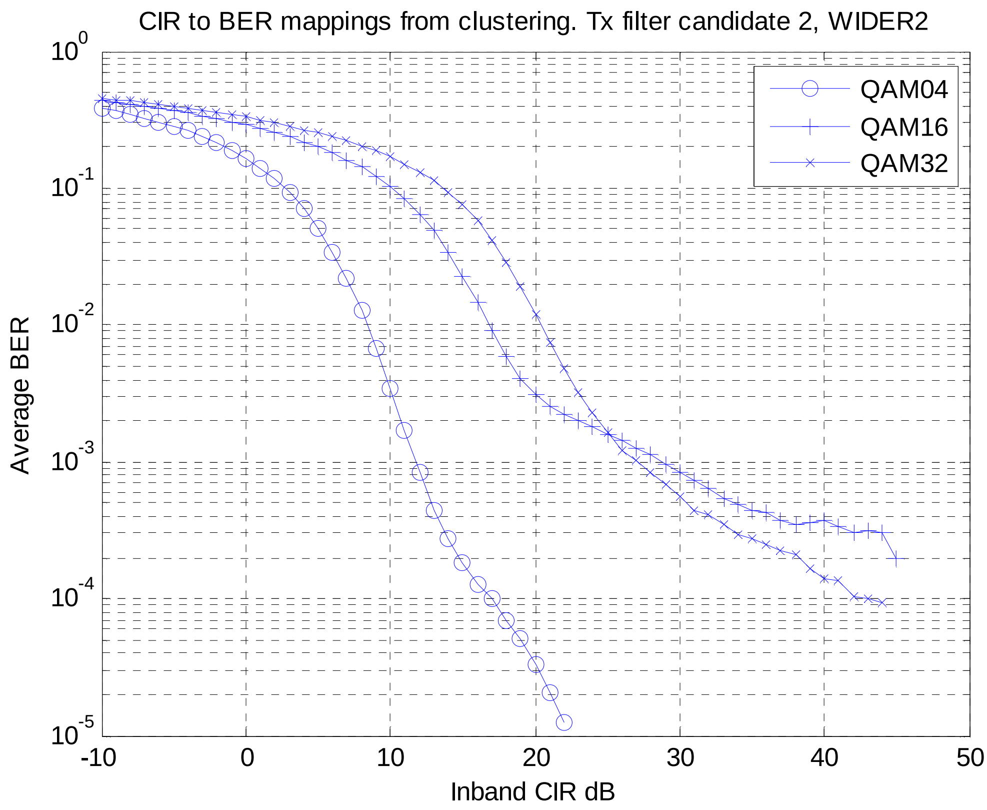
N (dBm) = -118.7 + NF for higher symbol rate

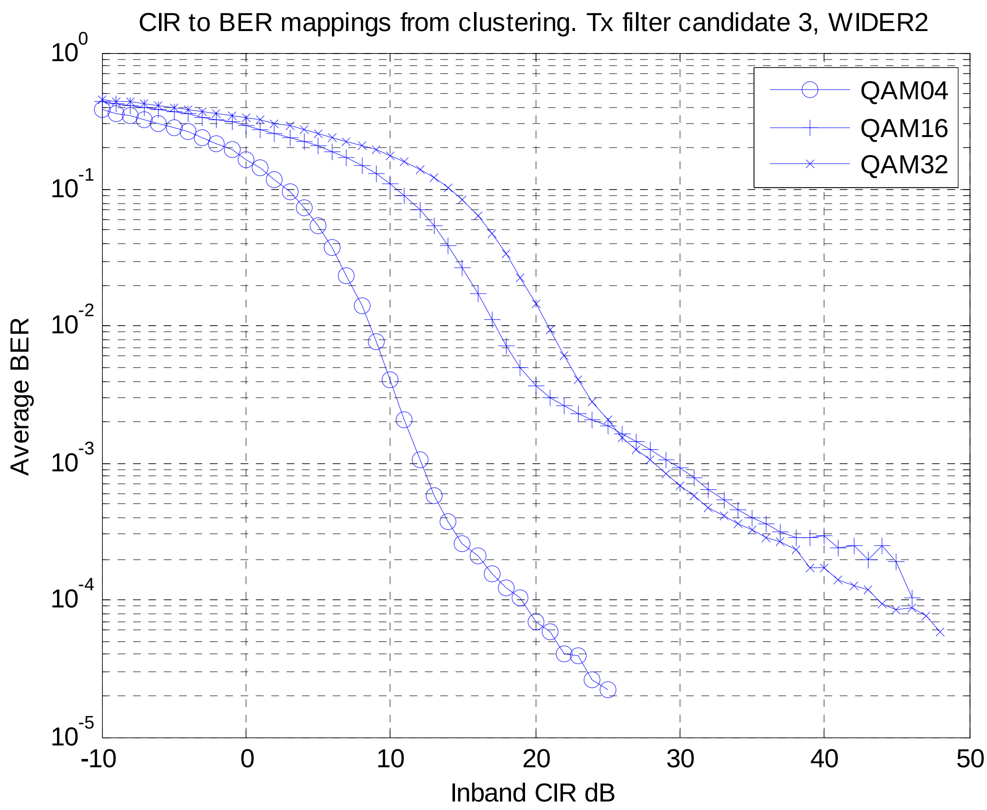
In the simulator, this noise component was implemented level relative to the dominant co-channel narrow interferer.

8.2.5.6 First Stage Mapping (CIR to BER)

This section gives the CIR to BER mappings for the reference LGMSK pulse, candidate pulse #2 and candidate pulse #3.


CIR to BER mappings from clustering. Tx filter LGMSK, WIDER2
Average BER
Inband CIR dB
QAM04
QAM16
QAM32
10^0
10^-1
10^-2
10^-3
10^-4
-10
0
10
20
30
40
50
60

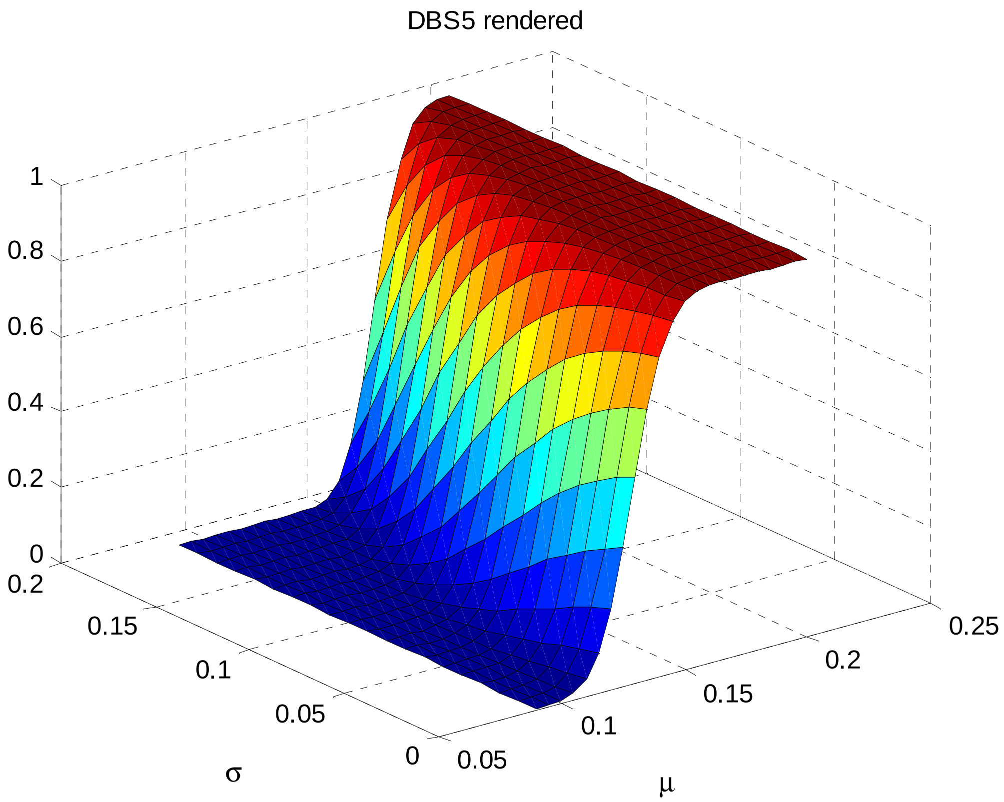

CIR to BER mappings from clustering. Tx filter candidate 2, WIDER2
Average BER
Inband CIR dB
QAM04
QAM16
QAM32
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
-10
0
10
20
30
40
50

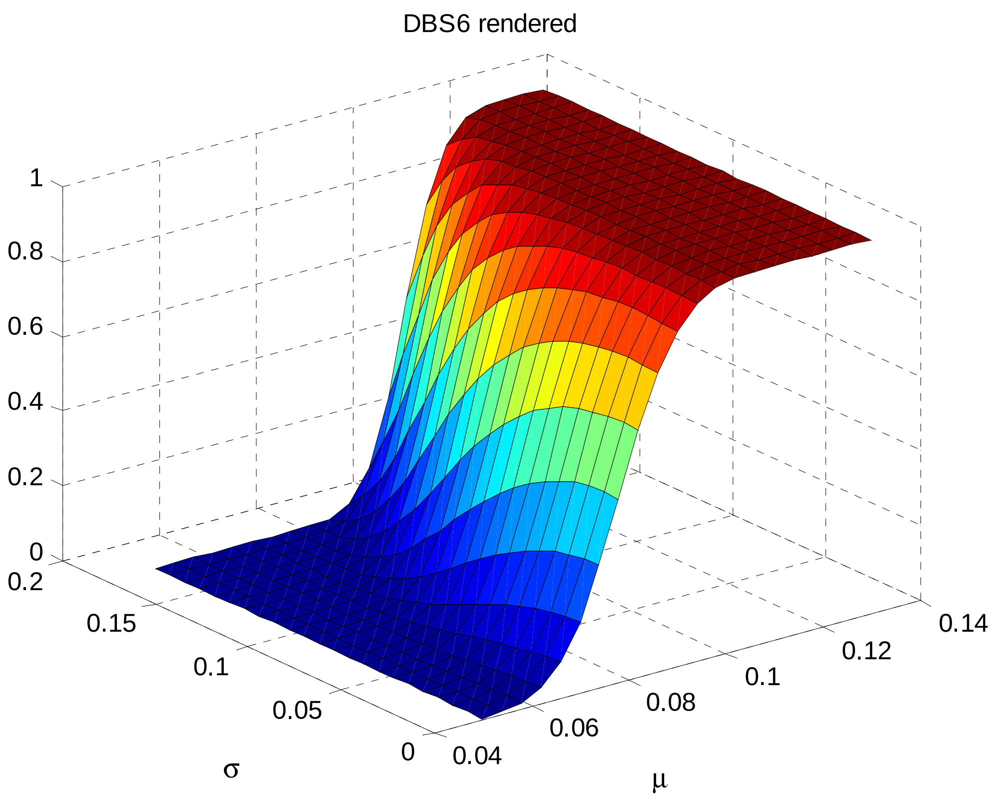


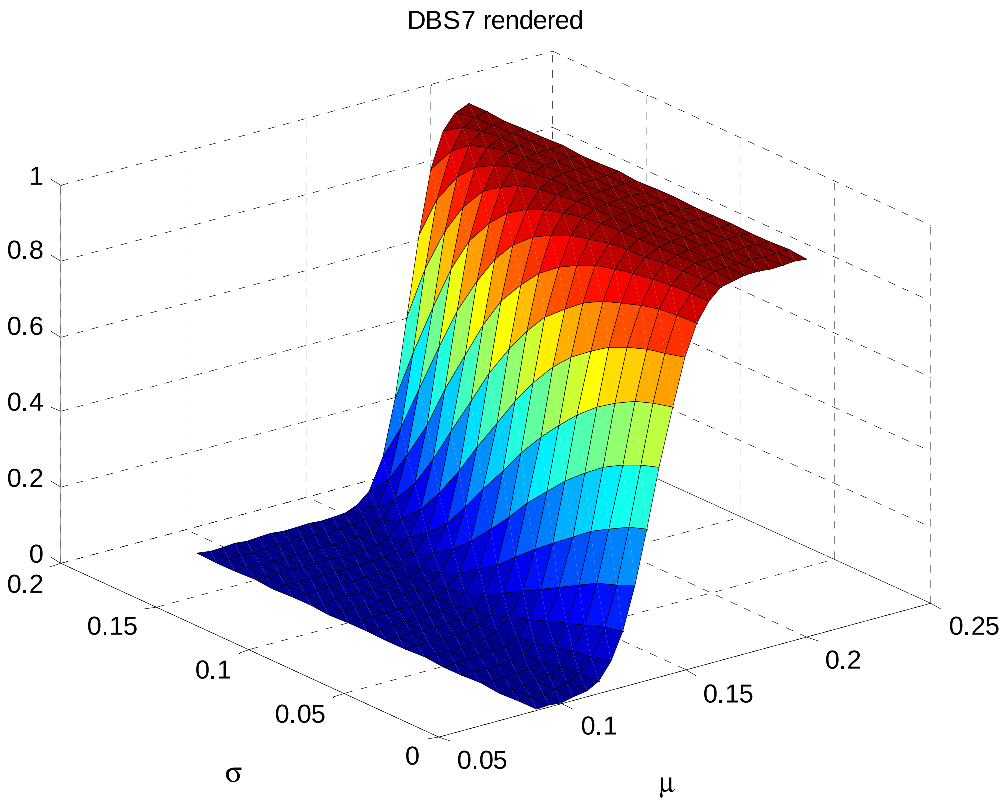
8.2.5.7 Second Stage Mapping (BER to BLER)

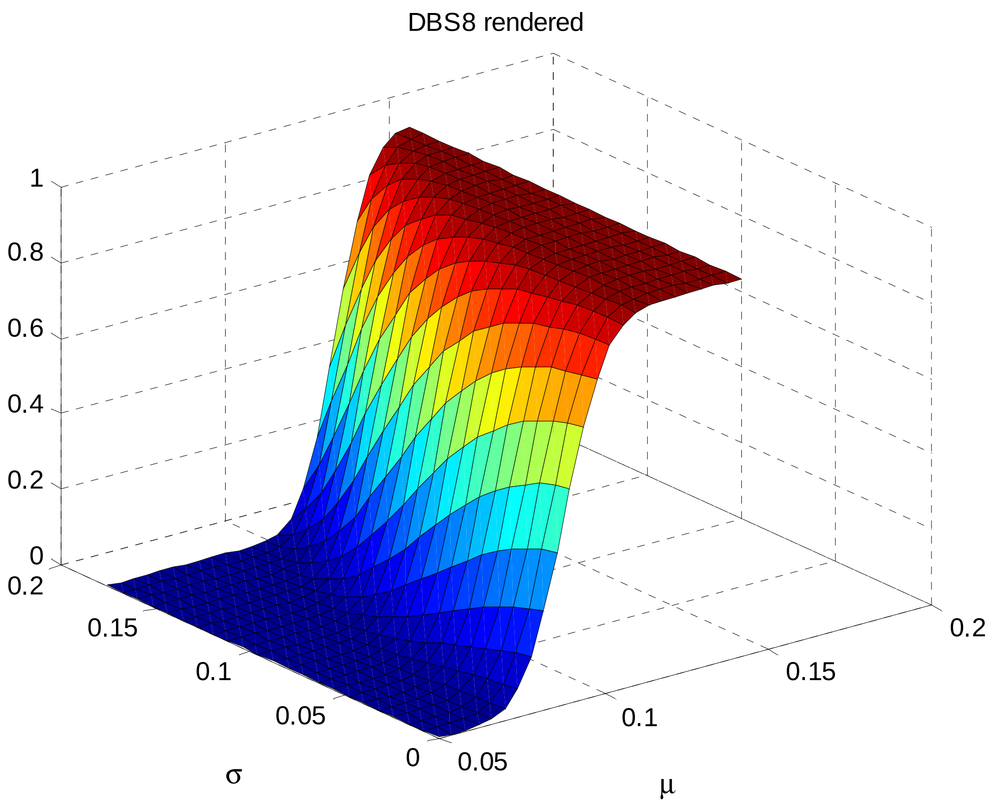
In this section, the second stage mappings are given, i.e. the expected BLER as a function of the mean (μ) and the variance (σ) of the uncoded BER for each burst of the RLC data block or speech frame that was predicted by the 1st stage mapping.

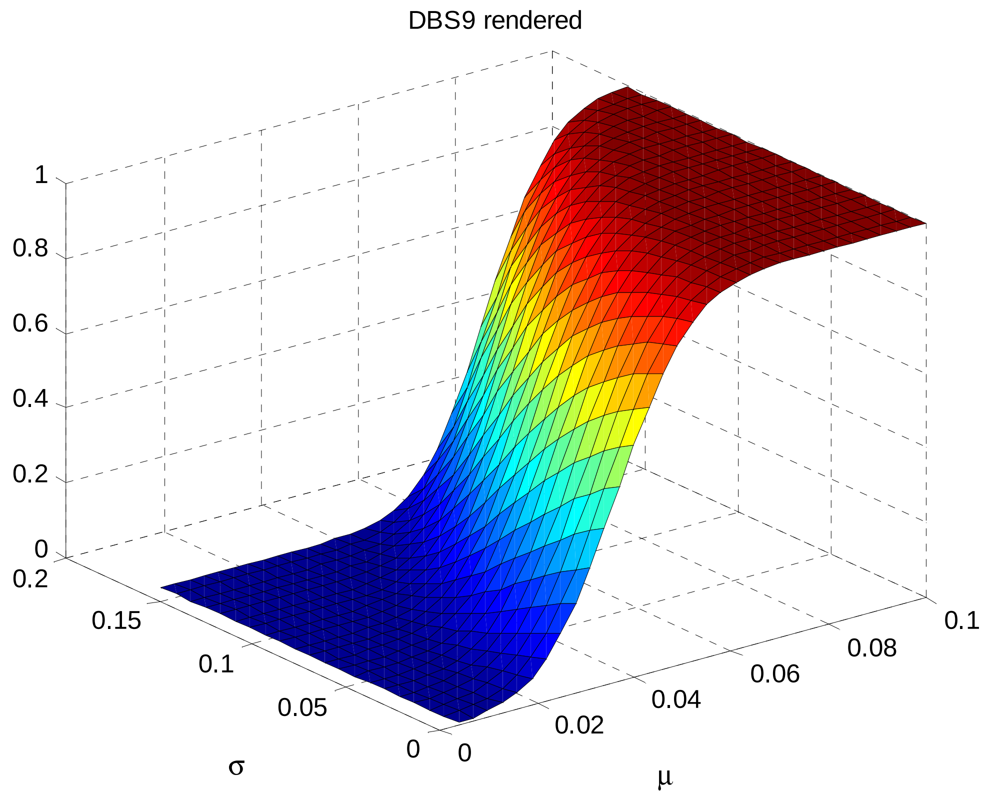
In the case of DBS-11 and DBS-12, the RLC data block is interleaved over a single burst, hence the variance in these cases is zero.

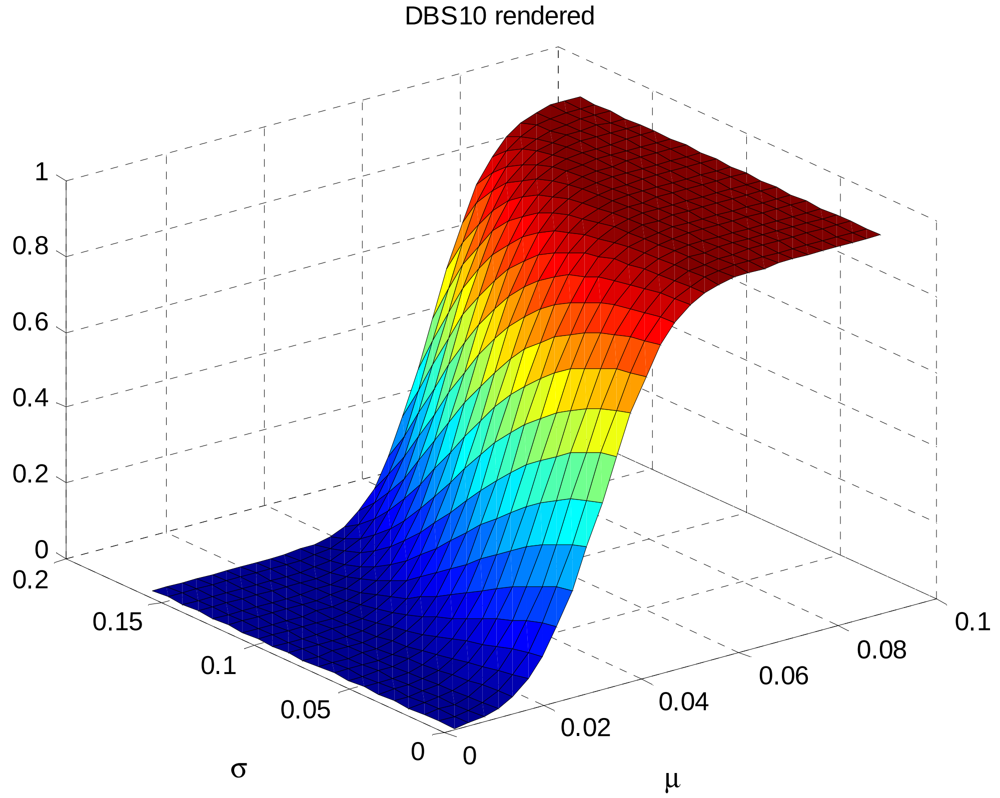

DBS5 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0.05
0.1
0.15
0.2
0.25
μ

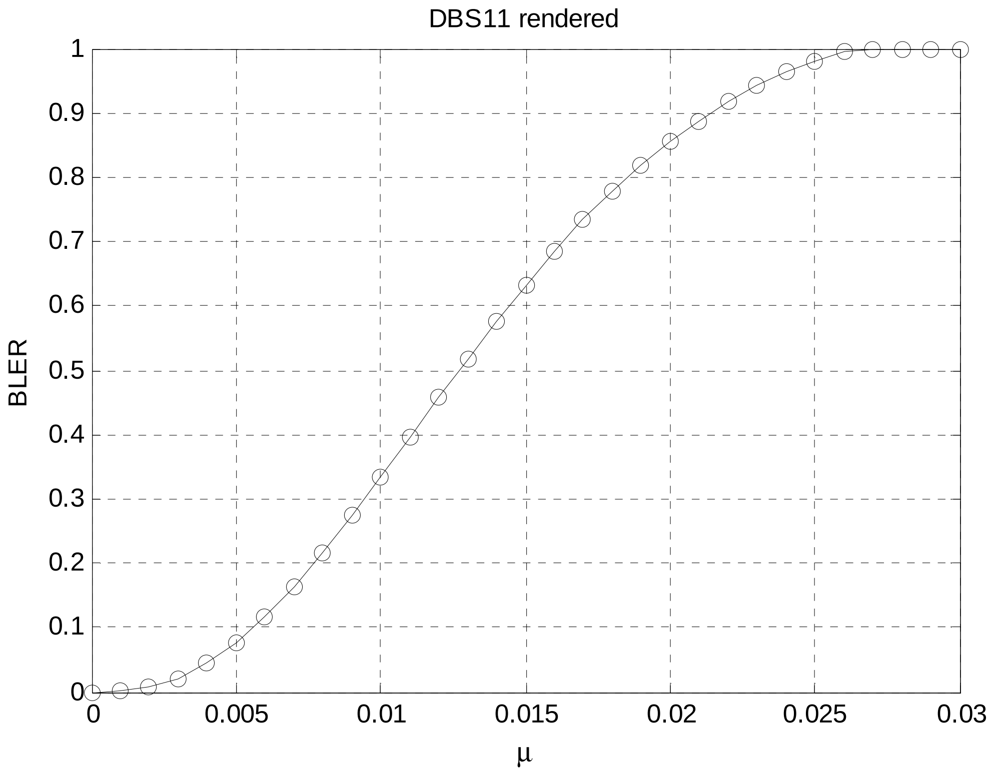

DBS6 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0.04
0.06
0.08
0.1
0.12
0.14
μ

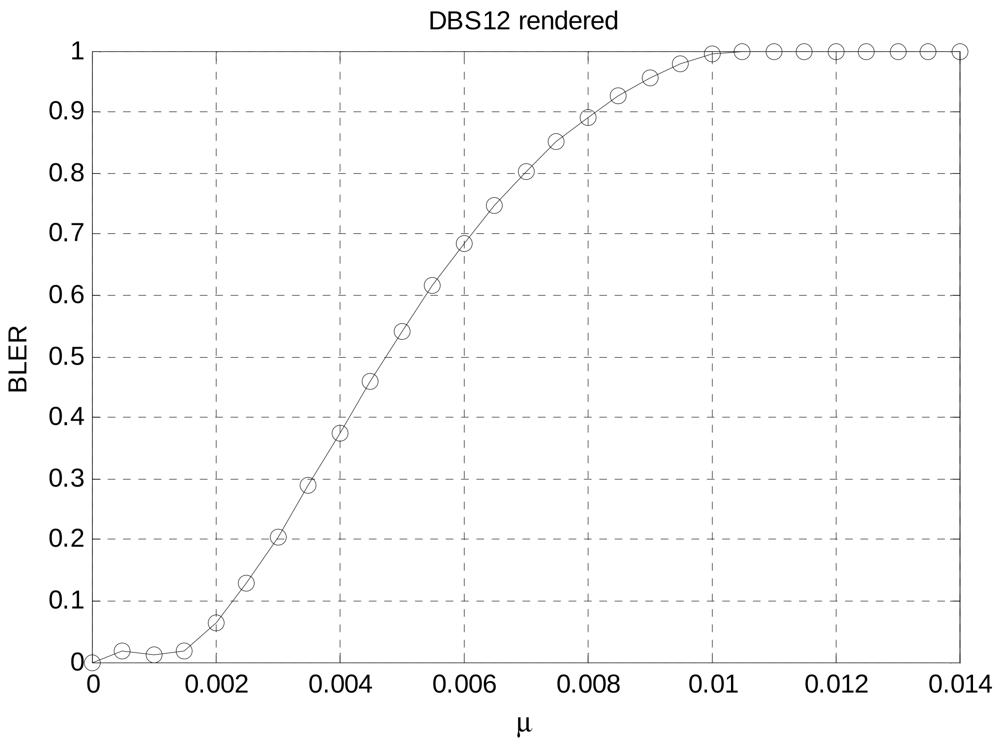

DBS7 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0.05
0.1
0.15
0.2
0.25
μ


DBS8 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0.05
0.1
0.15
0.2
μ


DBS9 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0
0.02
0.04
0.06
0.08
0.1
μ


DBS10 rendered
1
0.8
0.6
0.4
0.2
0
0.2
0.15
0.1
0.05
0
σ
0
0.02
0.04
0.06
0.08
0.1
μ

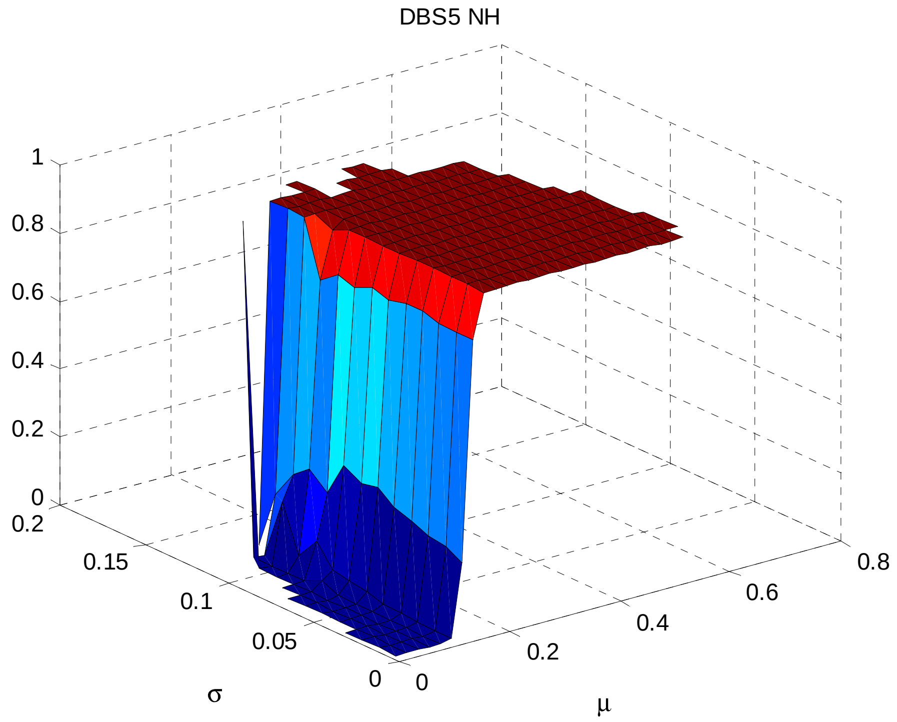




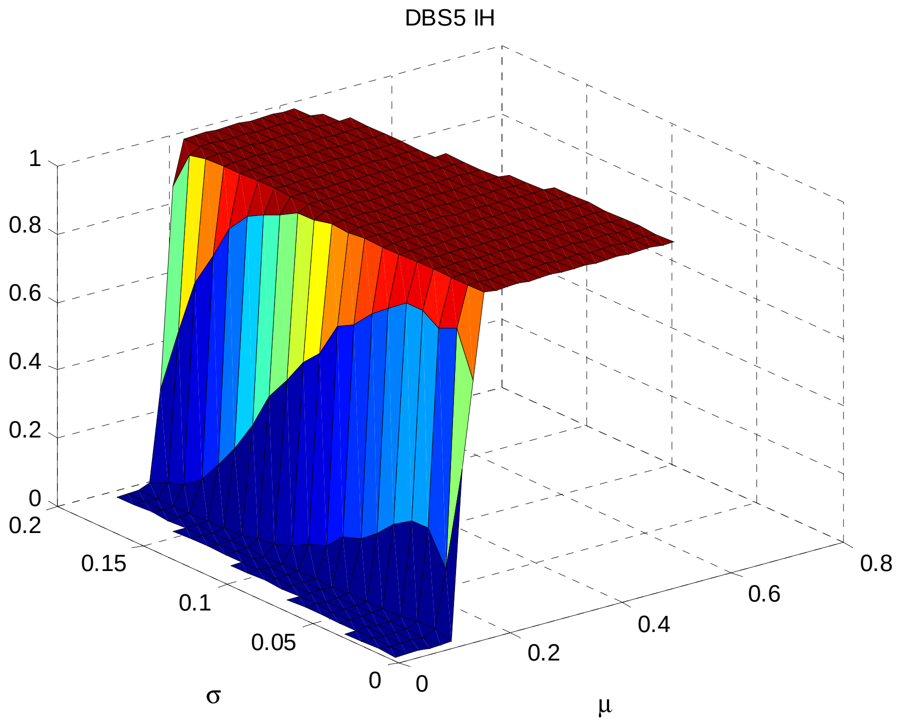
8.2.5.8 Second Stage Mapping for Non-hopping Channel

The inter-burst correlation that exists in a non-hopping channel for a slowly moving user can be seen in the BER to BLER mapping in the low variance part of the surface. This is because the SNIR is correlated between consecutive bursts resulting in a reduced variance of the BER within a radio block.

For example, the figure below shows the surface taken from a non-hopping simulation for DBS-5 (DTS-2 profile).

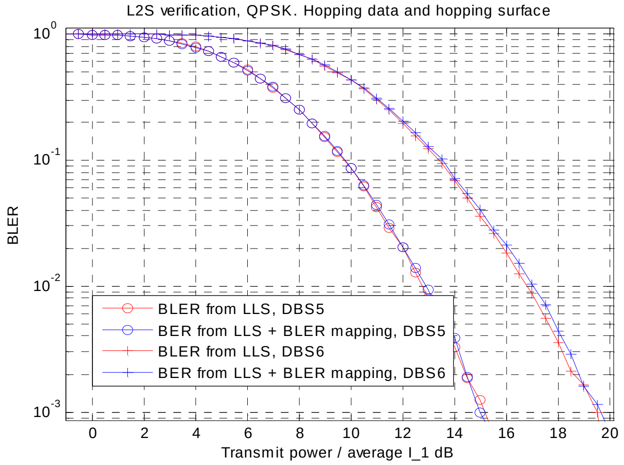


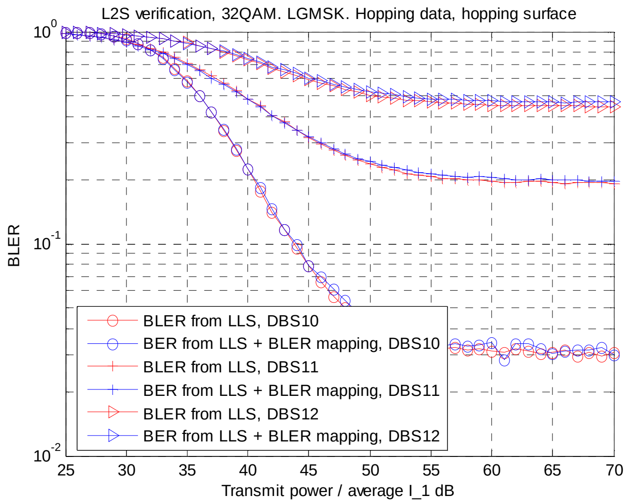
When the surface from a hopping simulation is examined, a corresponding low variance part can also be seen. For example, the figure below shows the surface taken from a hopping simulation for DBS-5 (DTS-2 profile).



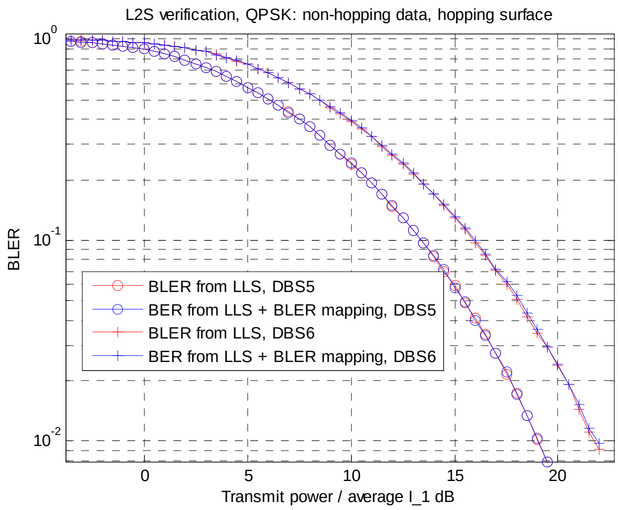
This section investigates whether the surface obtained by a hopping simulation can be used in non-hopping simulations.

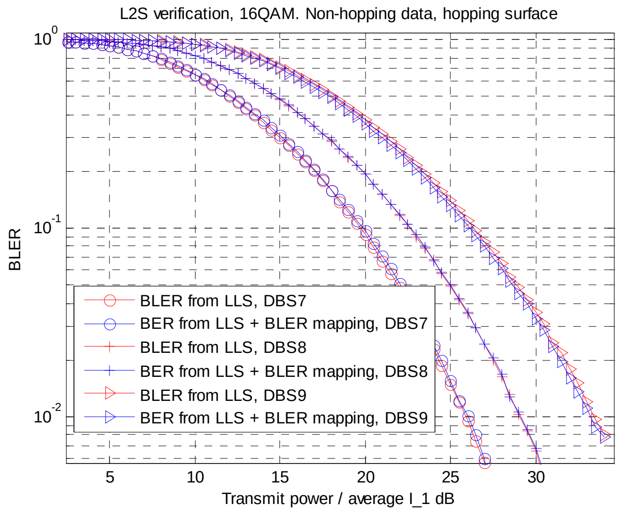
First, the hopping surface is validated against data generated from a hopping simulation for DBS-5 to DBS-12. In all figures, TU3 channel and DTS-2 interference and wide Tx pulse has been assumed with the exception of 32QAM for hopping data, where the LGMSK Tx pulse has been used.

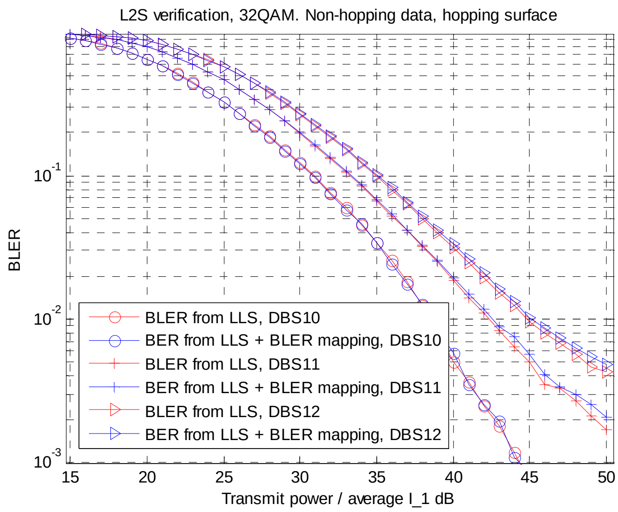




The hopping surface is next validated against data generated from a non-hopping simulation for DBS-5 to DBS-12.







The above figures show the error is negligible in both cases. It can therefore be concluded that the BER to BLER mapping derived for the hopping channel is also valid also for a non-hopping channel.

9 System level studies

9.1 Introduction

System level studies will be performed for each network configuration, to determine the impact of the candidate pulse shapes to legacy services and to determine the throughput gain of the wide pulse shape compared to the reference i.e. EGPRS2-B using the narrowband pulse shape.

9.2 System Performance Evaluation

9.2.1 Evaluation method

The evaluation method is ffs.

9.2.2 System performance results

This clause contains the System performance results from Nokia & Nokia Siemens Networks.

9.2.2.1 Evaluation method

The load for the CS resources was set to give 2 % blocking. This blocking criterion was kept across all scenarios and pulse shapes, yielding more or less constant load in the CS resources.

In the PS resources, the load was determined by the call arrival rate, which was determined by the number of data users in the network (one call per user was assumed).

For the reference pulse simulation, the PS load was set to maximum, which is when the rate of newly arrived calls equalled the rate of ending calls (in this context a call is a temporary block flow).

For the wide pulse simulations, the PS load was first equal the PS load in the reference pulse simulation. This is to provide an evaluation of the existing users in the network. The PS load was then be increased to maximum to determine if more data users can be supported with the wide pulse without impacting legacy users (i.e. there is a 'data capacity' gain with the wide pulse). Note that this last step was not performed.

The PS load can be defined as the average number of active TBFs per timeslot. This is shown in Figure 9.1 and Figure 9.3 for each simulation. Figure 9.2 and Figure 9.4 depict the timeslot utilisation in each simulation.

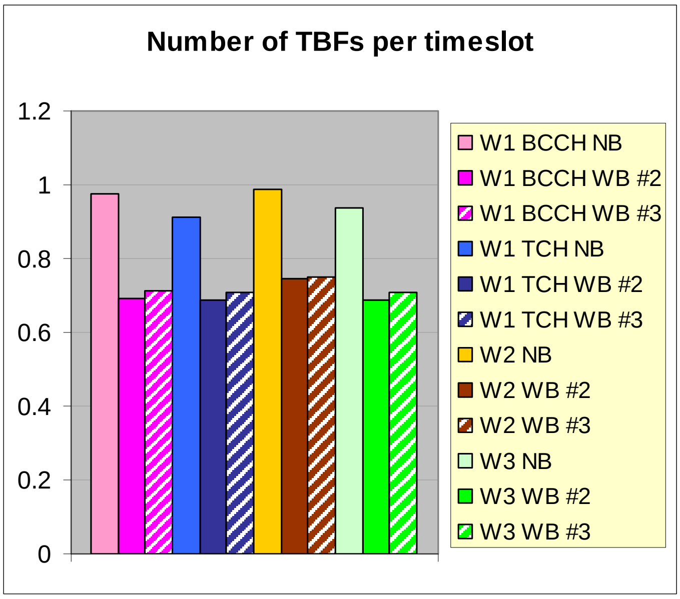


Figure 9.1: Average number of active TBFs per timeslot (at equal the PS load)

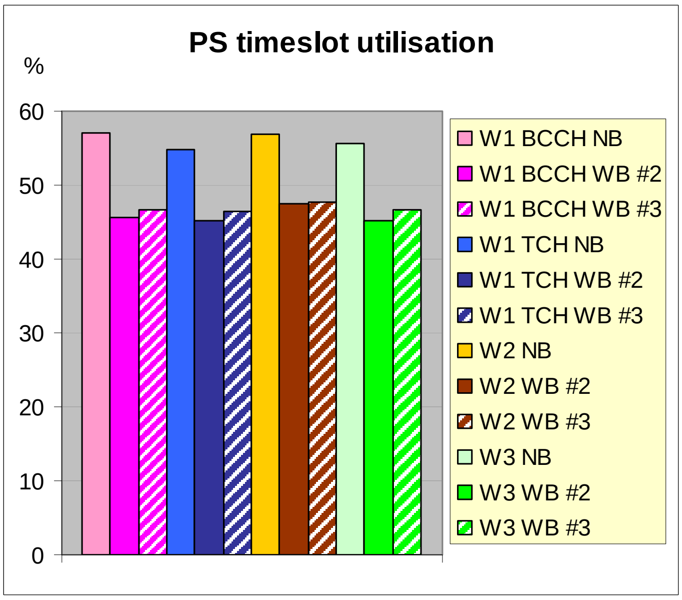


Figure 9.2: Timeslot utilisation in each simulation (at equal the PS load)

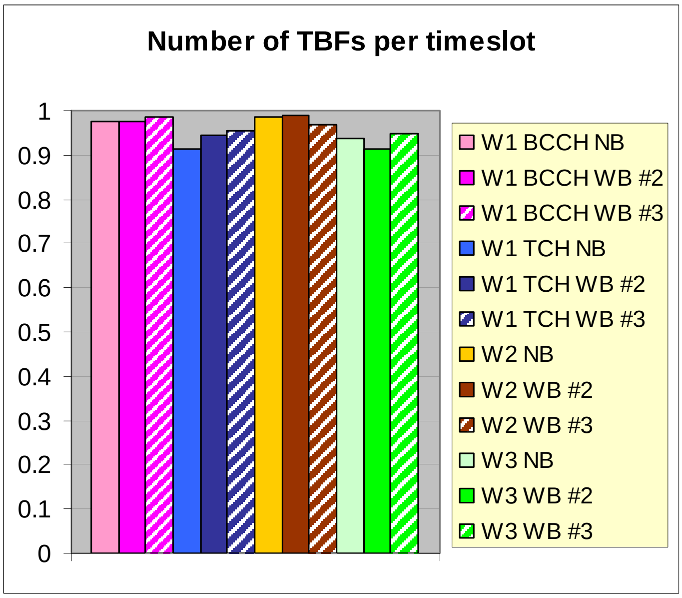


Figure 9.3: Average number of active TBFs per timeslot (at maximum PS loads)

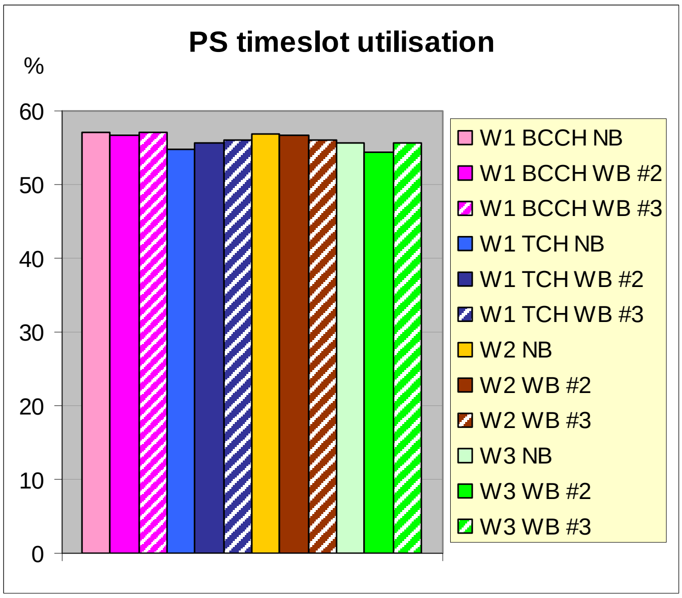


Figure 9.4: Timeslot utilisation in each simulation (at maximum PS loads)

9.2.2.2 Impact on speech quality

The impact of each pulse shape to legacy speech users is given in Figure 9.5 and Figure 9.6 – reference pulse (NB) vs candidate pulse #2 (WB#2) vs candidate pulse #3 (WB#3).

The criteria for a BQC is average FER > 1 % except in network scenario WIDER-1 where it is > 2 %.

The target percentage of BQCs is < 5 %, which is more or less met in all the scenarios.

Impact to speech quality is the difference in percentage of BQCs between the reference pulse simulation and the wide pulse simulations.

At equal PS load, the impact is more or less the same between the reference pulse and either of the wide pulses.

This means:

- speech quality of legacy users is not degraded by either of the wide pulses;
- any increase in ACI from the wide pulse is entirely compensated by a reduction in activity time;
- it will not be possible to support more data users with either wide pulse without some impact to legacy speech users.

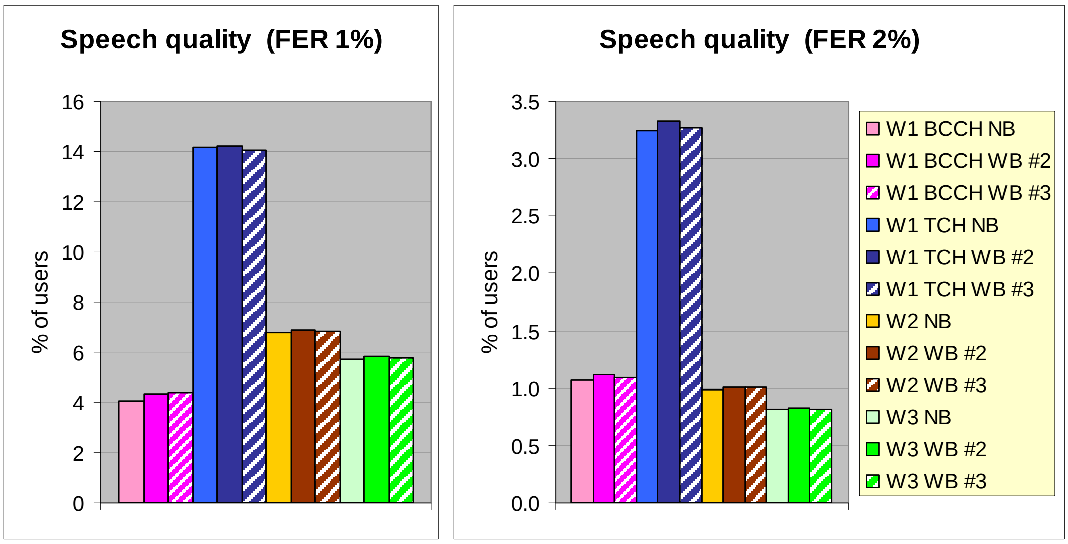


Figure 9.5: Percentage of BQCs at equal PS load

At maximum PS load, an impact to legacy voice users is apparent with the candidate pulse shapes only for the network configuration WIDER-1 on the TCH layer. This configuration has a high proportion of PS timeslots relative to the total number of timeslots (4 PS timeslots out of a total of 16). The impact to legacy voice users is nevertheless very small.

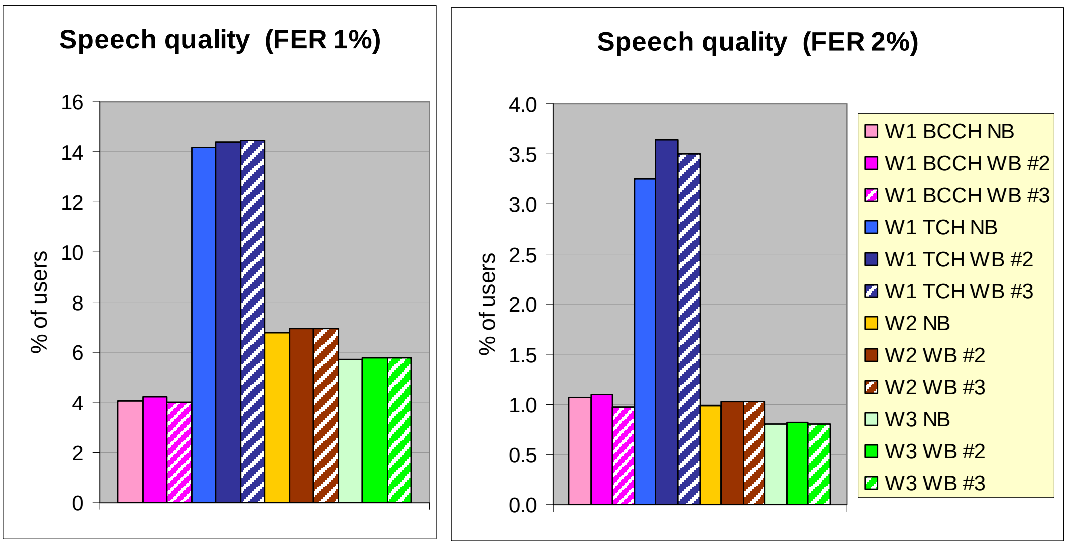


Figure 9.6: Percentage of BQCs at maximum PS loads

9.2.2.3 Impact on data throughput

Three percentiles were evaluated for the connection throughput:

10 % - the 10 % of connections having the lowest throughput (~cell edge)

50 % - the throughput median (~cell median)

90 % - 10 % of connections having the highest throughput (~cell centre)

At equal PS load, the median throughput is about 35 kbit/s/TS for the reference pulse. With the candidate pulse #2, the gain was about 40 % and with the candidate pulse #3, the gain was about 35 %.

A constant gain can be seen for all of the users.

When the data throughput is evaluated at maximum PS loads, the median throughput gain is lower at about 20 % for both pulse shapes. However, there is a data capacity gain for both pulse shapes of about 20 %.

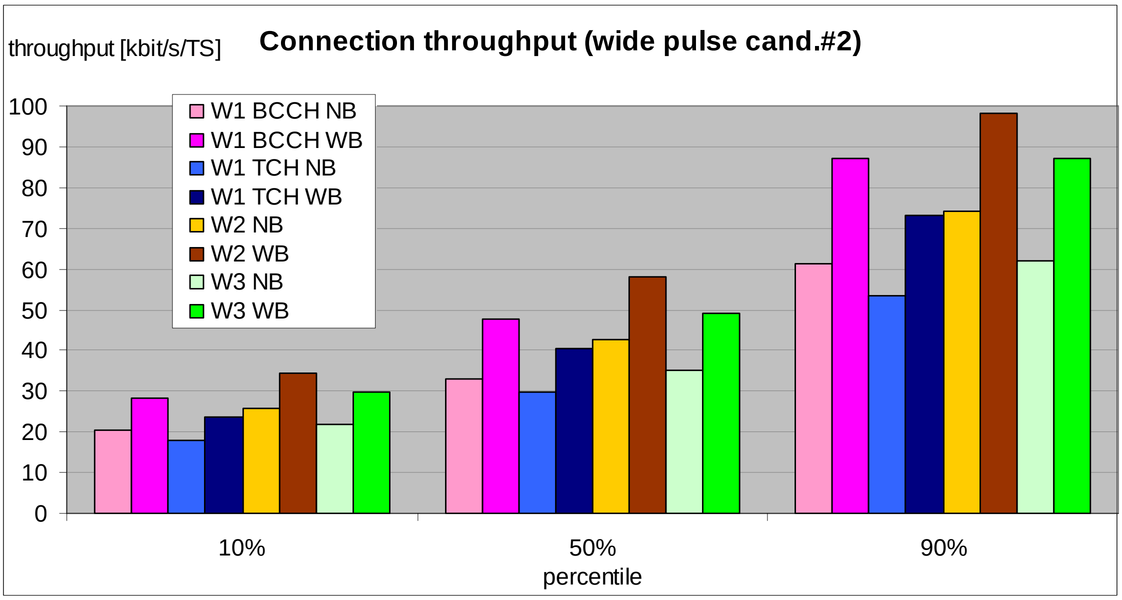


Figure 9.7: Connection throughput at equal load (WB = candidate pulse #2)

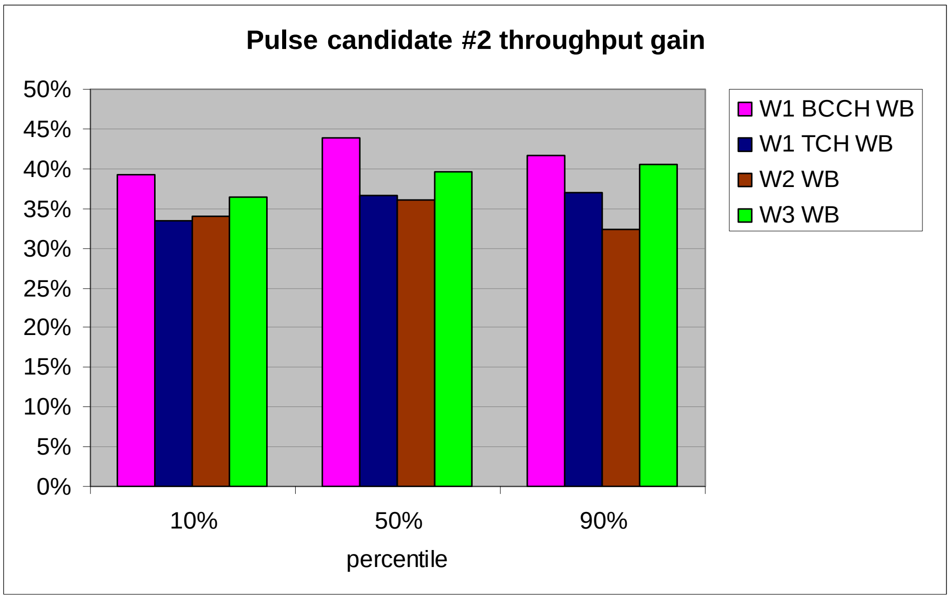


Figure 9.8: Throughput gain at equal load of the wide pulse (WB = candidate pulse #2)

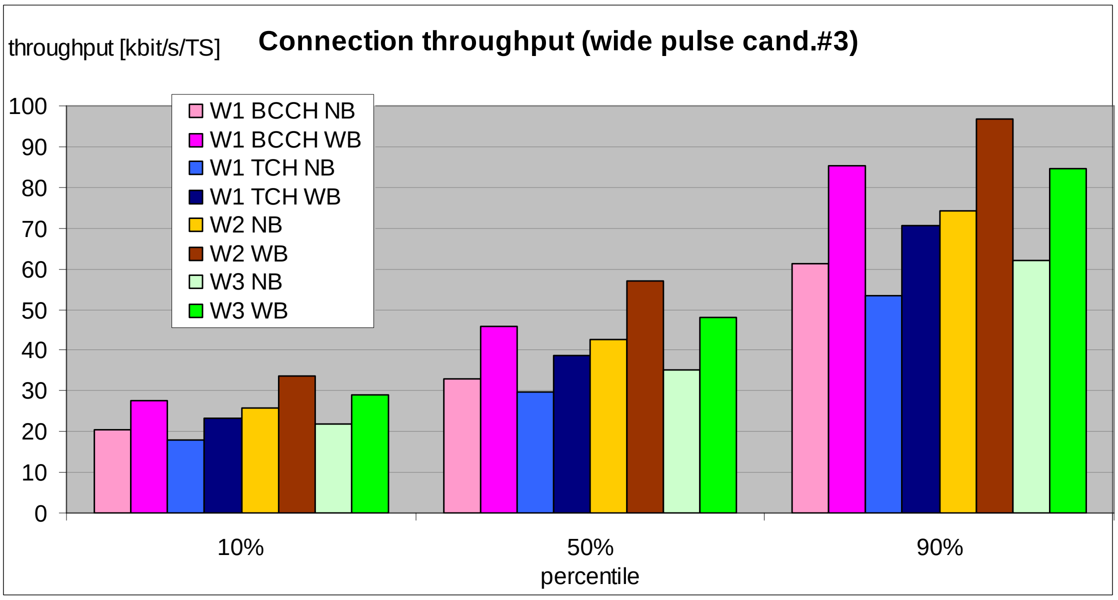


Figure 9.9: Connection throughput at equal load (WB = candidate pulse #3)

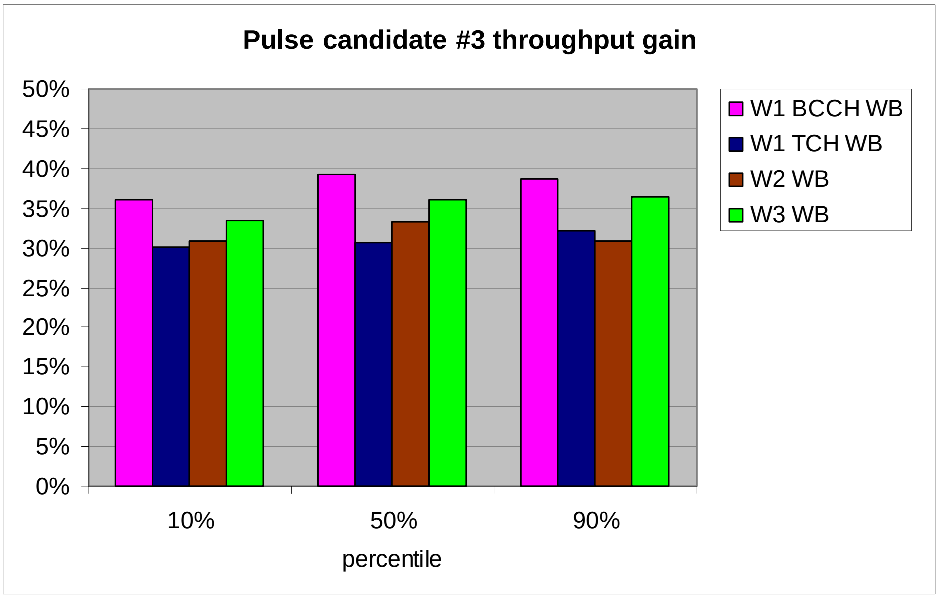


Figure 9.10: Throughput gain at equal load of the wide pulse (WB = candidate pulse #3)

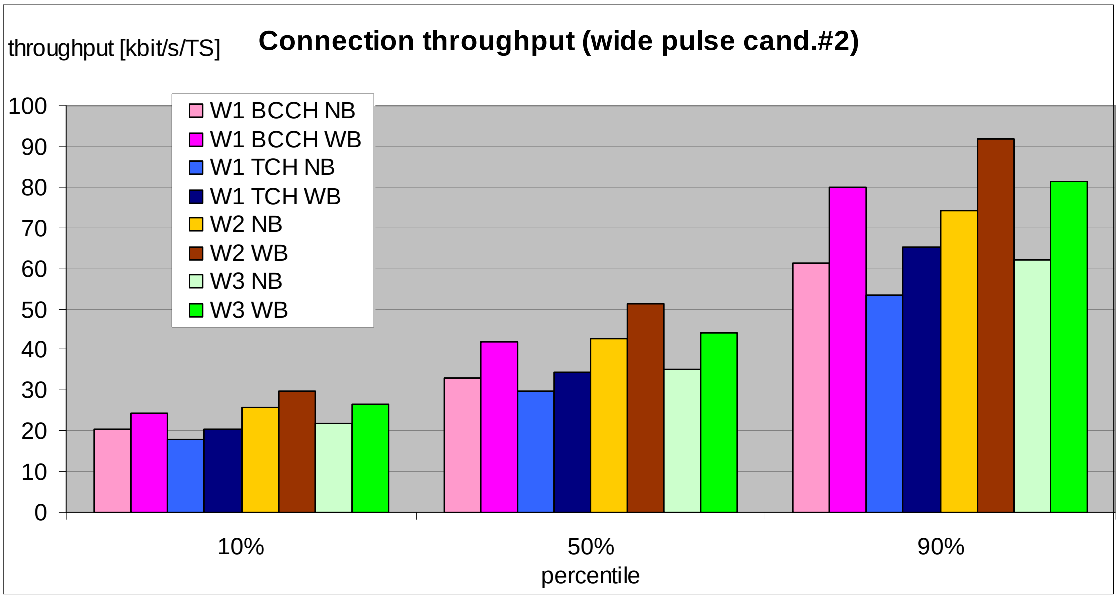


Figure 9.11: Connection throughput at maximum loads (WB = candidate pulse #2)

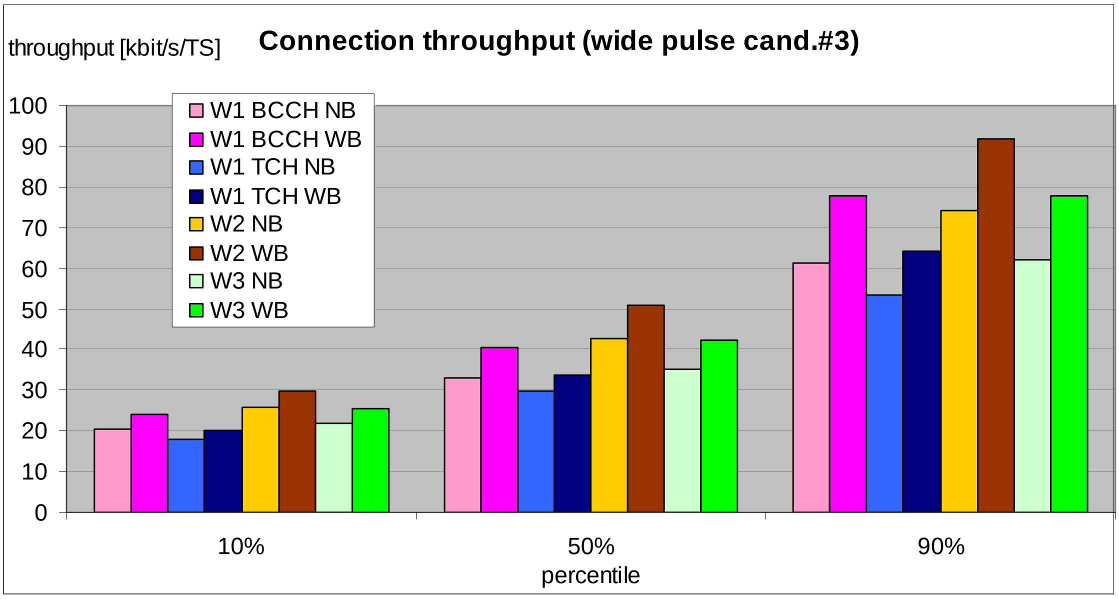


Figure 9.12: Connection throughput at equal load (WB = candidate pulse #3)

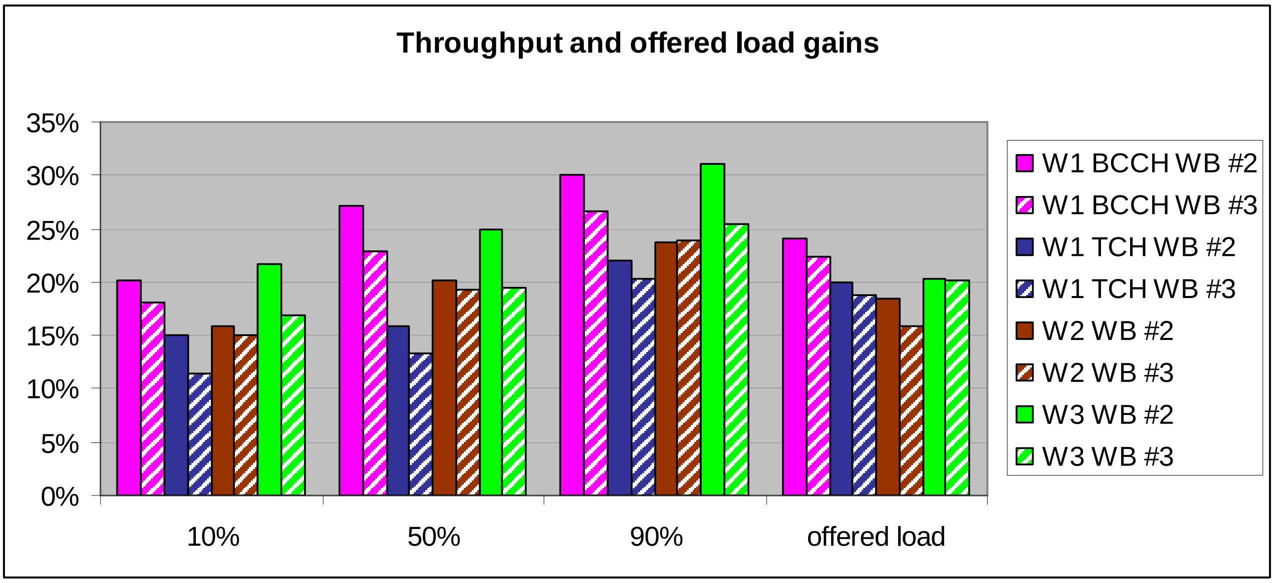


Figure 9.13: Summary of the throughput gains at maximum loads and also the gain in PS load for the wide pulse shapes

10 Summary

The study considered a number of evaluation scenarios including different network scenarios (WIDER-1, WIDER-2 and WIDER-3) and different deployment strategies e.g. EGPRS2-B timeslot allocations on non-hopping BCCH frequencies, hopping TCH frequencies and on hopping over both BCCH and TCH frequencies (see 6.2 for details).

In general, the assumptions taken were worse case:

- Penetration of the EGPRS2-B service was set to 100 % (i.e. all the PS resources were dedicated to EGPRS2-B);
- PS traffic load was set to saturation (corresponding to maximum timeslot utilization);

- CS traffic load was set to give 2 % blocking in all the scenarios.

Two pulse shapes with different spectral properties were evaluated (denoted as Candidate #2 and Candidate #3). They exhibited lower inter-symbol interference than the LGMSK pulse shape and lower adjacent-channel protection (see clause 7.2.2.2 for details). Their link level performance (as well as the reference pulse's) was disclosed corresponding to the TU3 propagation channel for the 900MHz band when assuming ideal frequency hopping (see clauses 8.2.2 and 8.2.3).The throughput performance of EGPRS2-B users was evaluated for each pulse shape. The findings can be found in clause 9.2.2.3 and are summarized in Table 10.1 (for the scenario where the reference load was set to saturation and the network load when evaluating the wide pulse shapes was set to the reference load) and in Table 10.2 (for the scenario where the reference load and the network load when evaluating the wide pulse shapes was set to saturation).

Table 10.1: Median throughput gains (network load = reference load)

Network load = reference load Network configuration	**Median throughput gains**	
	Candidate #2	**Candidate #3**
WIDER-1 (BCCH layer)	44 %	39 %
WIDER-1 (TCH layer)	37 %	31 %
WIDER-2	36 %	33 %
WIDER-3	40 %	36 %

Table 10.2: Median throughput and capacity gains (network load = saturated)

Network load = saturated Network configuration	**Candidate #2**		**Candidate #3**	
	Median throughput gain	**Data capacity gain**	**Median throughput gain**	**Data capacity gain**
WIDER-1 (BCCH layer)	27 %	24 %	23 %	22 %
WIDER-1 (TCH layer)	16 %	20 %	13 %	19 %
WIDER-2	20 %	18 %	19 %	16 %
WIDER-3	25 %	20 %	19 %	20 %

In the figures in Table 10.2, data capacity is defined by the call arrival rate that can be supported before the network becomes saturated (i.e. when the call arrival rate equaled the call ending rate) and data capacity gain is the percentage difference in data capacity between the wide bandwidth pulse and the LGMSK pulse. Throughput gain is the percentage difference in the median throughput of the data calls between the wide bandwidth pulse and the LGMSK pulse measured before the network becomes saturated (i.e. when the call arrival rate equaled the call ending rate). The findings demonstrate that a throughput gain of 13 – 27 % and a data capacity gain of 16 – 24 % (depending on the network scenario and pulse shape) can be achieved when a wide bandwidth pulse shape is utilized. This is a result of the improved receiver performance as a result of the lower inter-symbol interference.

The study also evaluated the impact of the lower adjacent-channel protection on the speech quality of legacy users. The findings can be found in clause 9.2.2.2 and are summarized in Table 10.3 and Table 10.4.

Table 10.3: Change in Bad Quality Calls for legacy users (network load = reference load)

Network load = reference load Network configuration	**Change in BQCs (FER > 2 %)**	
	Candidate #2	**Candidate #3**
WIDER-1 (BCCH layer)	**0**	**0**
WIDER-1 (TCH layer)	**+0.1 %**	**0**
WIDER-2	**0**	**0**
WIDER-3	**0**	**0**

Table 10.4.:Change in Bad Quality Calls for legacy users (network load = saturated).=

Network load = saturated Network configuration	**Change in BQCs (FER > 2 %)**	
	Candidate #2	**Candidate #3**
WIDER-1 (BCCH layer)	0	-0.1 %
WIDER-1 (TCH layer)	+0.3 %	+0.4 %
WIDER-2	0	0
WIDER-3	0	0

The findings demonstrate that the lower adjacent-channel protection did not degrade the speech performance of a legacy mobile, or resulted in a degradation considered acceptable, even though the network saturation level was reached. This is because there were fewer PS timeslots than CS timeslots in the evaluated scenarios. The speech performance in Table 10.3 had the added benefit of lower timeslot occupancy of the wide pulse shape as a result of the throughput gain.

11 Conclusion

Based on the findings of the WIDER study item which have been collated in this Technical Report, it is concluded that for the evaluated scenarios, a throughput gain of 13 – 27 % and a data capacity gain of 16 – 24 % (depending on the network scenario and pulse shape) can be achieved for EGPRS2-B users when a wide bandwidth pulse shape is utilized without degrading the speech performance of a legacy mobile, or resulted in a degradation considered acceptable, even though the network saturation level was reached. While the evaluated scenarios were believed to represent the most relevant for the EGPRS2-B service, they should not be considered as representing all network scenarios. Hence it is recommended that the mandatory Tx pulse shall be the linearised GMSK pulse and the use of the wide bandwidth pulse shall be optional to an operator.

Further investigations into the performance of a wide bandwidth pulse shape and its impact to legacy users may be taken into account into future versions of this Technical Report.

Annex A: Candidate pulse shape coefficients

A.1: Candidate pulse shapes from [4]

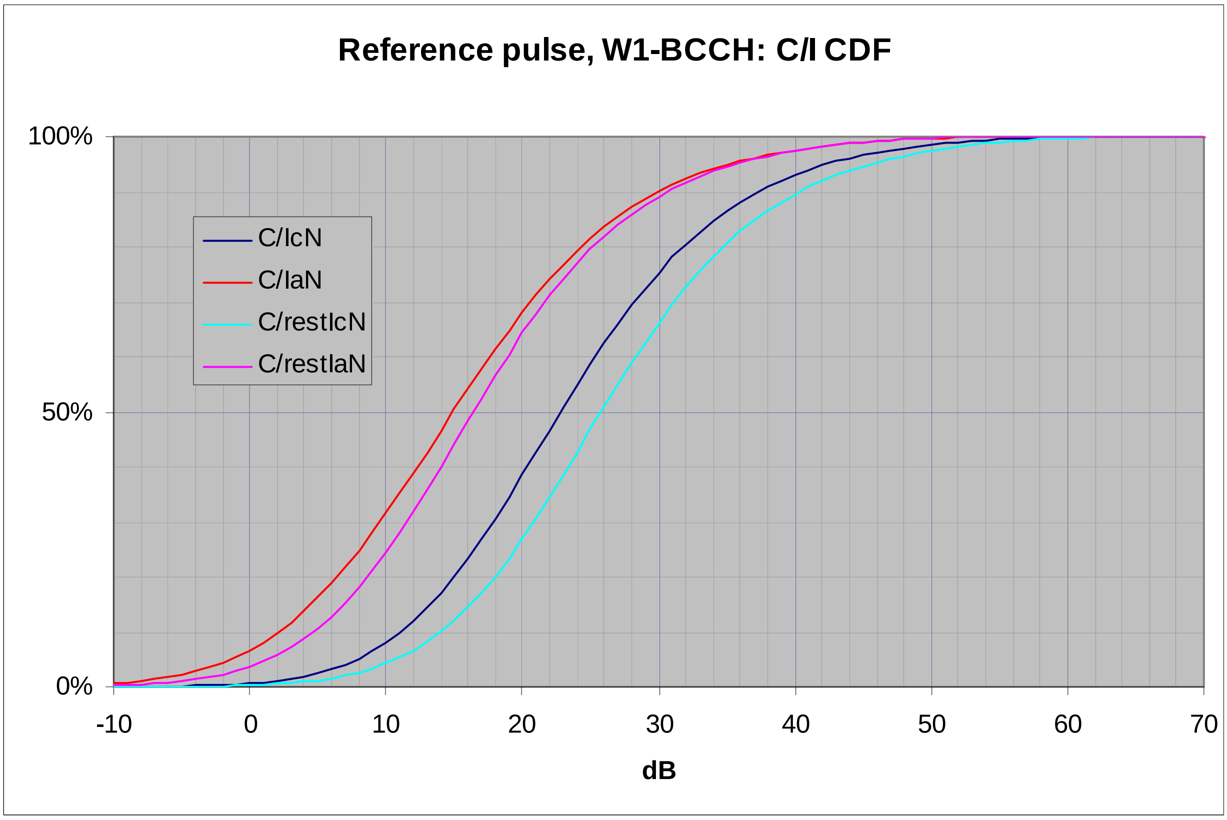
Each pulse shape is 59 taps long sampled at 3.25Msamples/s (oversampling factor of 10).

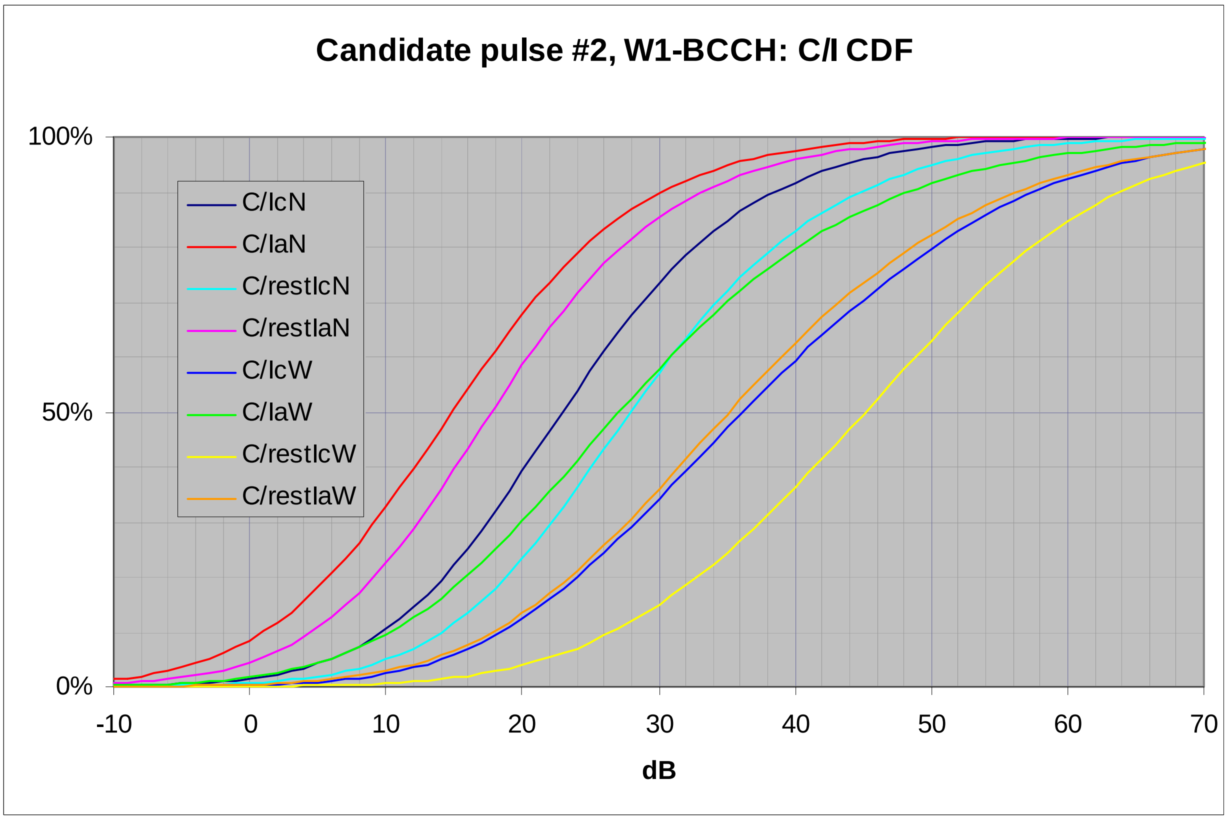
Candidate #1	Candidate #2	Candidate #3
1.0846177e-003	2.6977180e-005	1.0968144e-003
2.2139509e-003	4.0426372e-004	2.0180204e-003
3.8923368e-003	1.0268149e-003	3.2510978e-003
6.1616664e-003	1.9311868e-003	4.7521387e-003
8.9338494e-003	3.1123964e-003	6.3853412e-003
1.1973940e-002	4.4869017e-003	7.9401519e-003
1.4941378e-002	5.8817692e-003	9.1836646e-003
1.7421315e-002	7.0465266e-003	9.8942347e-003
1.8985251e-002	7.6981057e-003	9.9030879e-003
1.9266989e-002	7.5857250e-003	9.1385544e-003
1.8050315e-002	6.5670222e-003	7.6719795e-003
1.5352852e-002	4.6845205e-003	5.7529665e-003
1.1490058e-002	2.2284937e-003	3.8247766e-003
7.1100892e-003	-2.2824295e-004	2.5207068e-003
3.1916999e-003	-1.8344948e-003	2.6431724e-003
9.9327413e-004	-1.5092070e-003	5.1161133e-003
1.9409757e-003	1.9571783e-003	1.0906589e-002
7.4539299e-003	9.7659302e-003	2.0908125e-002
1.8748255e-002	2.2939497e-002	3.5808647e-002
3.6636990e-002	4.2141972e-002	5.5962780e-002
6.1360473e-002	6.7520344e-002	8.1289361e-002
9.2470697e-002	9.8595522e-002	1.1120693e-001
1.2878719e-001	1.3422400e-001	1.4461647e-001
1.6843702e-001	1.7263977e-001	1.7993990e-001
2.0898281e-001	2.1157546e-001	2.1521837e-001
2.4760556e-001	2.4843482e-001	2.4824688e-001
2.8140739e-001	2.8055862e-001	2.7679448e-001
3.0774152e-001	3.0551549e-001	2.9884307e-001
3.2447135e-001	3.2134315e-001	3.1277366e-001
3.3020839e-001	3.2676635e-001	3.1753808e-001

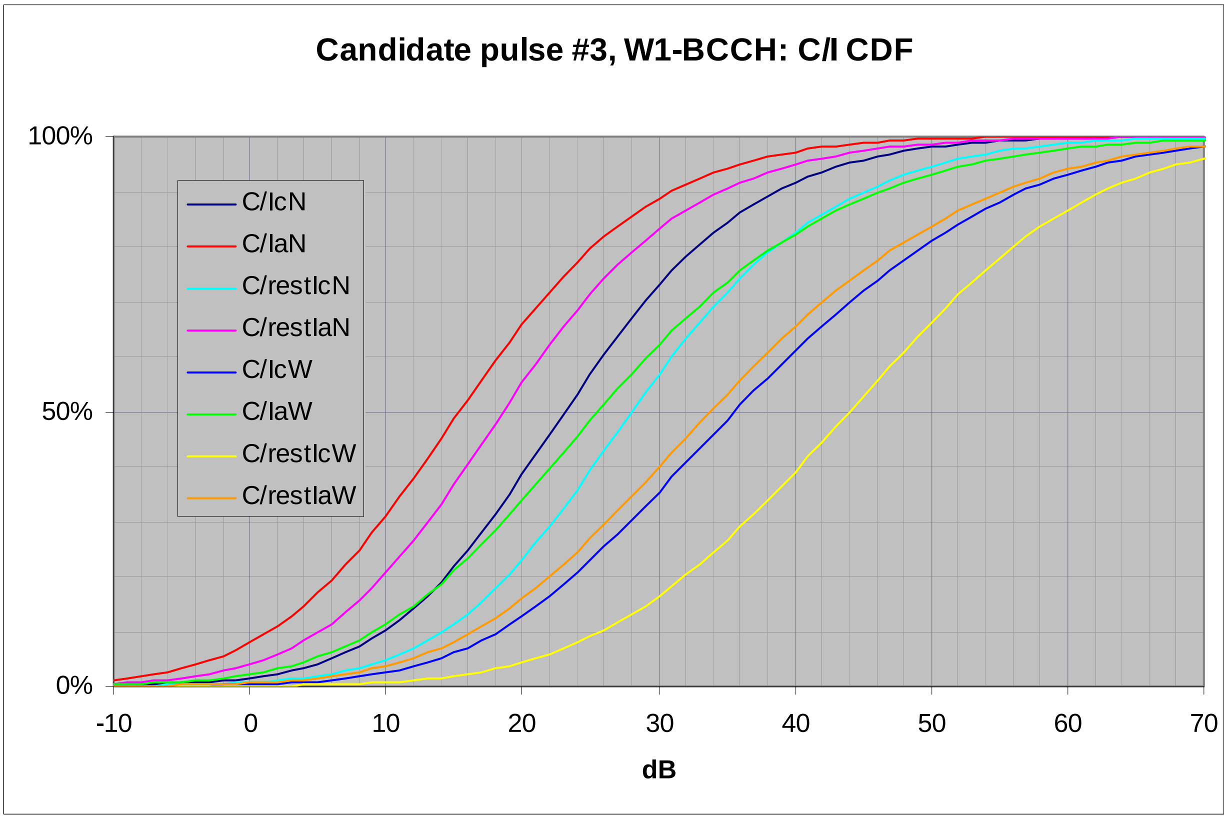
Candidate #1	Candidate #2	Candidate #3
3.2447135e-001	3.2134315e-001	3.1277366e-001
3.0774152e-001	3.0551549e-001	2.9884307e-001
2.8140739e-001	2.8055862e-001	2.7679448e-001
2.4760556e-001	2.4843482e-001	2.4824688e-001
2.0898281e-001	2.1157546e-001	2.1521837e-001
1.6843702e-001	1.7263977e-001	1.7993990e-001
1.2878719e-001	1.3422400e-001	1.4461647e-001
9.2470697e-002	9.8595522e-002	1.1120693e-001
6.1360473e-002	6.7520344e-002	8.1289361e-002
3.6636990e-002	4.2141972e-002	5.5962780e-002
1.8748255e-002	2.2939497e-002	3.5808647e-002
7.4539299e-003	9.7659302e-003	2.0908125e-002
1.9409757e-003	1.9571783e-003	1.0906589e-002
9.9327413e-004	-1.5092070e-003	5.1161133e-003
3.1916999e-003	-1.8344948e-003	2.6431724e-003
7.1100892e-003	-2.2824295e-004	2.5207068e-003
1.1490058e-002	2.2284937e-003	3.8247766e-003
1.5352852e-002	4.6845205e-003	5.7529665e-003
1.8050315e-002	6.5670222e-003	7.6719795e-003
1.9266989e-002	7.5857250e-003	9.1385544e-003
1.8985251e-002	7.6981057e-003	9.9030879e-003
1.7421315e-002	7.0465266e-003	9.8942347e-003
1.4941378e-002	5.8817692e-003	9.1836646e-003
1.1973940e-002	4.4869017e-003	7.9401519e-003
8.9338494e-003	3.1123964e-003	6.3853412e-003
6.1616664e-003	1.9311868e-003	4.7521387e-003
3.8923368e-003	1.0268149e-003	3.2510978e-003
2.2139509e-003	4.0426372e-004	2.0180204e-003
1.0846177e-003	2.6977180e-005	1.0968144e-003

Annex B: Network statistics

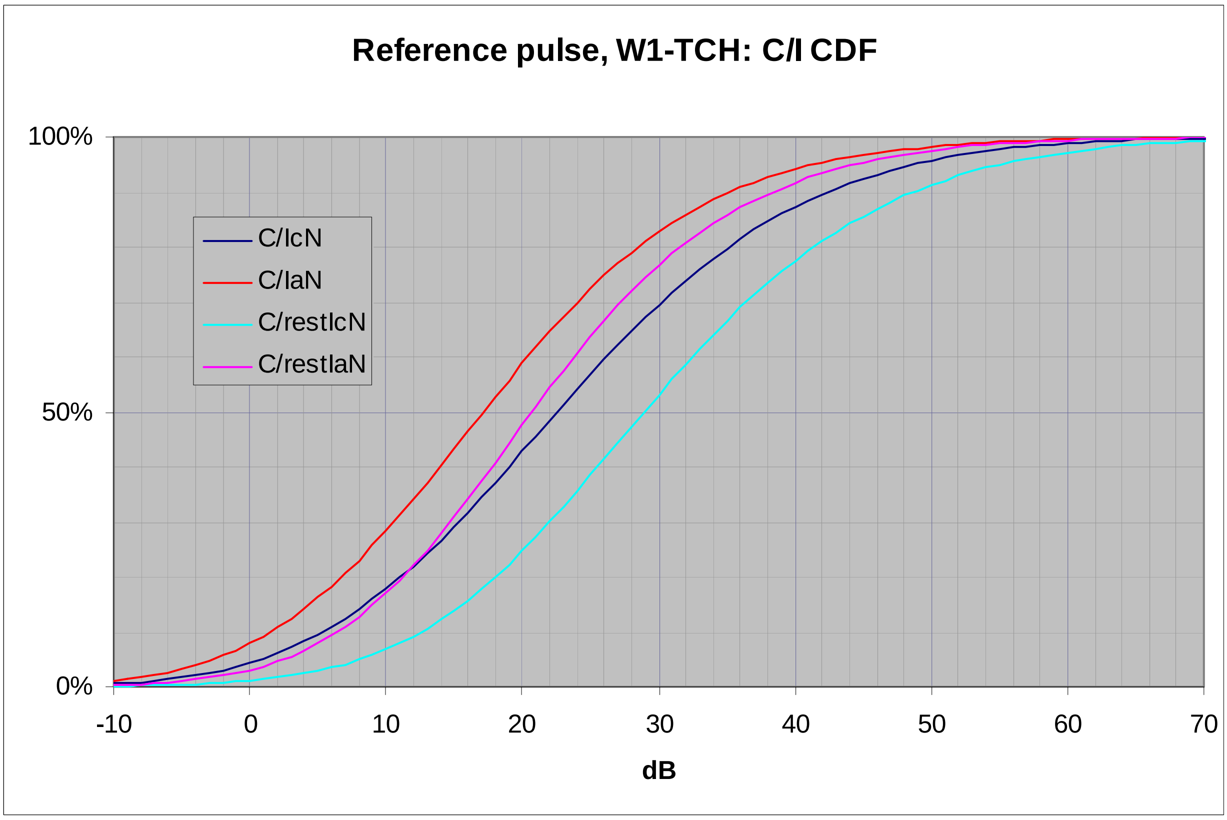
B.1 CDFs for Scenario A

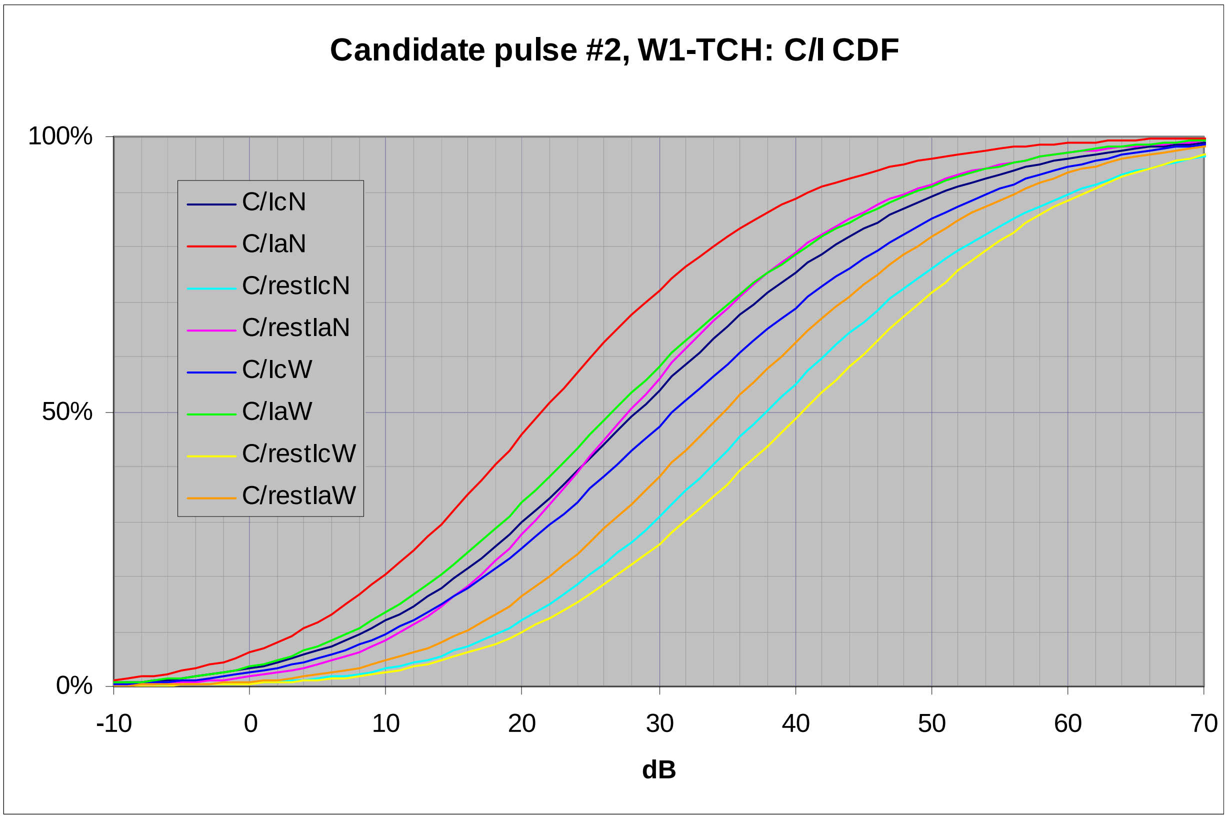


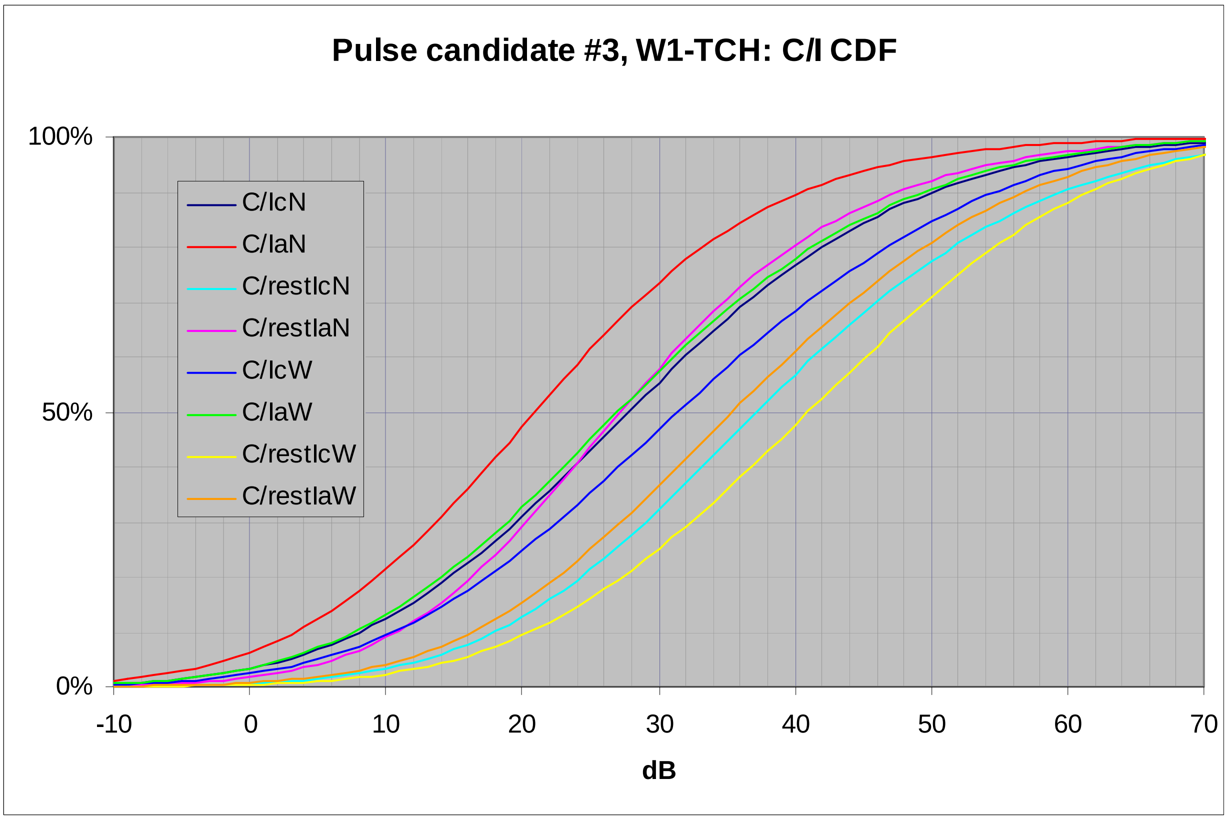




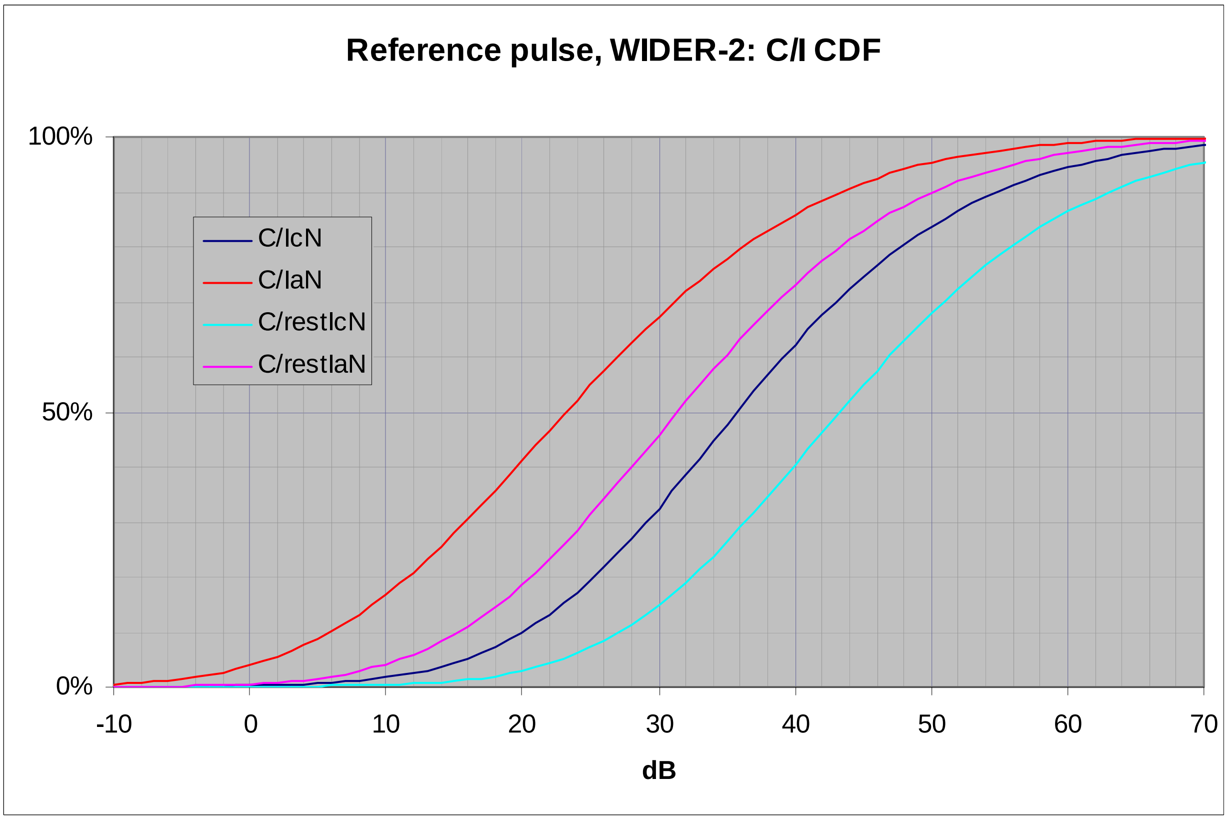
B.2 CDFs for Scenario B

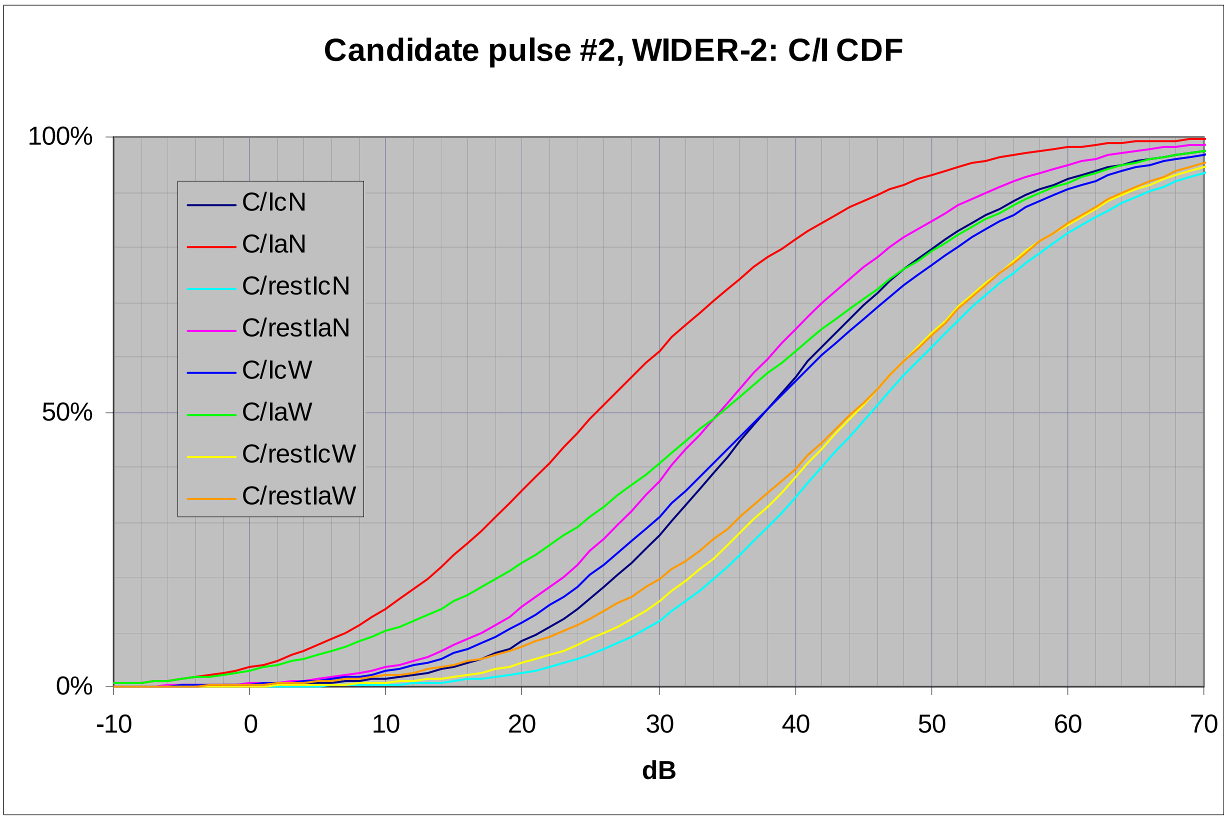

Reference pulse, W1-TCH: C/I CDF
100%
50%
0%
C/IcN
C/IaN
C/restIcN
C/restIaN
-10
0
10
20
30
40
50
60
70
dB

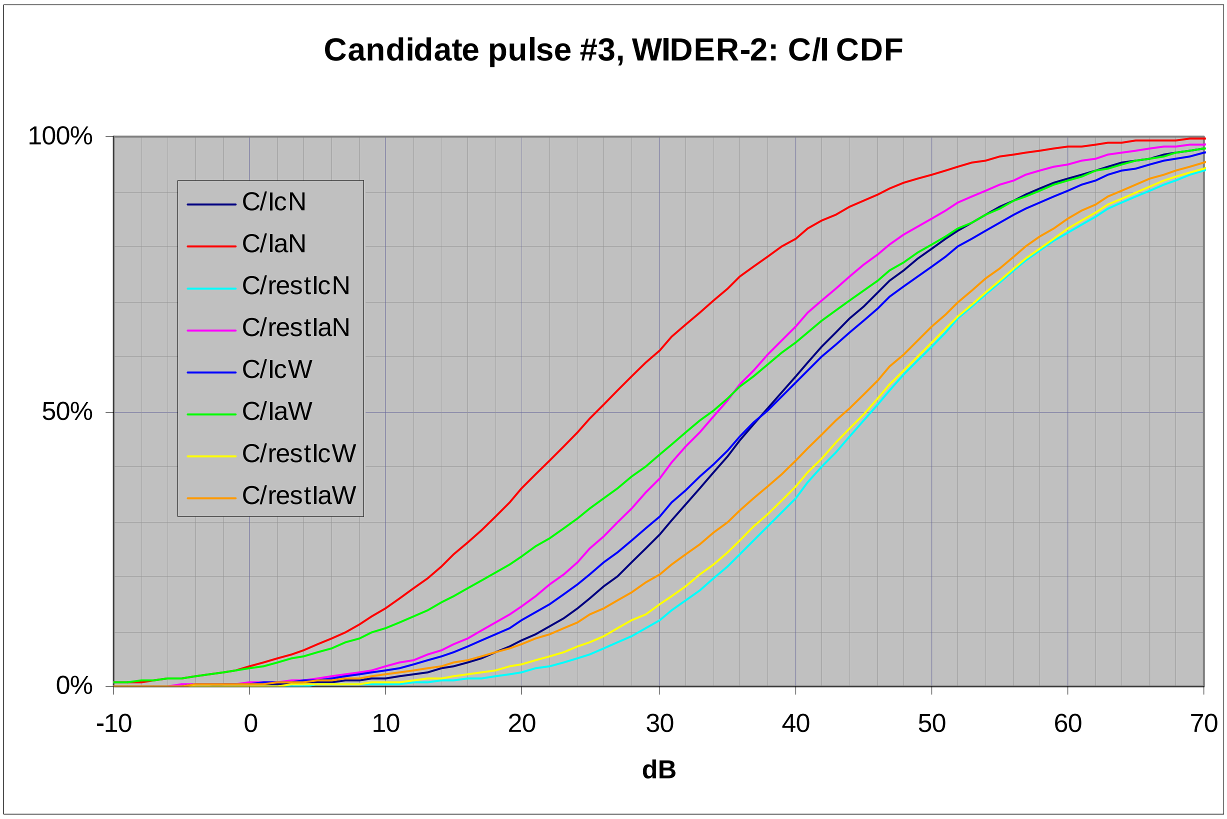

Candidate pulse #2, W1-TCH: C/I CDF
100%
50%
0%
C/IcN
C/IaN
C/restIcN
C/restIaN
C/IcW
C/IaW
C/restIcW
C/restIaW
-10
0
10
20
30
40
50
60
70
dB



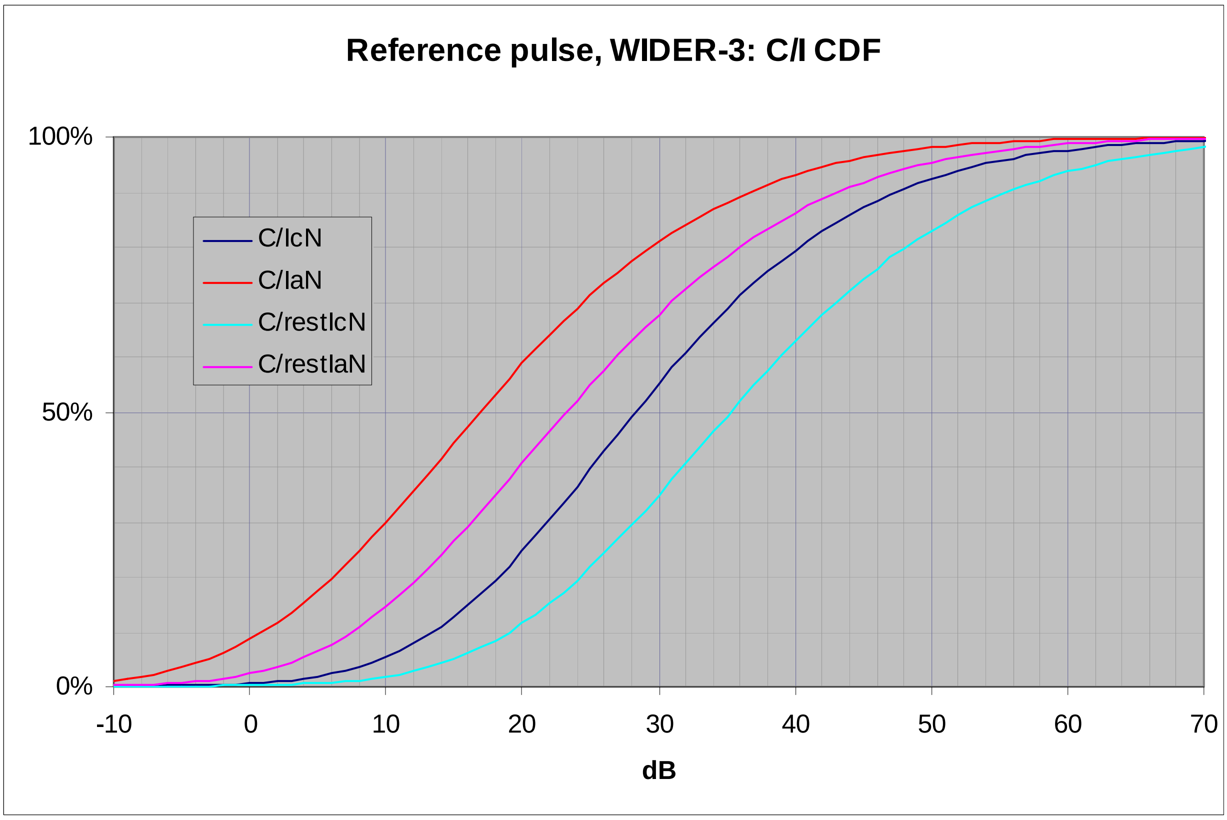
B.3 CDFs for Scenario C

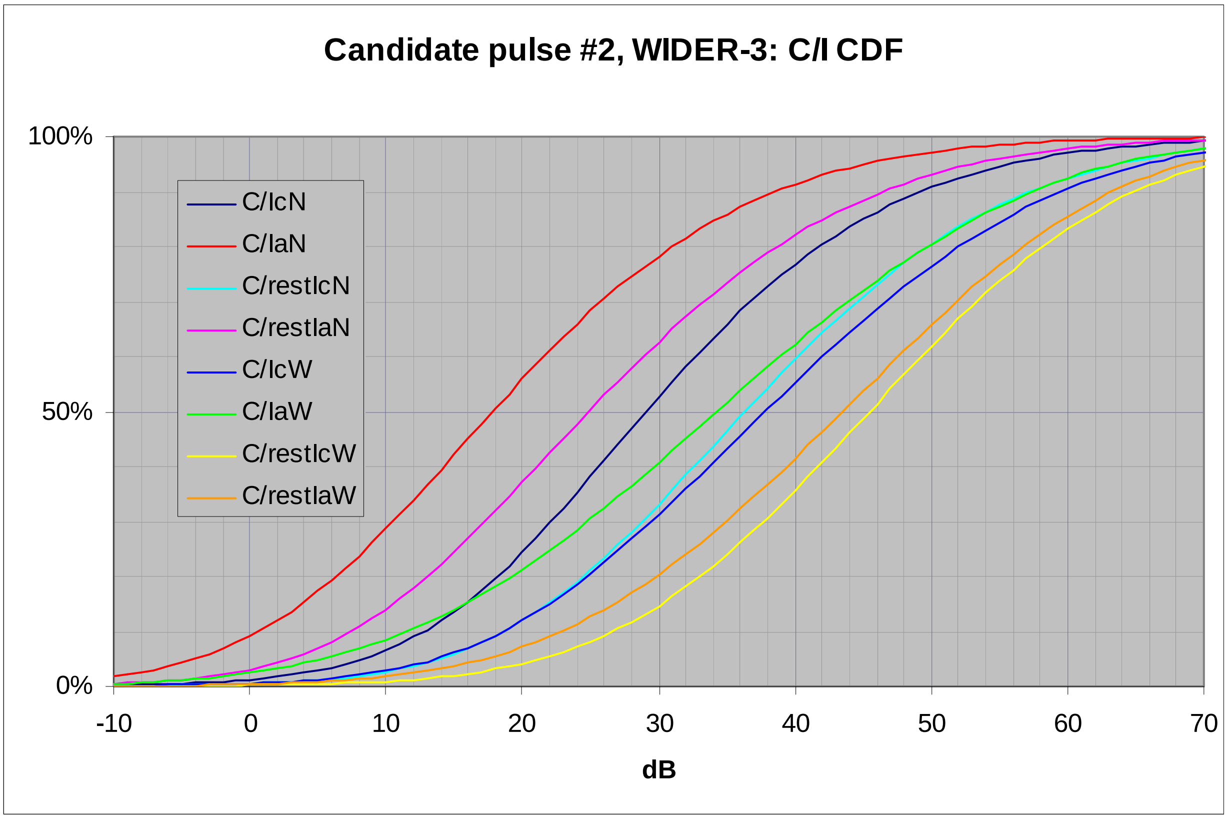


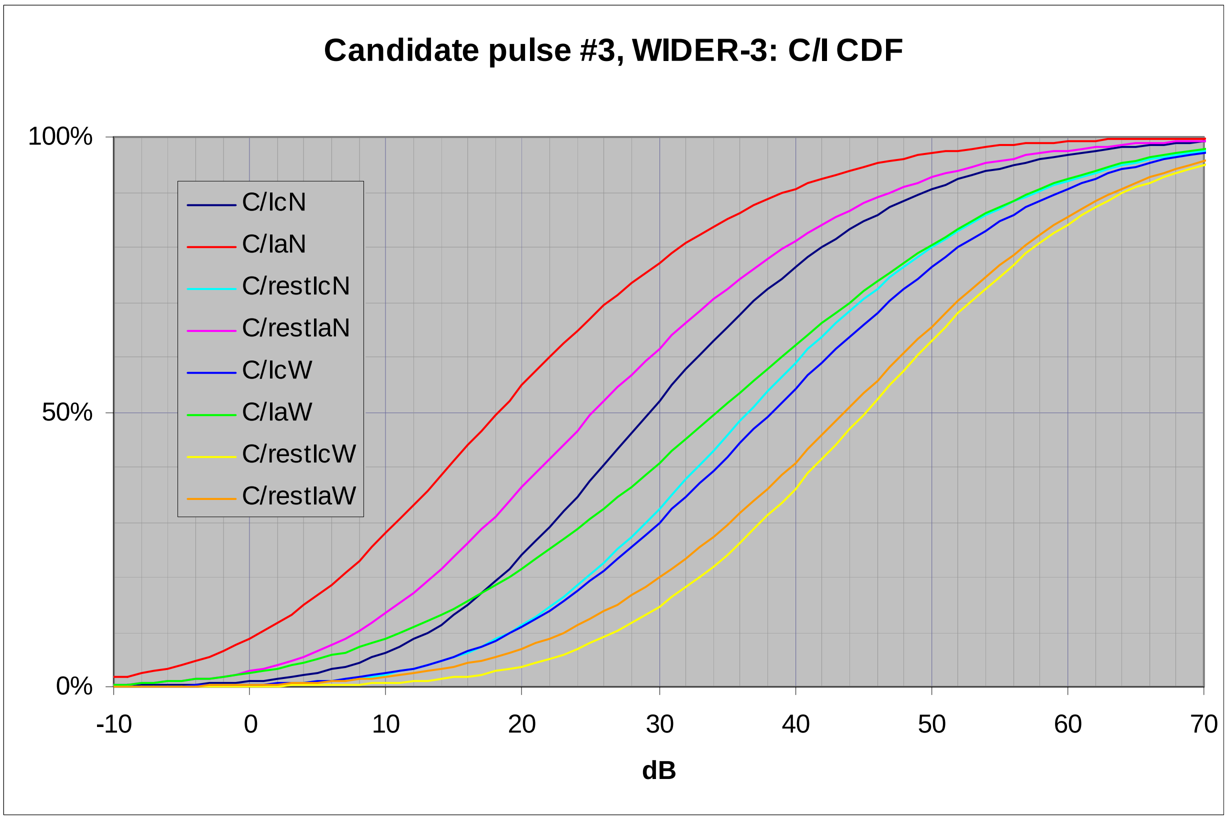




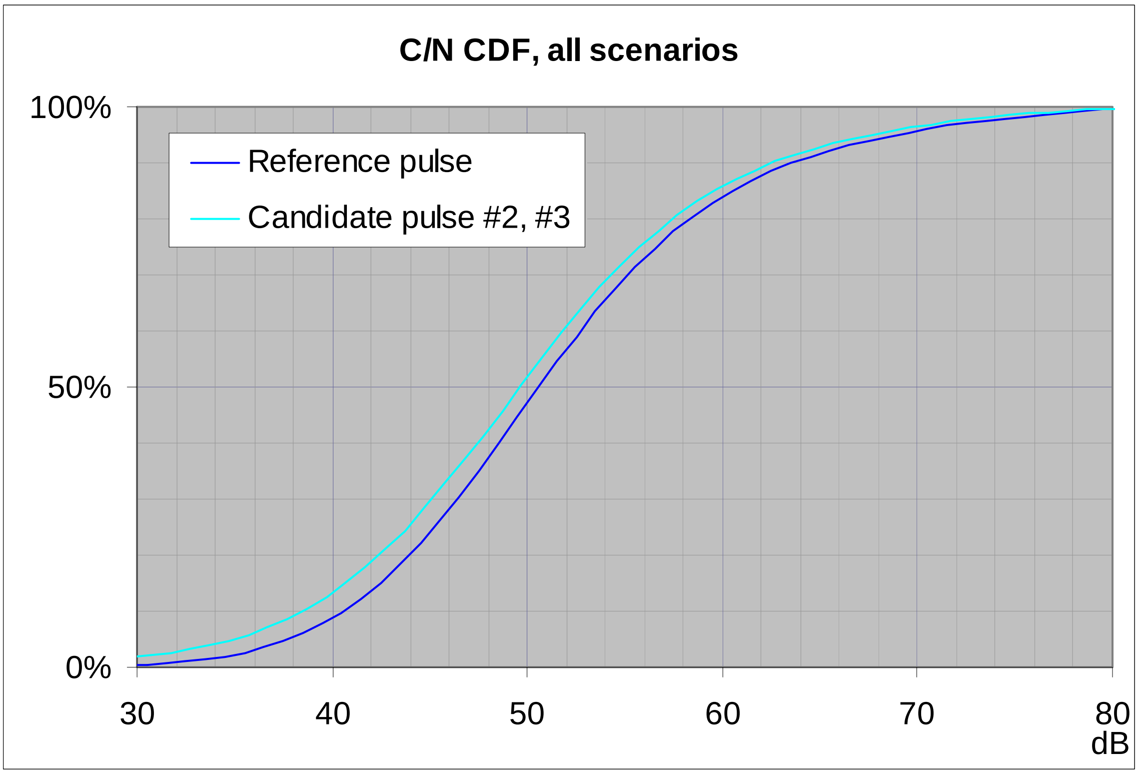
B.4 CDFs for Scenario D


Reference pulse, WIDER-3: C/I CDF
100%
50%
0%
-10
0
10
20
30
40
50
60
70
dB
C/IcN
C/IaN
C/restIcN
C/restIaN


Candidate pulse #2, WIDER-3: C/I CDF
100%
50%
0%
-10
0
10
20
30
40
50
60
70
dB
C/IcN
C/IaN
C/restIcN
C/restIaN
C/IcW
C/IaW
C/restIcW
C/restIaW



B.5 Noise CDFs for all scenarios



Annex C: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2010-09	47	GP-101611			Approved at TSG GERAN #47	-	8.0.0
2010-09					Version for Release 9	8.0.0	9.0.0
2011-03	49				Version for Release 10	9.0.0	10.0.0
2012-09	55				Version for Release 11	10.0.0	11.0.0
2014-09	63				Version for Release 12 (frozen at SP-65)	11.0.0	12.0.0
2015-12	68				Version for Release 13 (frozen at SP-70)	12.0.0	13.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2017-03	RP-75	-	-	-	-	Version for Release 14 (frozen at TSG-75)	14.0.0
2018-06	RP-80	-	-	-	-	Version for Release 15(frozen at TSG-80)	15.0.0
2020-07	RP-88e	-	-	-	-	Upgrade to Rel-16 version without technical change	16.0.0

History

Document history		
V16.0.0	September 2020	Publication