Component Specifications for a Re-Configurable Multi Mode Receiver

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For further information please refer to www.mumor.org.

Overview

- Design Process: From BER to SNR
- Overall RF-Performance
- Self blocking in the UMTS FDD mode
- Breakdown to Building Block Level
- Comparison: Specification – Measured Performance

Design Process

Technical Specifications

- UMTS FDD:

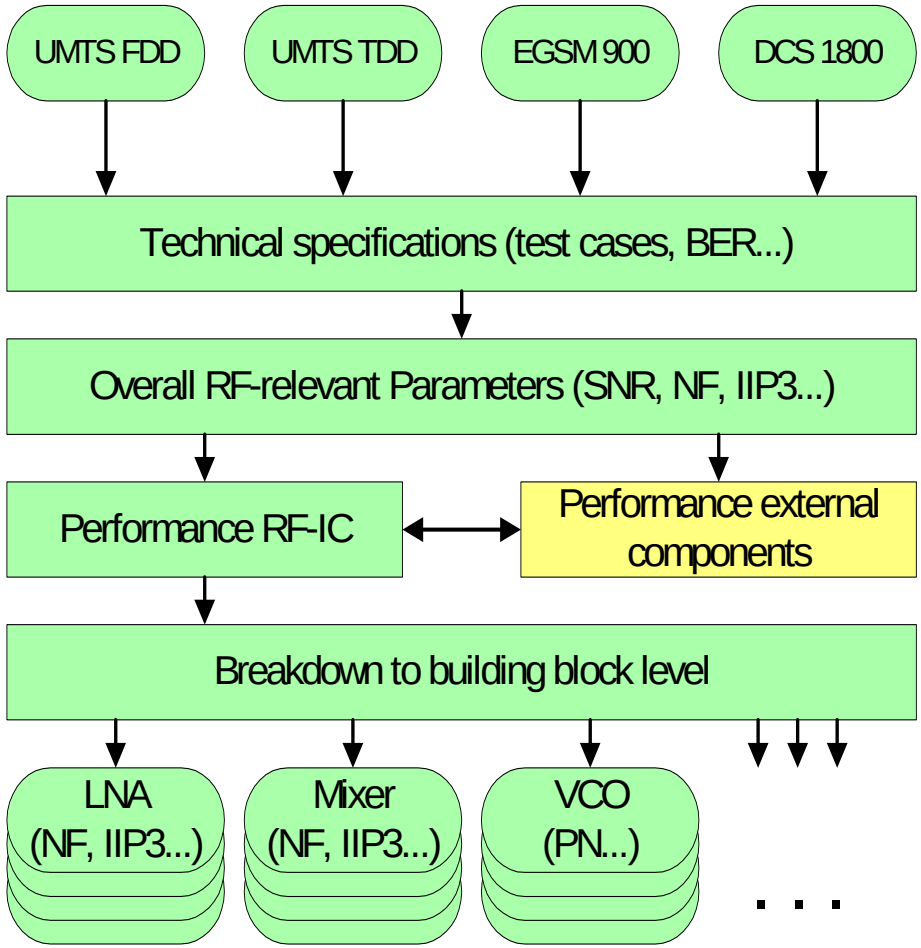
3GPP TS 25.101 v 5.2.0

- UMTS TDD:

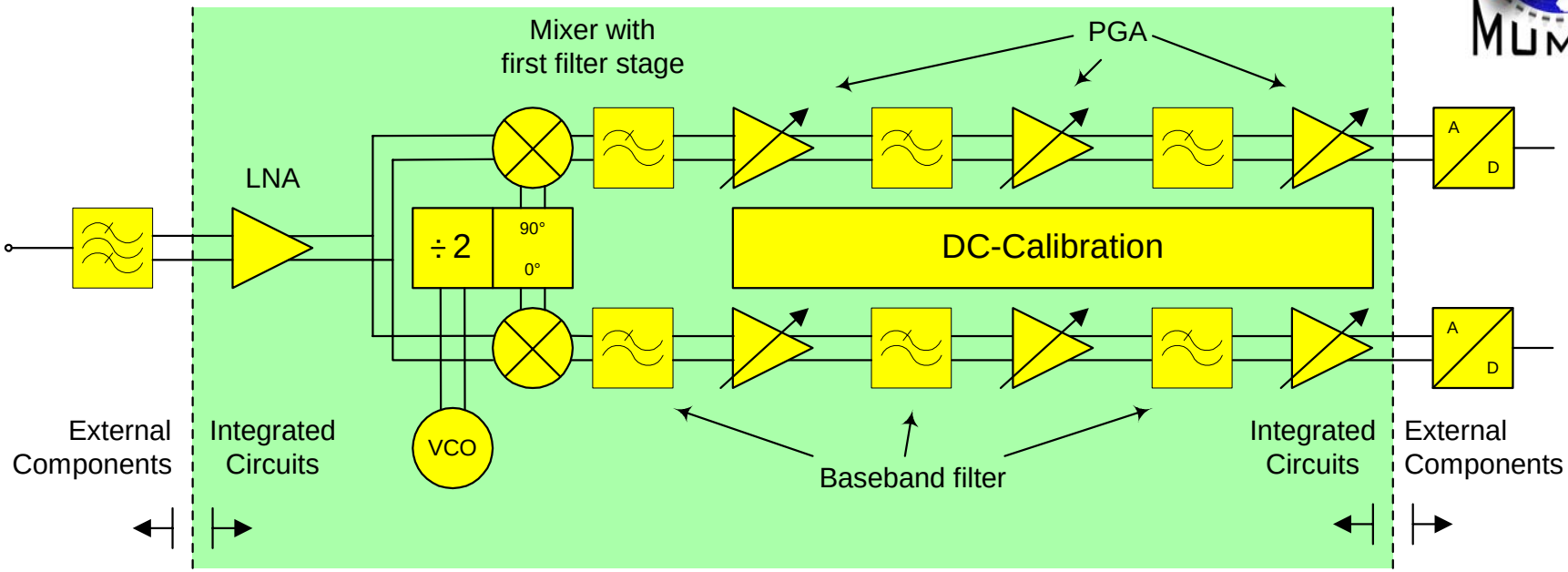
3GPP TS 25.102 v 5.0.1

- GSM, DCS:

ETSI GSM 05.05 v 8.4.0



Design Process



LNA: Noisefigure, IIP3, IIP2...
Mixer: Noisefigure, IIP3, IIP2...
...

From BER to SNR

- **Problem:**

  Test cases specified by Bit Error Rates that shall not be exceeded. BER < 0.001 contains no information about RF performance.

- **Solution:**

  Find relation between BER and SNR by baseband simulation or estimation from test cases described in the specifications.

From BER to SNR

UMTS FDD and TDD:

- For all test cases the BER shall not exceed 0.001
- All test cases use the same DL reference channel
- Test case maximum input level employs well defined signal- and interferer-level
- Signal and interferer definitely exceed all other noise sources
- Interferer can be regarded as noise

From BER to SNR

UMTS FDD:

Test case maximum input power

$$\frac{DPCH\_Ec}{I_{or}} = -19dB$$

Energy per chip in DPCH over total power spectral density

$$\hat{I}_{or} = -25\frac{dBm}{3.84MHz}$$

Total received power spectral density

$$\frac{S}{I} = \frac{\frac{DPCH\_Ec}{I_{or}}}{1-\frac{DPCH\_Ec}{I_{or}}} = \frac{10^{-\frac{19}{10}}}{1-10^{-\frac{19}{10}}} = 0.0127 \Leftrightarrow \text{SNR} = -18.9\ \text{dB}$$

From BER to SNR

EGSM 900 / DCS 1800:

Test case cochannel interference

C/Ic = 9 dB $\Rightarrow$ SNR = 9 dB

Mode	UMTS FDD	UMTS TDD	GSM DCS
SNR	-18.9 dB	-6 dB	9 dB

Overall RF-Performance

Mode	SNR	NF_{max}	$IIP2_{min}$	$IIP3_{min}$
UMTS FDD	-18.9 dB (spread spectrum)	9.6 dB	8 dBm	-21.3 dBm
UMTS TDD	-6 dB (spread spectrum)	9.2 dB	8 dBm	-20.9 dBm
EGSM 900	9 dB	10 dB	43 dBm	-18 dBm
DCS 1800	9 dB	10 dB	43 dBm	-18 dBm

Overall RF-Performance

Mode	P_{min}	P_{max}	$A_{V,min}$	$A_{V,max}$
UMTS FDD	-117 dBm	-25 dBm	22 dB	95 dB
UMTS TDD	-105 dBm	-25 dBm	10 dB	83 dB
EGSM 900	-102 dBm	-15 dBm	-7 dB	80 dB
DCS 1800	-102 dBm	-23 dBm	1 dB	80 dB

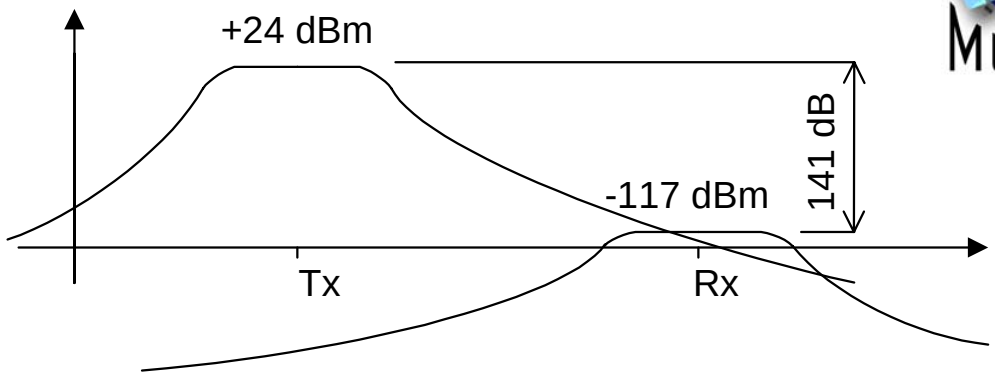
Problem:

Transmit signal:

+24 dBm at f_{TX}

Received signal:

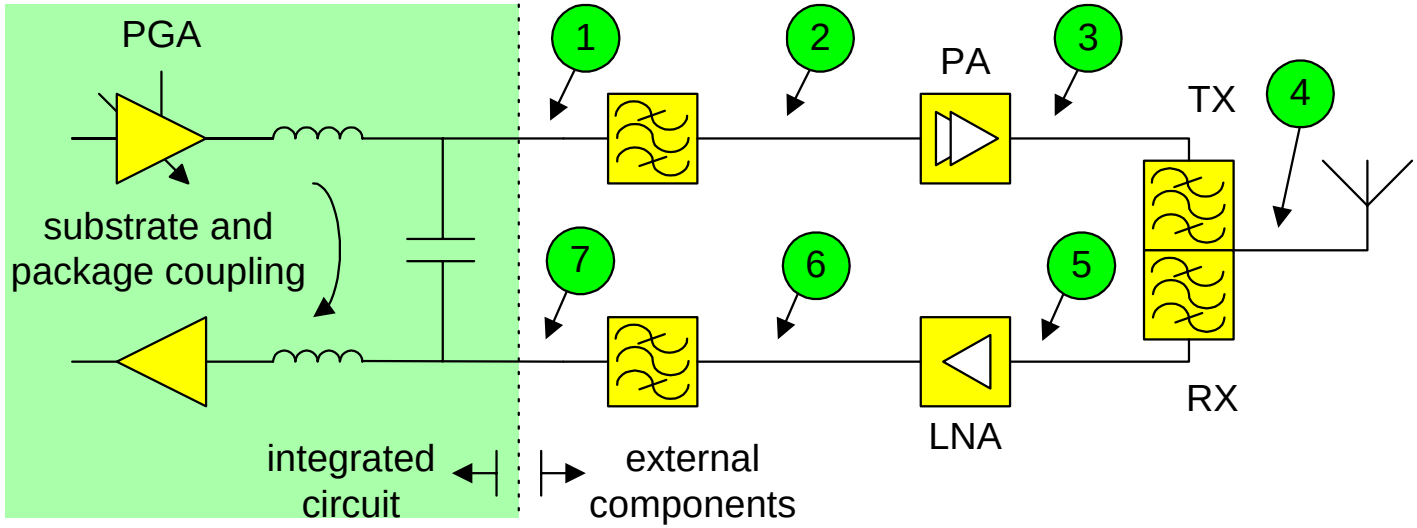
-117 dBm at f_{RX}



The TX-Signal itself is a blocking signal for the receiver

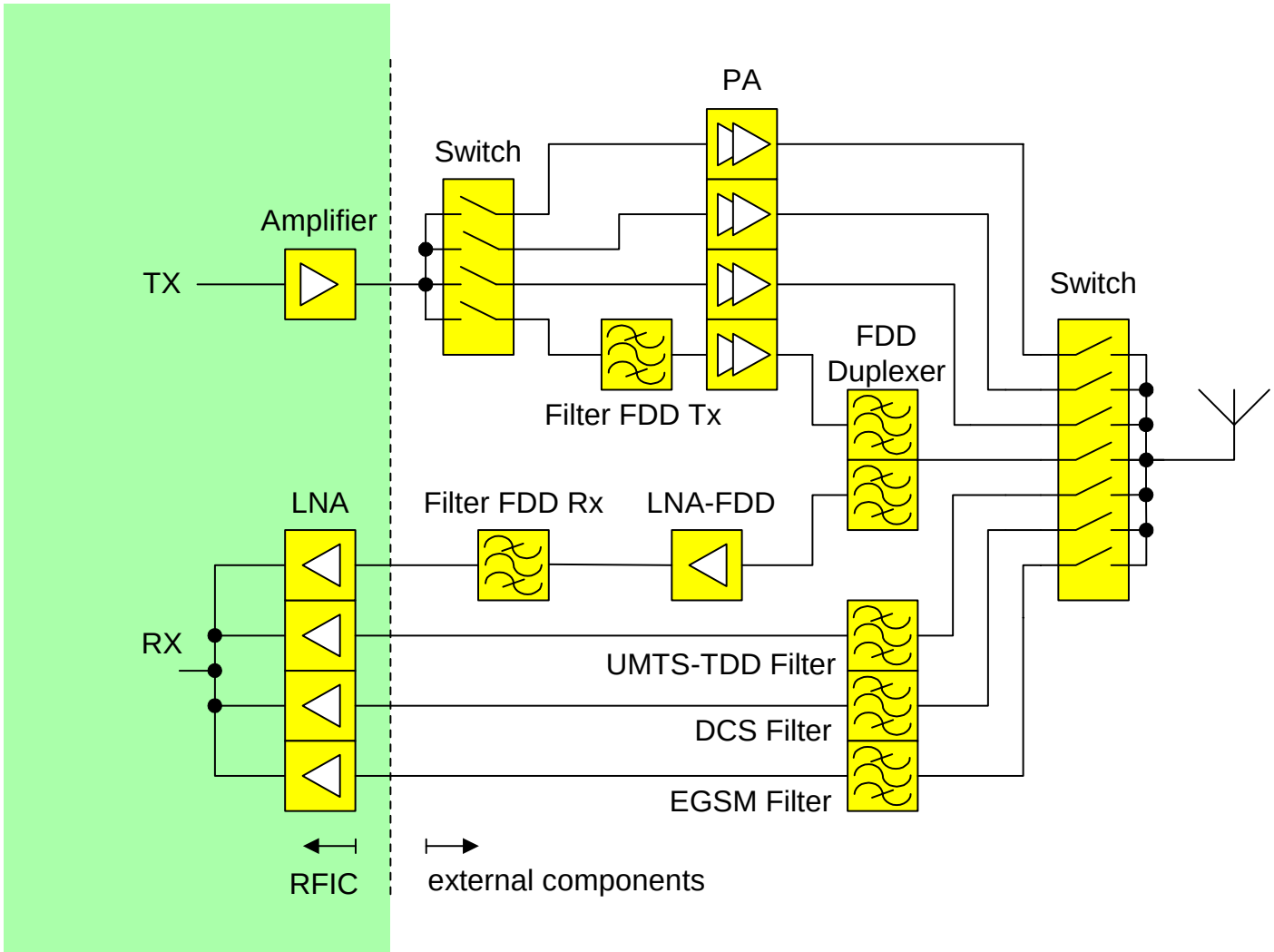
The noise sidebands of the signal shall be considerably below the thermal noise floor

UMTS FDD



	1. PGA out	2. Filter out	3. PA out	4. Antenna	5. LNA in	6. Filter in	7. Amp. in
Signal Rx				-117 dBm	-120 dBm	-105 dBm	-109 dBm
Signal Tx	+1 dBm	-2.5 dBm	25.5 dBm	24 dBm	-23 dBm	-8 dBm	-38 dBm
N_{TX} @ f_{RX}	-147 dBm/Hz	-174 dBm/Hz	-136 dBm/Hz	-174 dBm/Hz	-174 dBm/Hz	-157 dBm/Hz	-160.7 dBm/Hz

Re-configurable Front End



Blocking Performance

- **Out of band blocking**

  Blocking Performance Blockers outside the desired band can be attenuated by front end filters

- **In band blocking**

  Blockers inside the desired band can be attenuated by a channel filter at baseband frequency

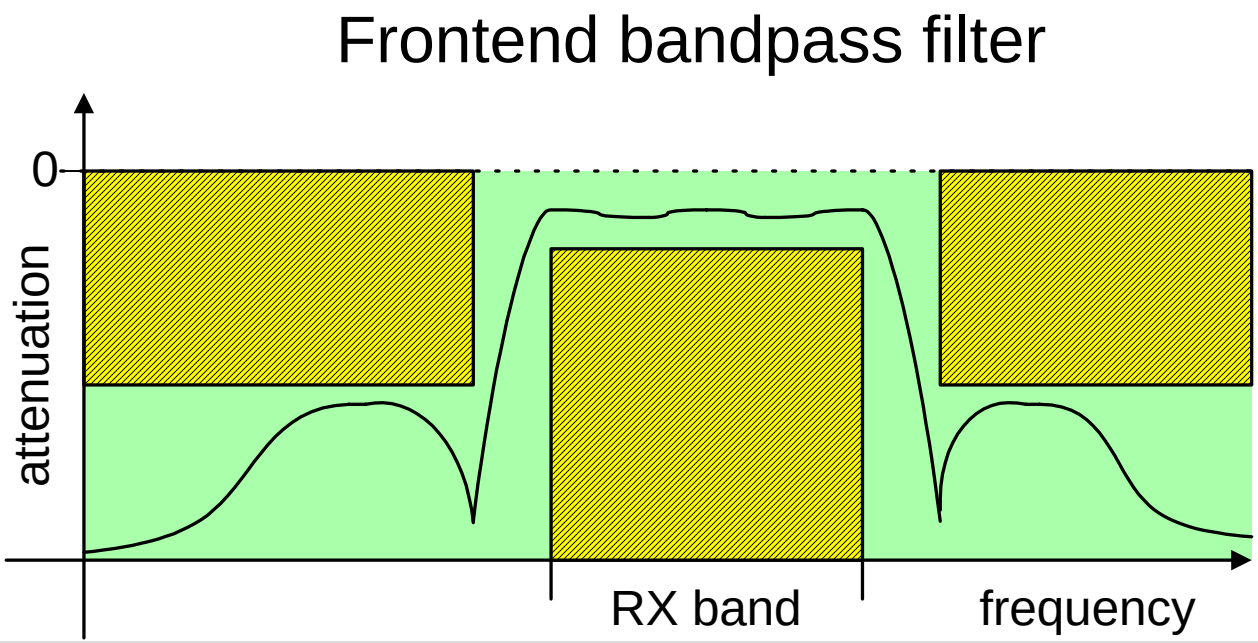
- **Adjacent channel selectivity (ACS)**

  Blockers in adjacent channels are too close for a considerable attenuation by the baseband filter

Blocking Performance

Out of band blockers specify the frontend filters

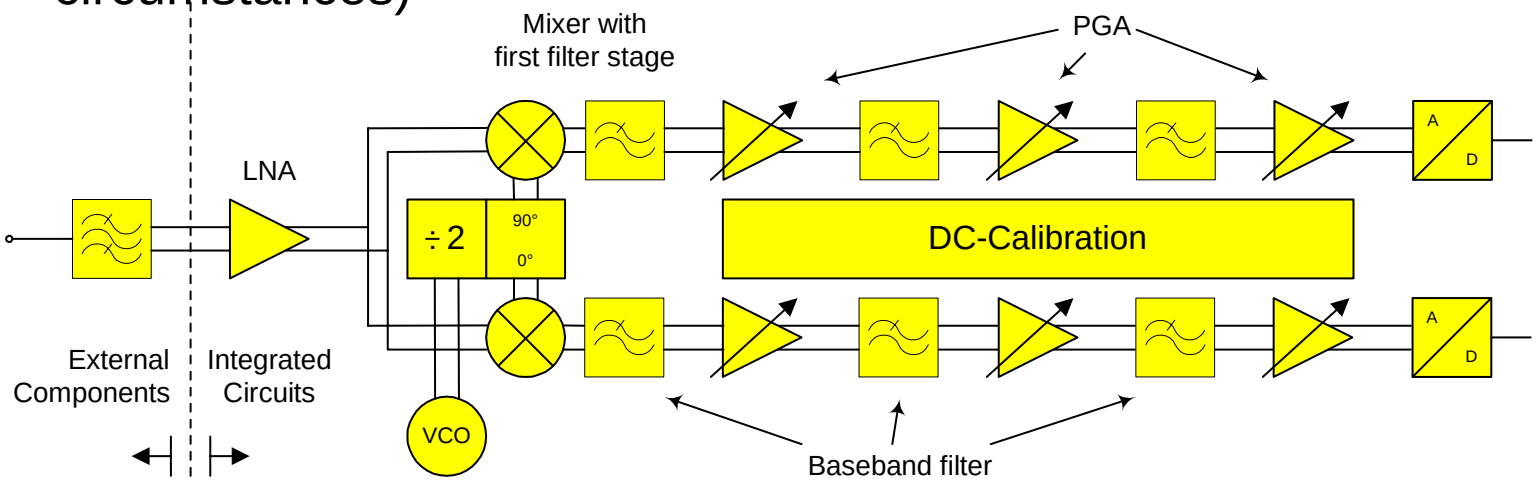
Blockers outside the desired band have to be attenuated to a level comparable to in band blockers



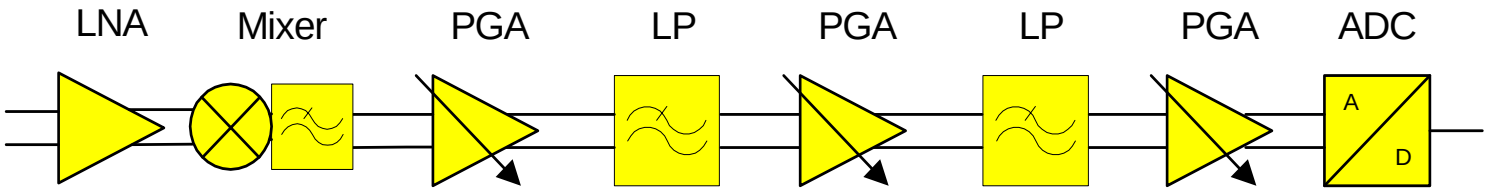
Blocking Performance

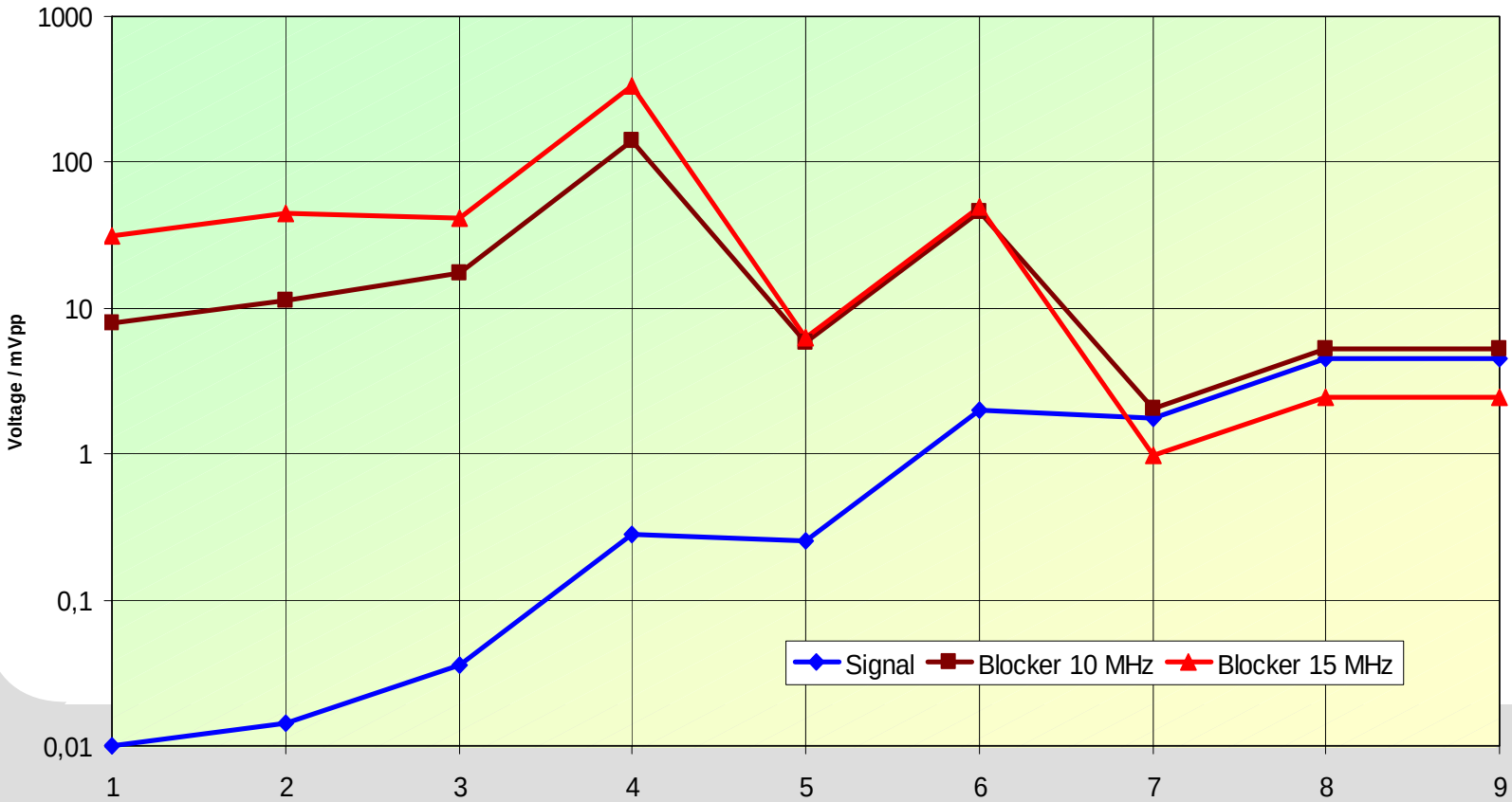
In band blocker

- Specify linearity of the front end stages (LNA...)
- Specify the characteristic of the baseband filter
- Gain partitioning for every input level has to be planned (no stage must be driven into saturation under any circumstances)

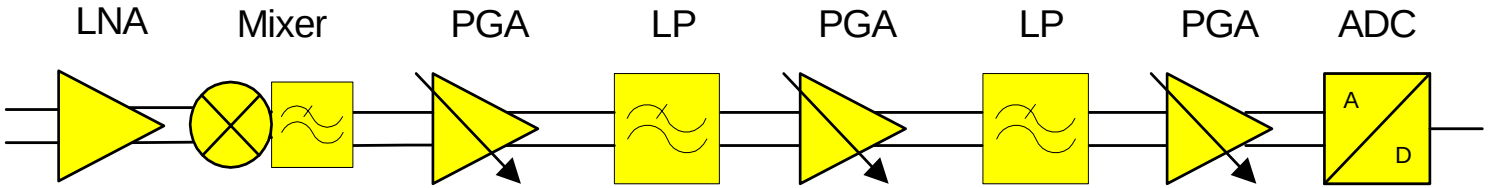


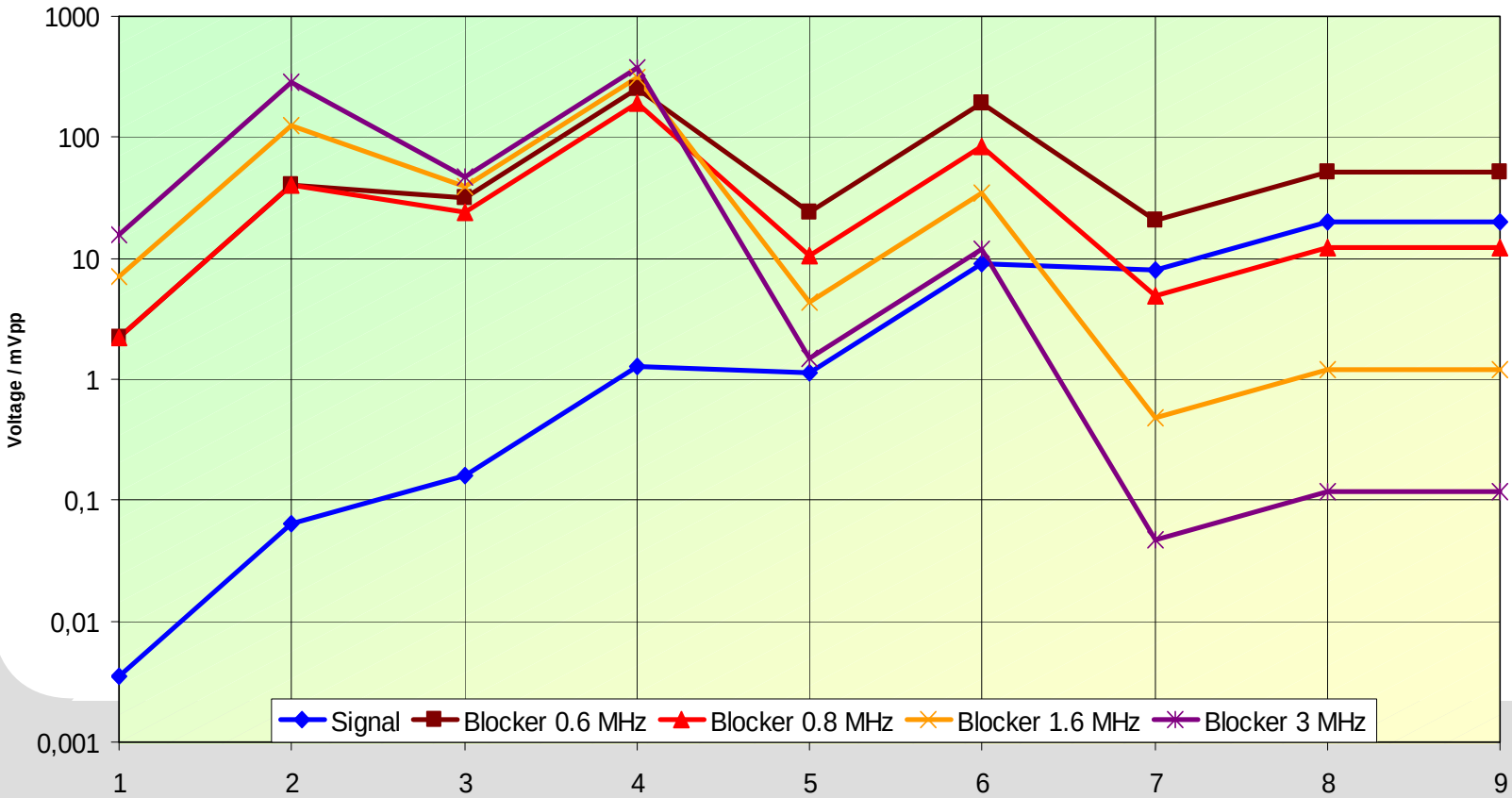
Example Blocking UMTS FDD



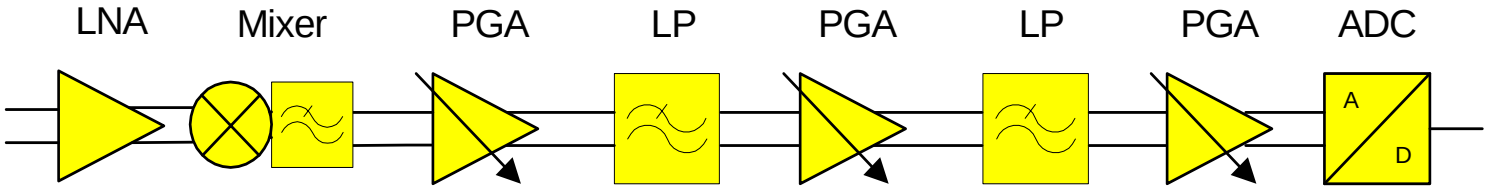


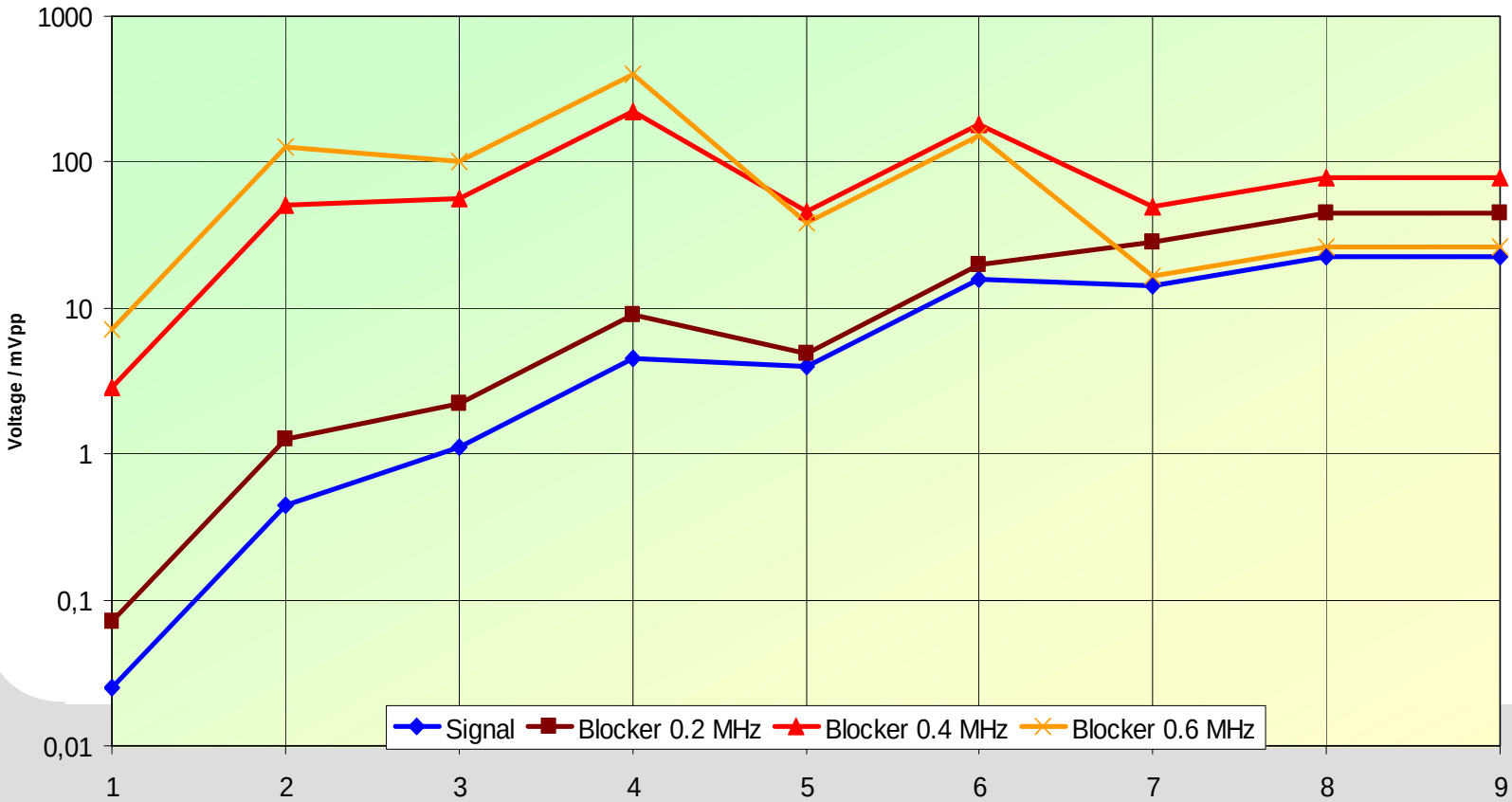
Example Blocking DCS





Example Adjacent Channel Selectivity DCS



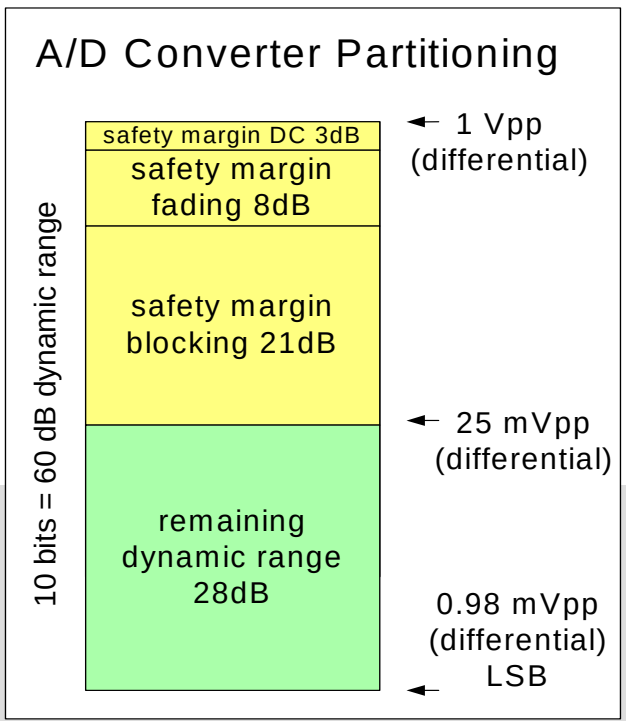


Blocking Performance

Adjacent channel performance GSM / DCS

Wanted signal: -82 dBm

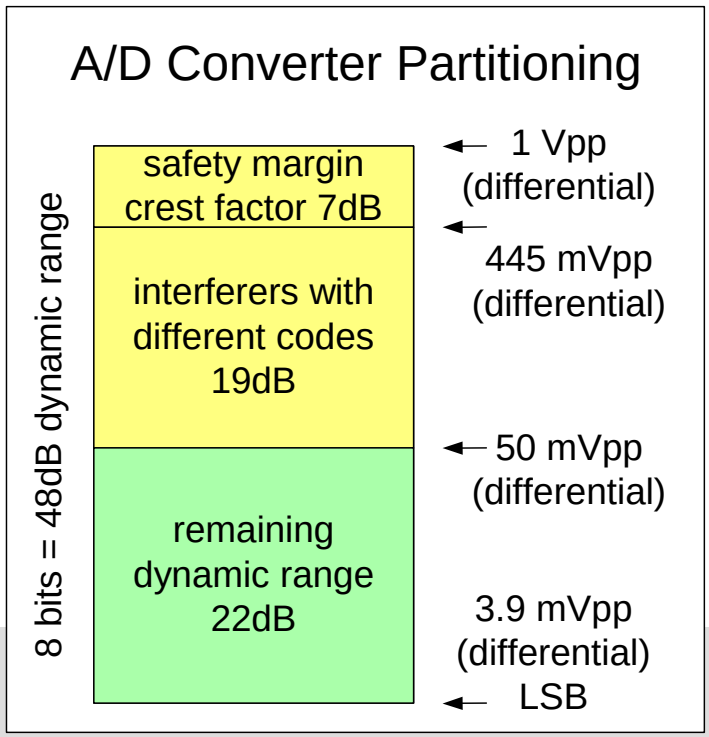
- Cochannel interference: C/Ic = 9 dB
- Adjacent channel (200 kHz) interference: C/Ia1 = -9 dB
- Adjacent channel (400 kHz) interference: C/Ia1 = -41 dB
- Adjacent channel (600 kHz) interference: C/Ia1 = -49 dB



Interferer at 400 kHz and 600 kHz offset can not be attenuated sufficiently to be neglected. At the end of the receiver chain residual interferer is considerably above the desired signal.

UMTS FDD: Maximum input power test case

$$\frac{DPCH\_Ec}{I_{or}} = -19dB \qquad \hat{I}_{or} = -25\frac{dBm}{3.84MHz}$$

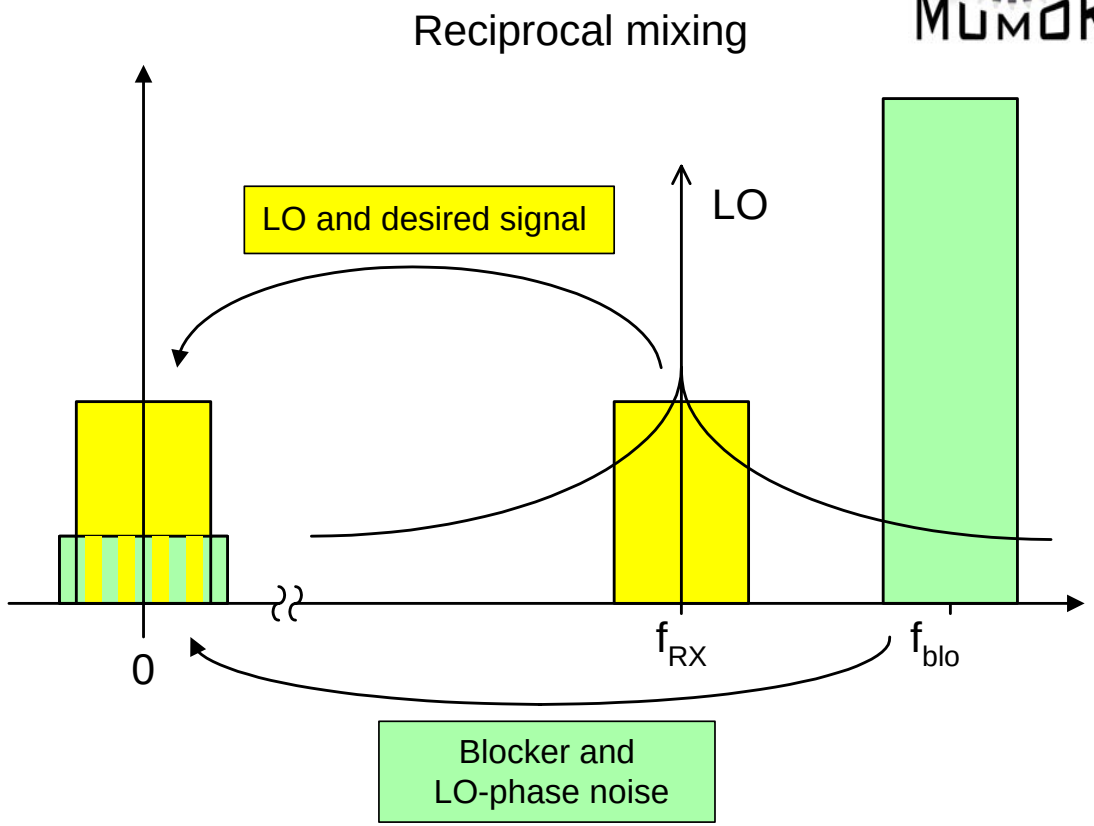


- -44 dBm useful data at f_{RX}
  $\Rightarrow$ 50 mVpp
- -25 dBm received signal at f_{RX}
  $\Rightarrow$ 445 mVpp

LO phase noise

LO and desired signal at f_{RX} produce a signal at baseband frequency

Blocker and LO-phase noise produce noise at baseband frequency



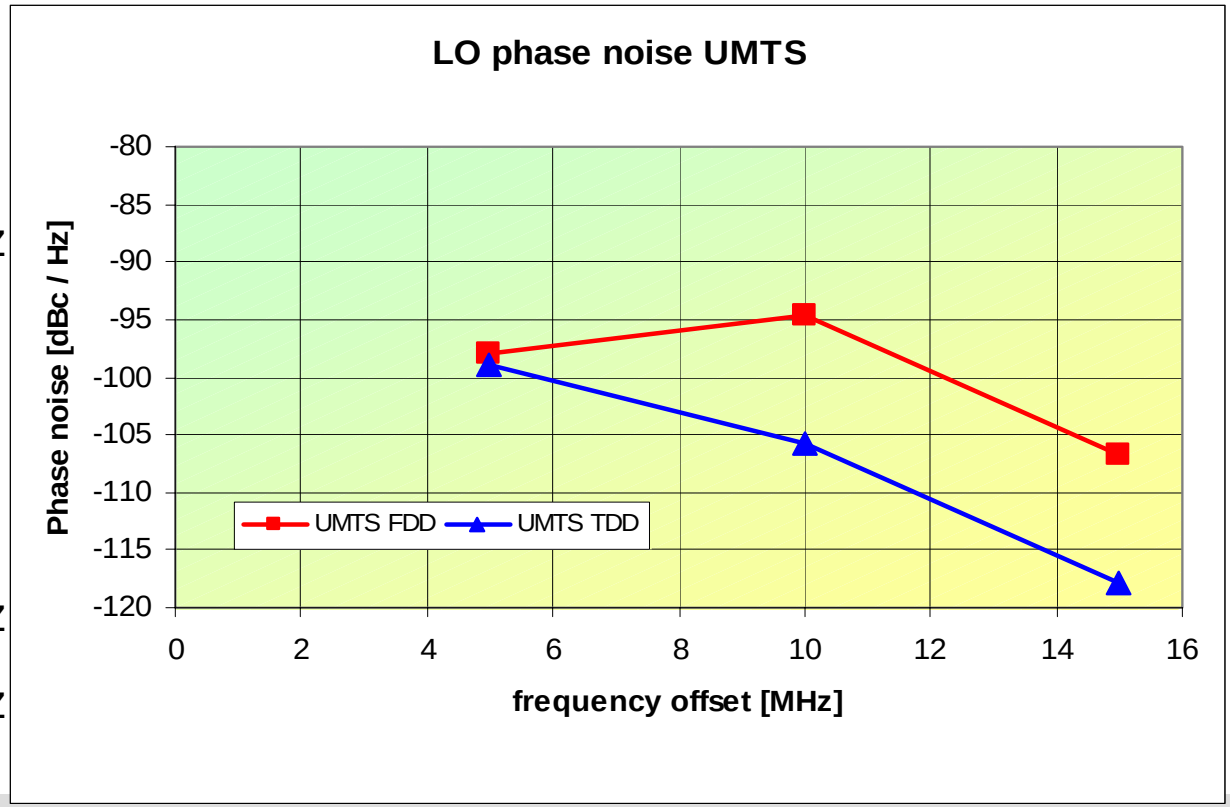
LO phase noise

UMTS FDD:

Offset:	Phase noise:
5 MHz	-97.8 dBc/Hz
10 MHz	-94.6 dBc/Hz
15 MHz	-106.6 dBc/Hz

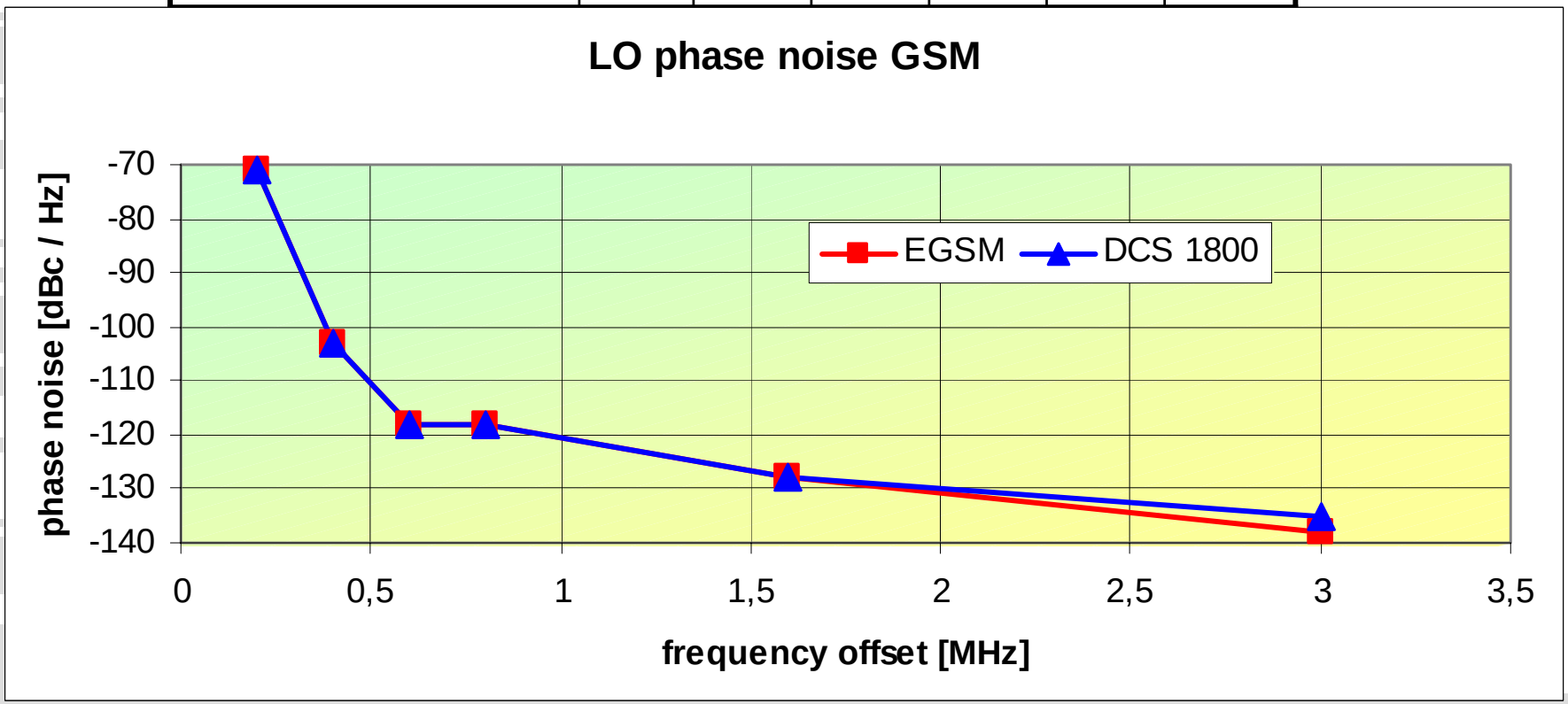
UMTS TDD:

Offset:	Phase noise:
5 MHz	-98.8 dBc/Hz
10 MHz	-105.9 dBc/Hz
15 MHz	-117.8 dBc/Hz

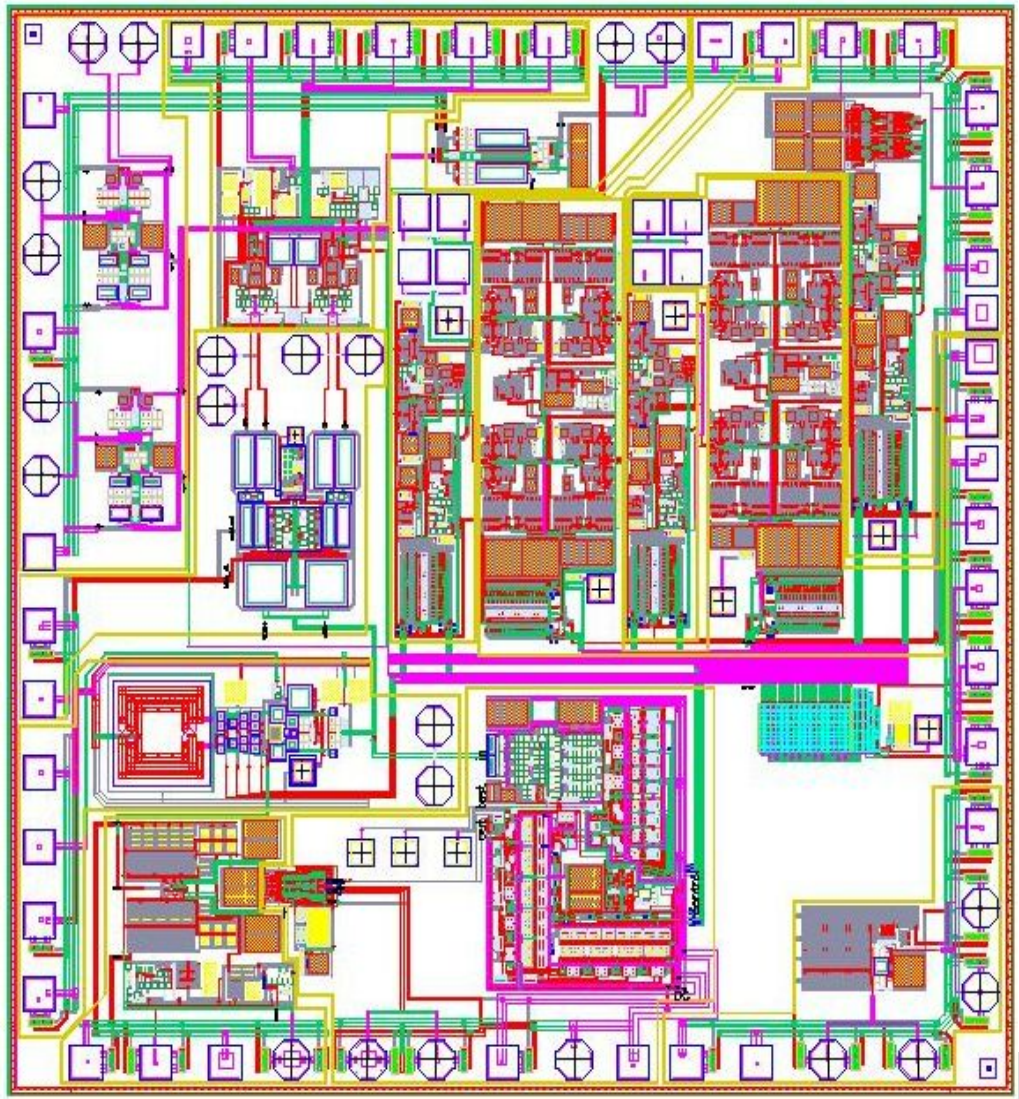


LO phase noise

Offset / MHz	0.2	0.4	0.6	0.8	1.6	3
PN EGSM / dBc/Hz	-71	-103	-118	-118	-128	-138
PN DCS / dBc/Hz	-71	-103	-118	-118	-128	-135



Realised RF-IC



Realised Receiver Chip:

- Process: BiCMOS 0.35µm
- f_T = 50 GHz
- Chip Area: 2.5mm x 2.5mm

Realised RF-IC

LNA:

Noise Figure, Gain, IIP3 within the specifications

VCO and Scaler:

Phase noise within the specifications for UMTS FDD and UMTS TDD.

Phase noise for GSM not within the specifications.

Cause: Noise produced in the voltage regulator.

Conclusion

- RF specifications can be derived from test cases described in standards
- Negative effects do not occur independently from each other
- The derived RF specifications for the building blocks are starting values for an iterative process
- Achievable performance of building blocks have to be considered for the next iteration