Progress in EMC Measurement Technology:

The CISPR-RMS Detector -
A new weighting detector for radio disturbances

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Overview

- Principles and definition for the weighting of radio disturbances
- Detectors and alternative methods for the weighting of disturbances:
  → Peak, Quasi-peak, RMS and Average detector
  → Distinction between narrowband and broadband disturbances
- Investigation of CISPR-RMS weighting characteristic:
  → Methods for the determination of the weighting function by a radio system
  → Mathematical investigations
  → Numerous measurement results
- Construction and properties of the CISPR-RMS detector
- Consequences for the measurement of typical disturbances
- Conclusion

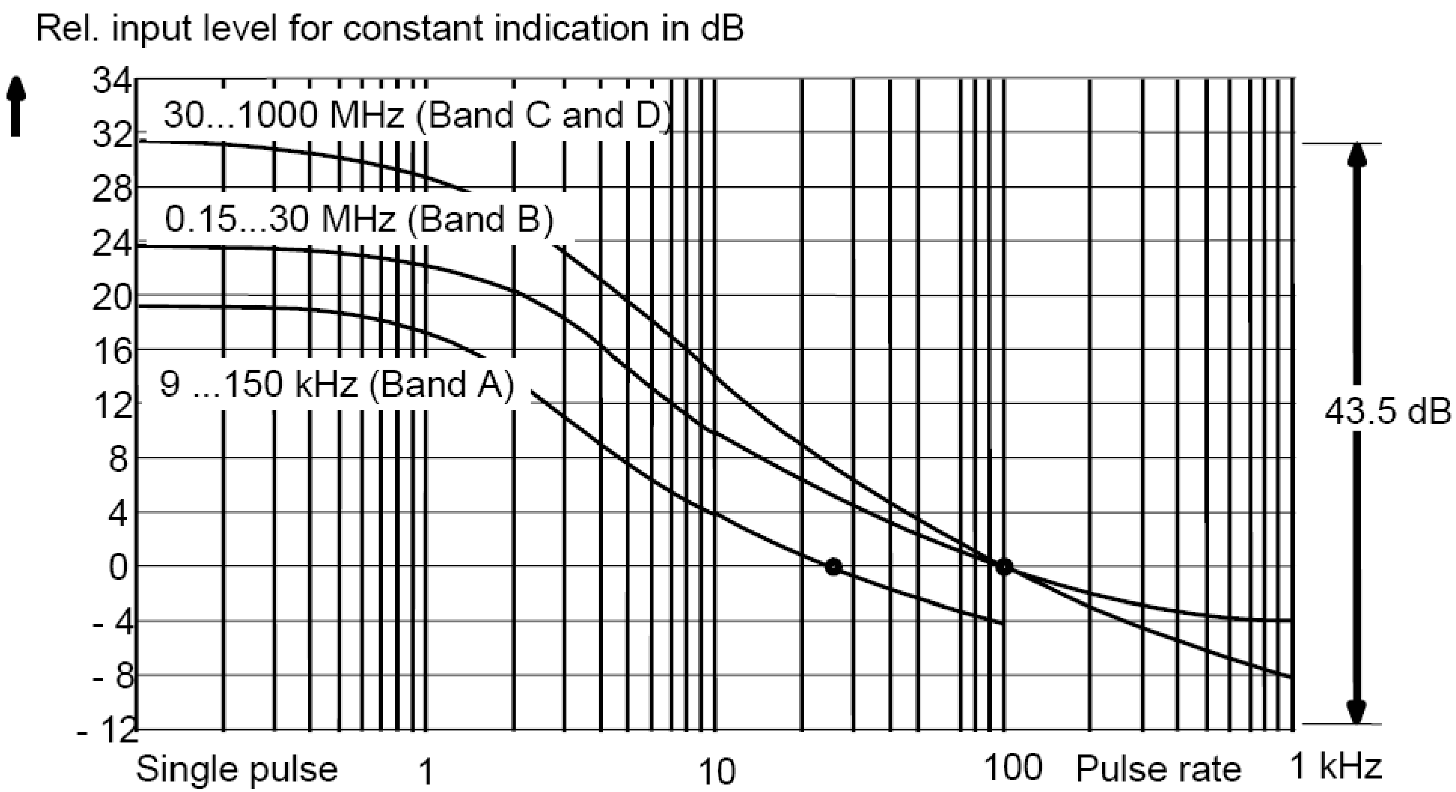
Motivation for weighting

Situation after installation of AM radio (from 1922):

- Numerous complaints from sound broadcast listeners
- Other electrical devices and apparatus were already existing **before** AM radio introduced
- Subsequent disturbance suppression was unavoidable
- Compromise between user and manufacturer of devices
- Minimizing the cost of disturbance suppression, while keeping an agreed level of radio protection
- First standards were instruction guides for disturbance suppression
- Measurement methods were not developed at that time; later on disturbance voltage measurement method; CISPR was founded in 1933
- The first CISPR measuring receiver in 1939 was already equipped with a Quasi-peak detector = Simulation of radio receiver plus listener

Rationale for Quasi-peak detector

To a listener the degradation of reception quality, caused by a 100-Hz pulse, is equivalent to the degradation from a 10-Hz pulse, if the pulse level is increased by an amount of 10 dB.



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Definition of weighting

Weighting (e.g. of impulsive disturbance) =

The pulse-repetition-frequency (PRF) dependent conversion (mostly reduction) of a peak-detected impulse voltage level to an indication which corresponds to the interference effect on radio reception

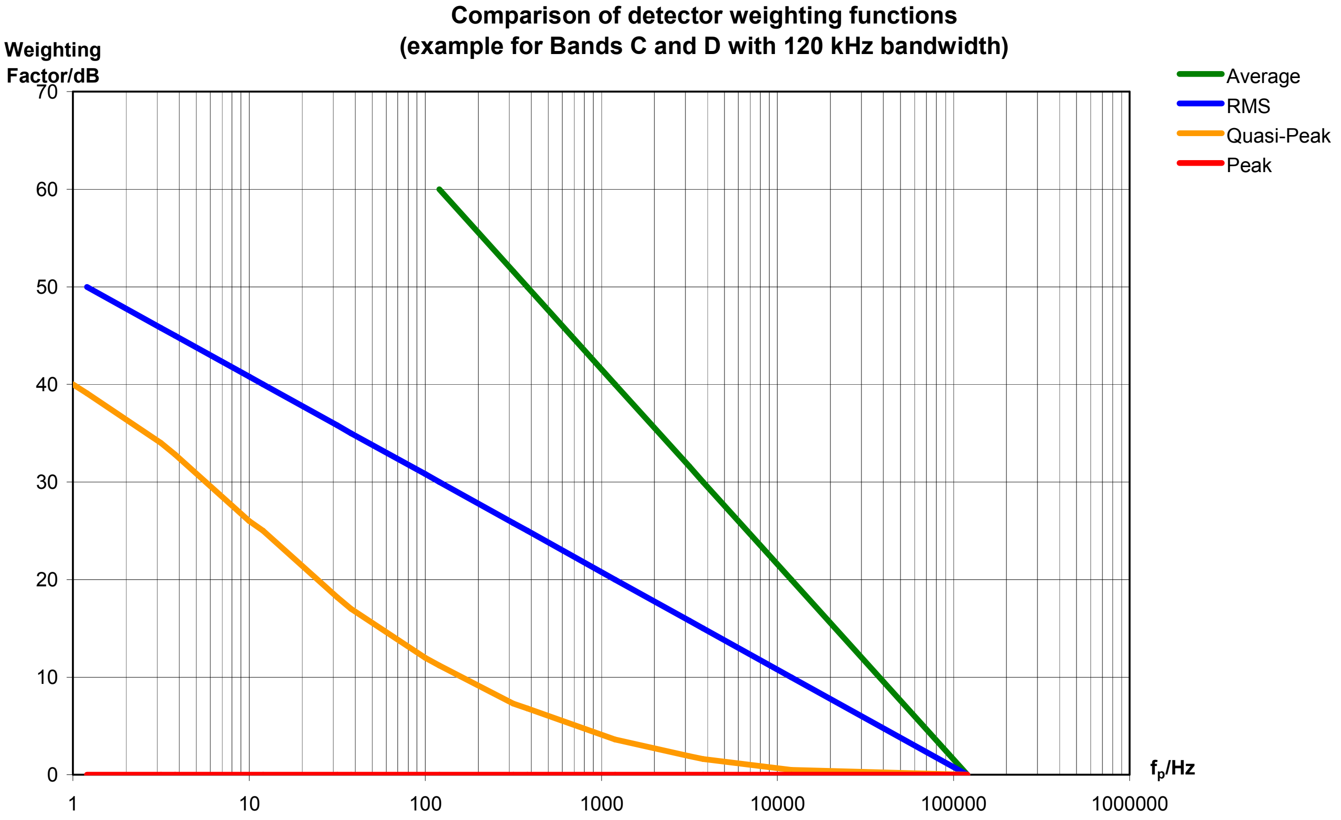
- For the analog receiver, the psychophysical annoyance of the interference effect is a subjective quantity (acoustic or visual, usually it cannot be measured in figures)
- For the digital receiver, the interference effect may be defined by the critical Bit Error Ratio (BER) or Bit Error Probability (BEP), for which perfect error correction can still occur or by another objective and reproducible parameter

Definition of weighting

- ***Weighting characteristic:*** The peak voltage level = f(fp) for a constant effect on a specific radio communication system, i.e. the disturbance is weighted by the radio communication system itself
- ***Weighting function** or **weighting curve:*** The relationship between input peak voltage level and PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses
- ***Weighting factor:*** The value in dB of the weighting function relative to a reference PRF or relative to the peak value
- ***Weighting detector:*** A detector which provides an agreed weighting function
- ***Weighted disturbance measurement:*** Measurement of disturbance using a weighting detector

Detectors and alternative methods of weighting

Weighting functions of Peak, Quasi-peak, RMS and Average detector:



Detectors and alternative methods of weighting

Distinction between narrowband and broadband disturbances (requires unique definition)

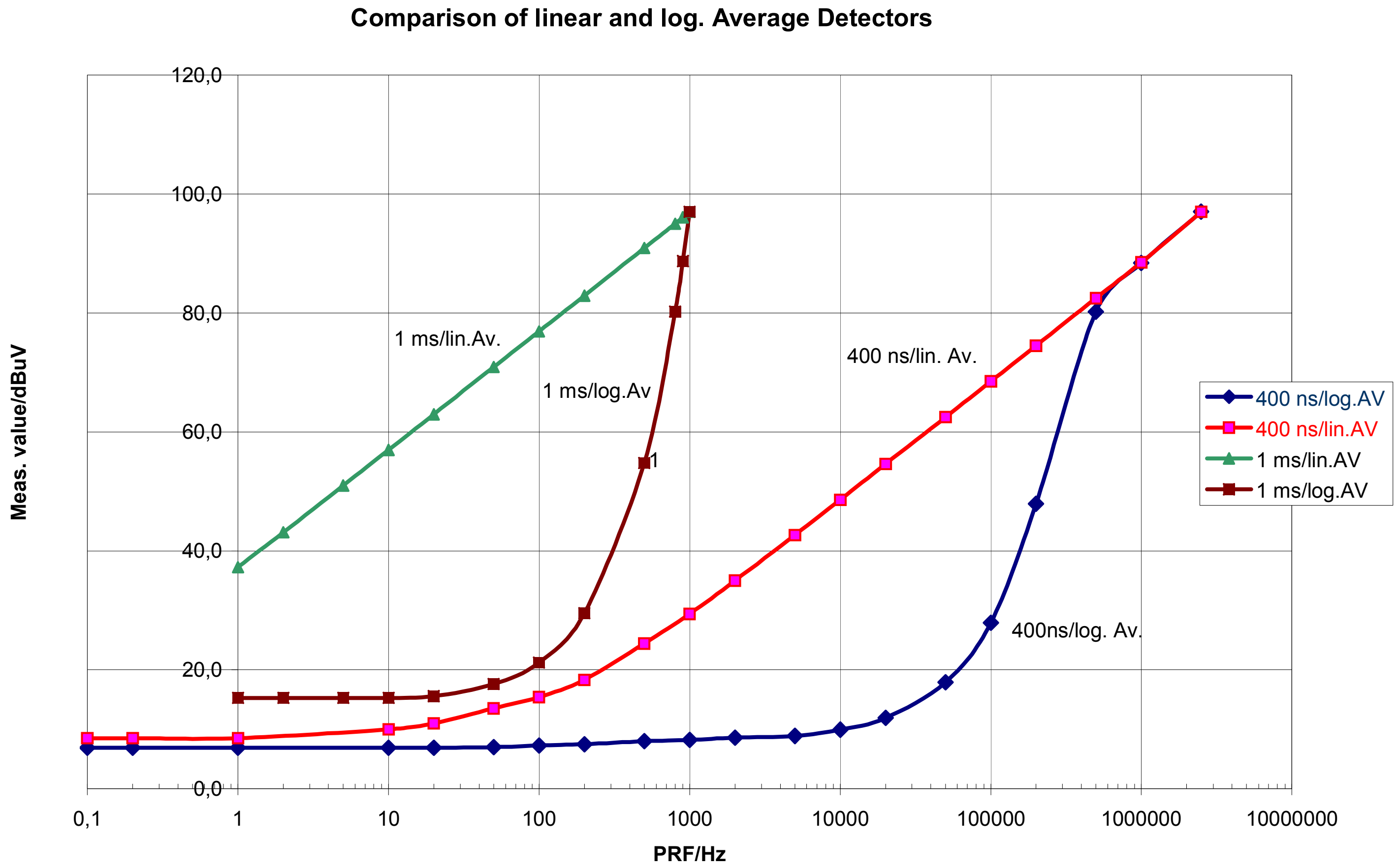
- Narrowband disturbances causing strong whistle noises on AM receivers, for that reason lower limits are necessary for narrowband disturbance

Distinction method:

- Comparison of Average and Peak values
- Comparison of Peak values by using different bandwidths
- Tuning method (+/-1 bandwidth)
- Different limit values for QP and Average

Detectors and alternative methods of weighting

Particular sharp suppression of impulsive disturbance: log AV



Projects to weighting characteristics

Weighting characteristic
is influenced by modulation and coding methods as well as error correction procedures

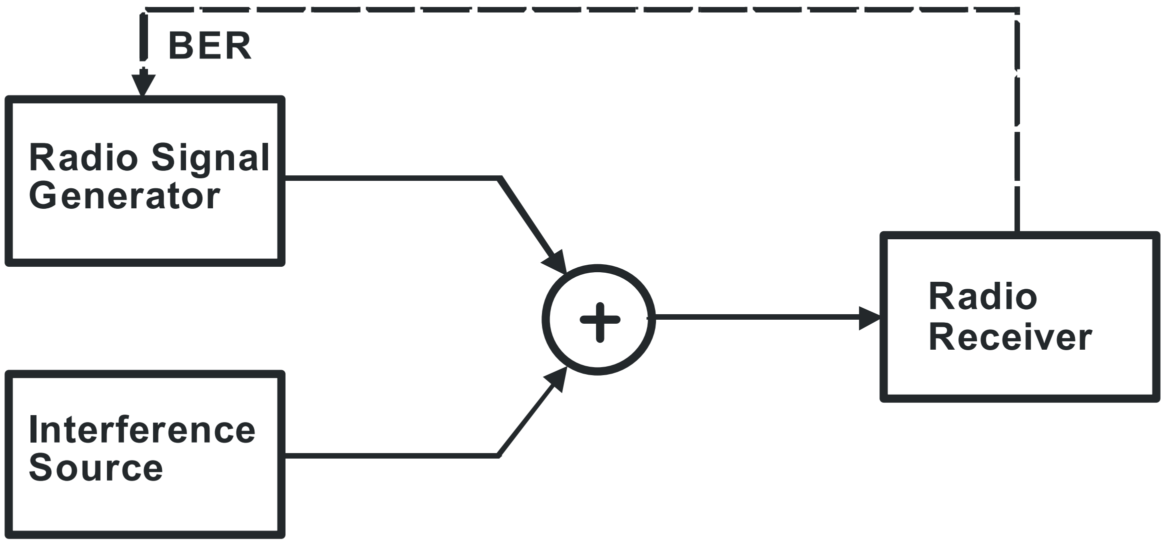
Digital Modulation - Fundamental Properties:

- Coding Method – by adding of „tail bits“ and „data frames“, „convolution coding“ and „interleaving“
  → Redundancy for error detection and correction
- Different modulation methods GMSK, QPSK, OFDM, QAM and adapted methods
- Data compression and preprocessing
- BER limitation for each System for perfect reception

→ **Projects in CISPR/A and ITU-R**

Investigation of weighting characteristics

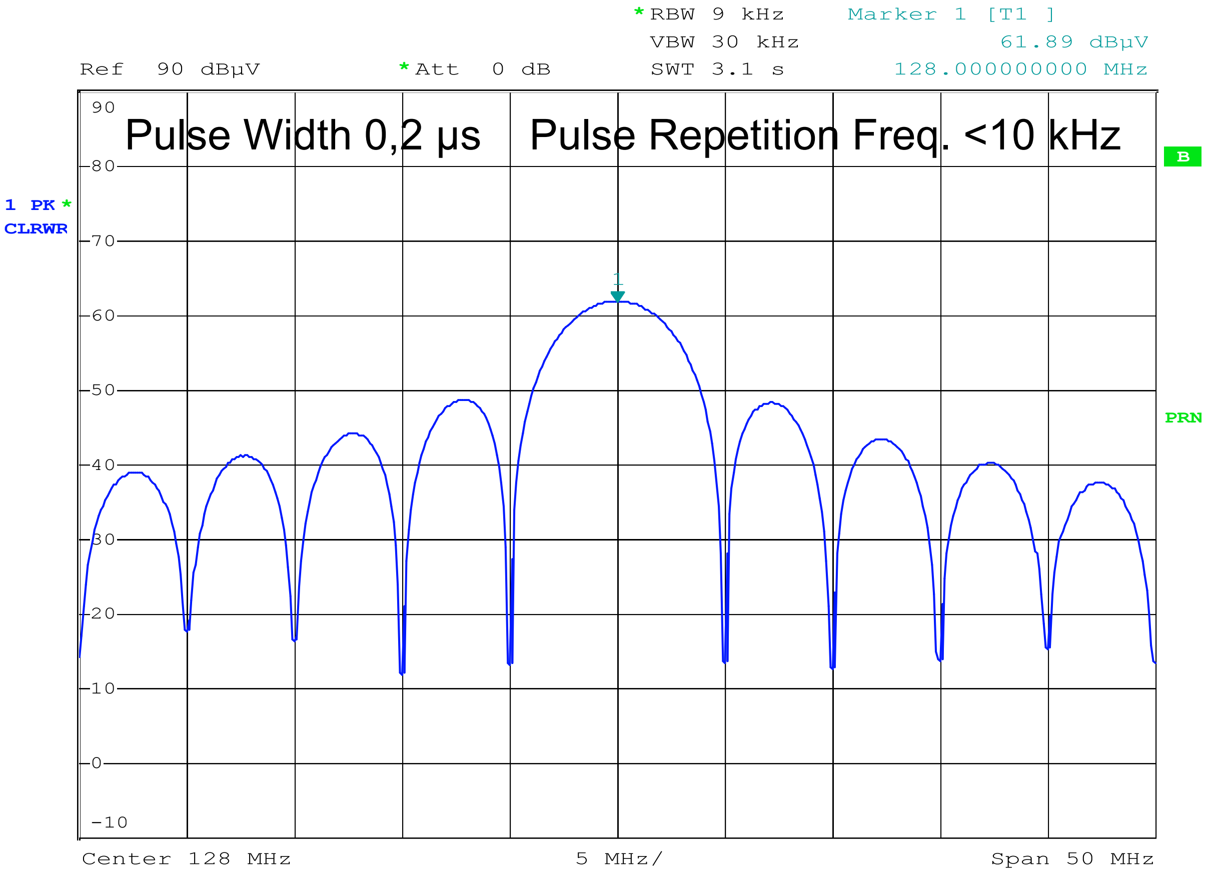
Principle investigation method by using measurement instrument with BER meter (e.g. communication analyzer)



Simulation of weighting function

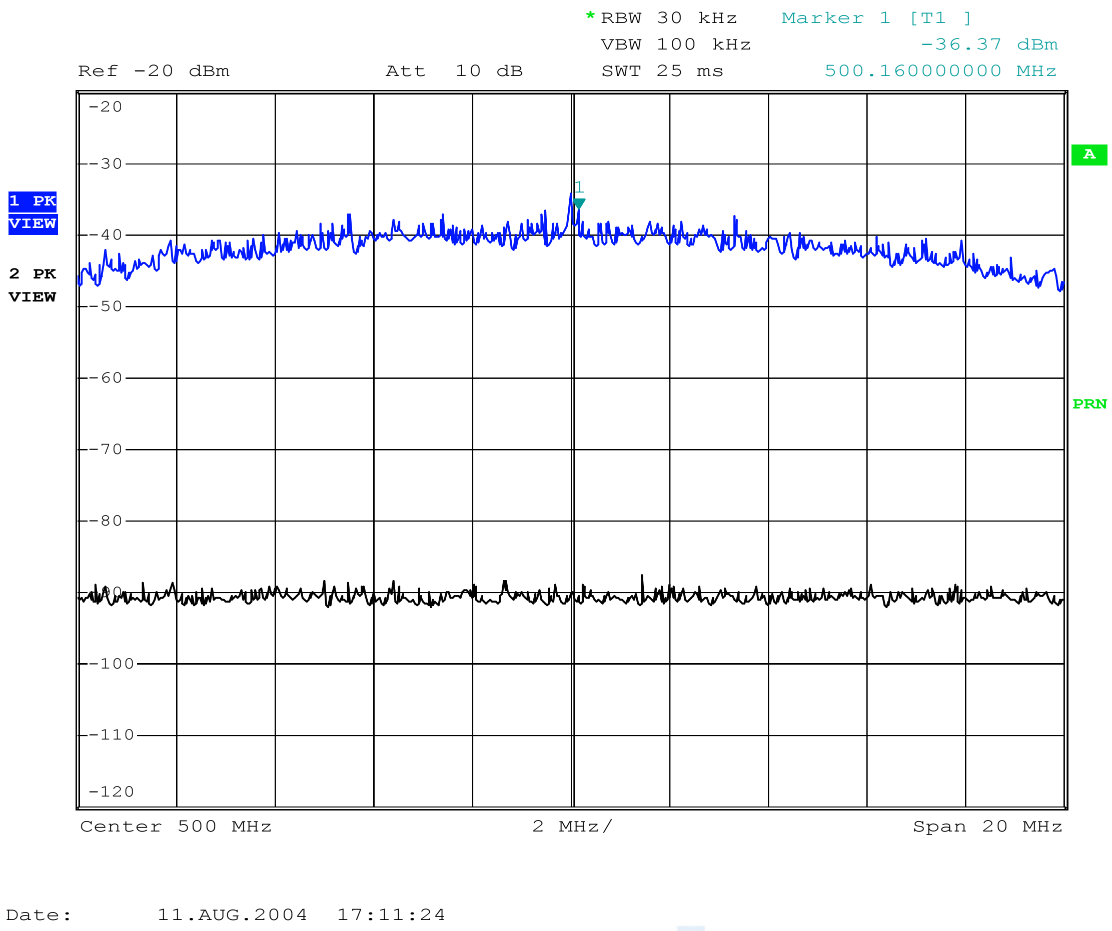
Investigation of weighting characteristics

Interference Signal Type 1: Pulse modulated carrier



Investigation of weighting characteristics

Interference Signal Type 2: Pulse signal with QPSK modulation



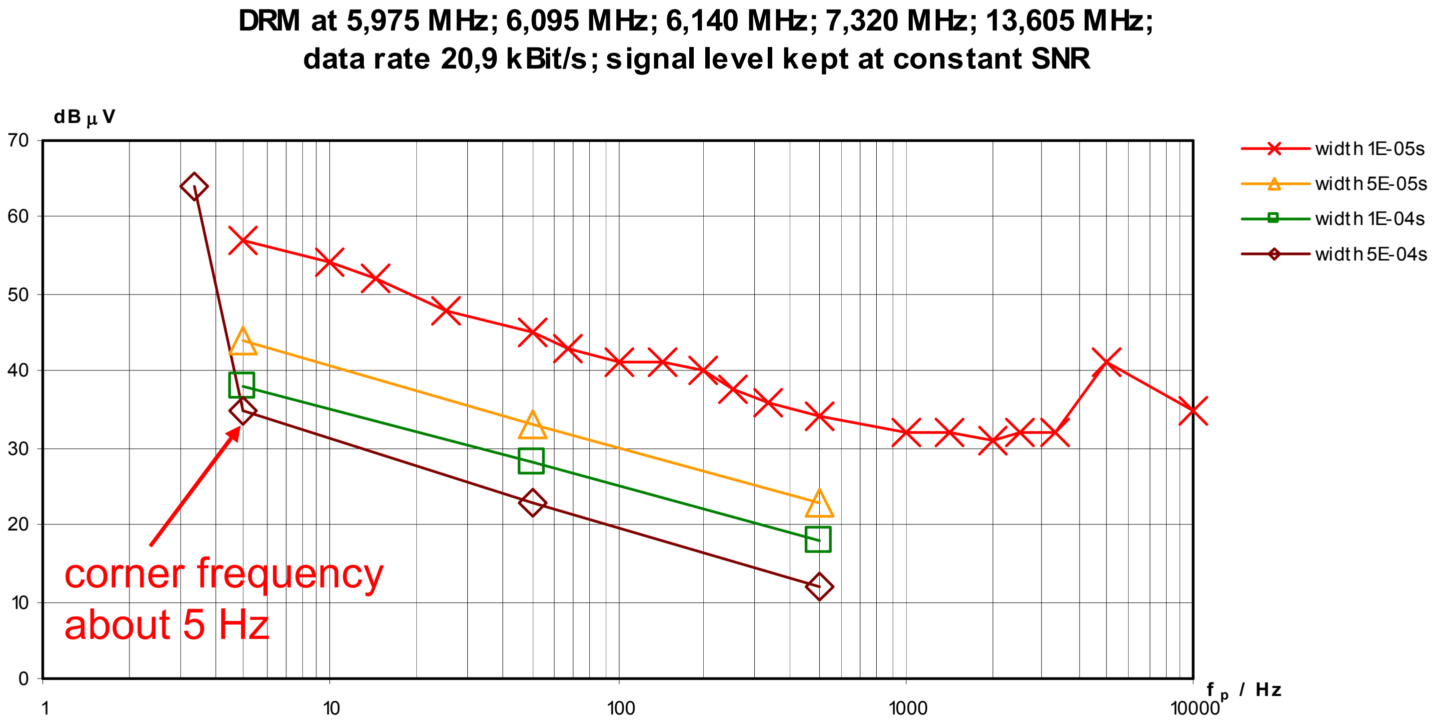
Investigation of weighting characteristics

Arrangement in CISPR frequency bands:

- CISPR Band A (9 k – 150 kHz):
  → no digital radio services at the moment
- CISPR Band B (0,15 – 30 MHz):
  → DRM (Digital Radio Mondial)
- CISPR Band C/D (30 – 1000 MHz):
  → DVB-T, DAB, TETRA, GSM 900, FM
- CISPR Band E (1 – 18 GHz):
  → GSM 1800, DECT, IS-95, J-STD 008, CDMA2000, W-CDMA

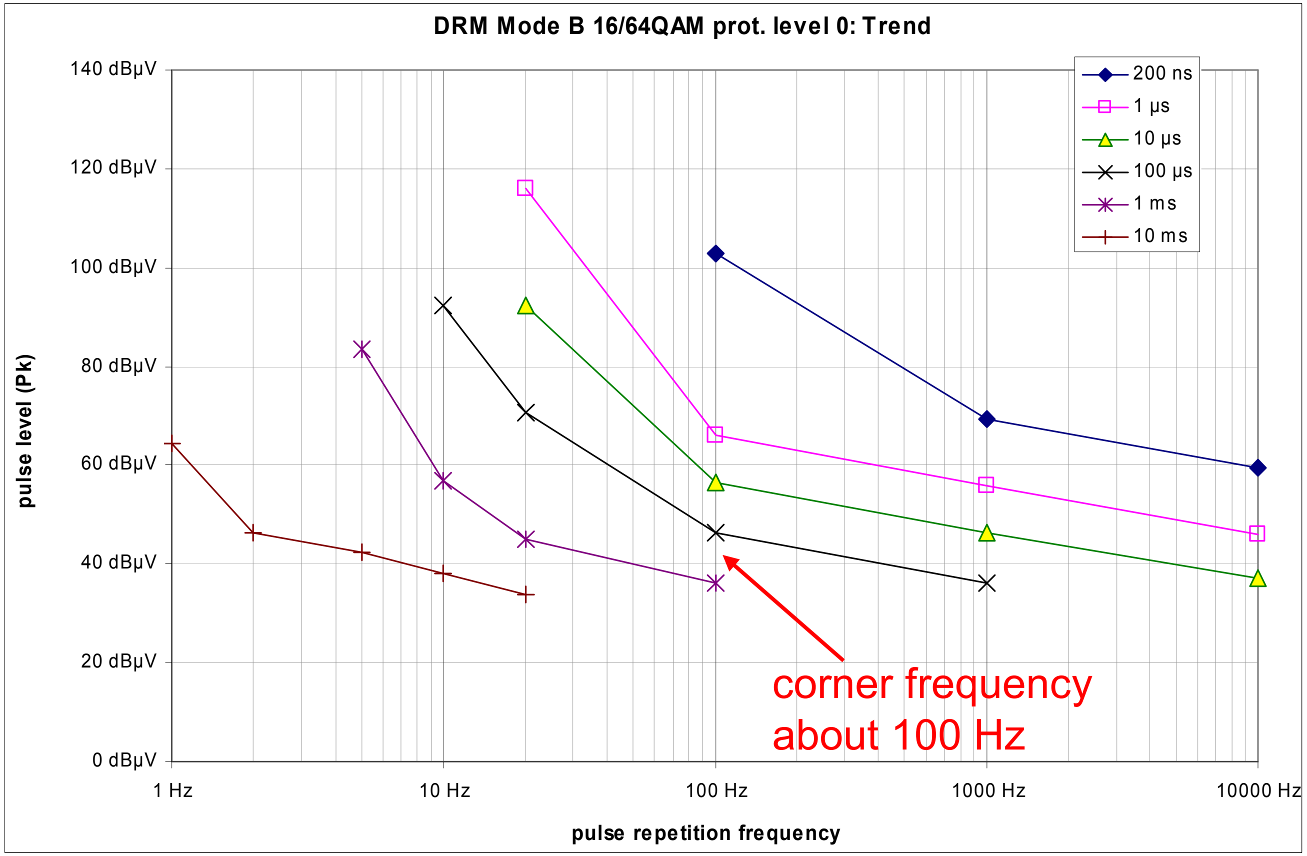
Investigation of weighting characteristics

Band B: DRM (Digital Radio Mondial), Interference Signal Type 1



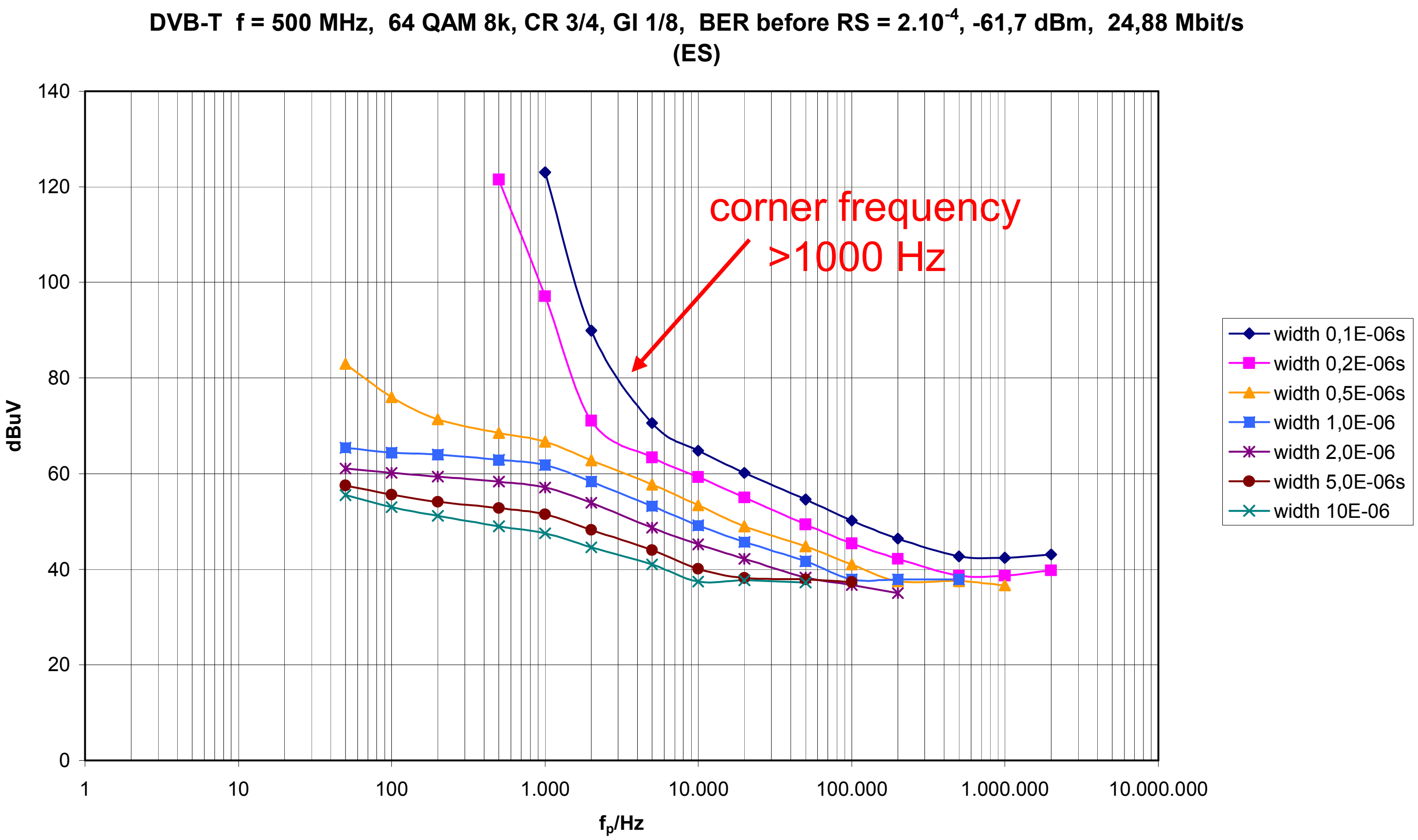
Investigation of weighting characteristics

Band B: DRM (Digital Radio Mondial), Interference Signal Type 2



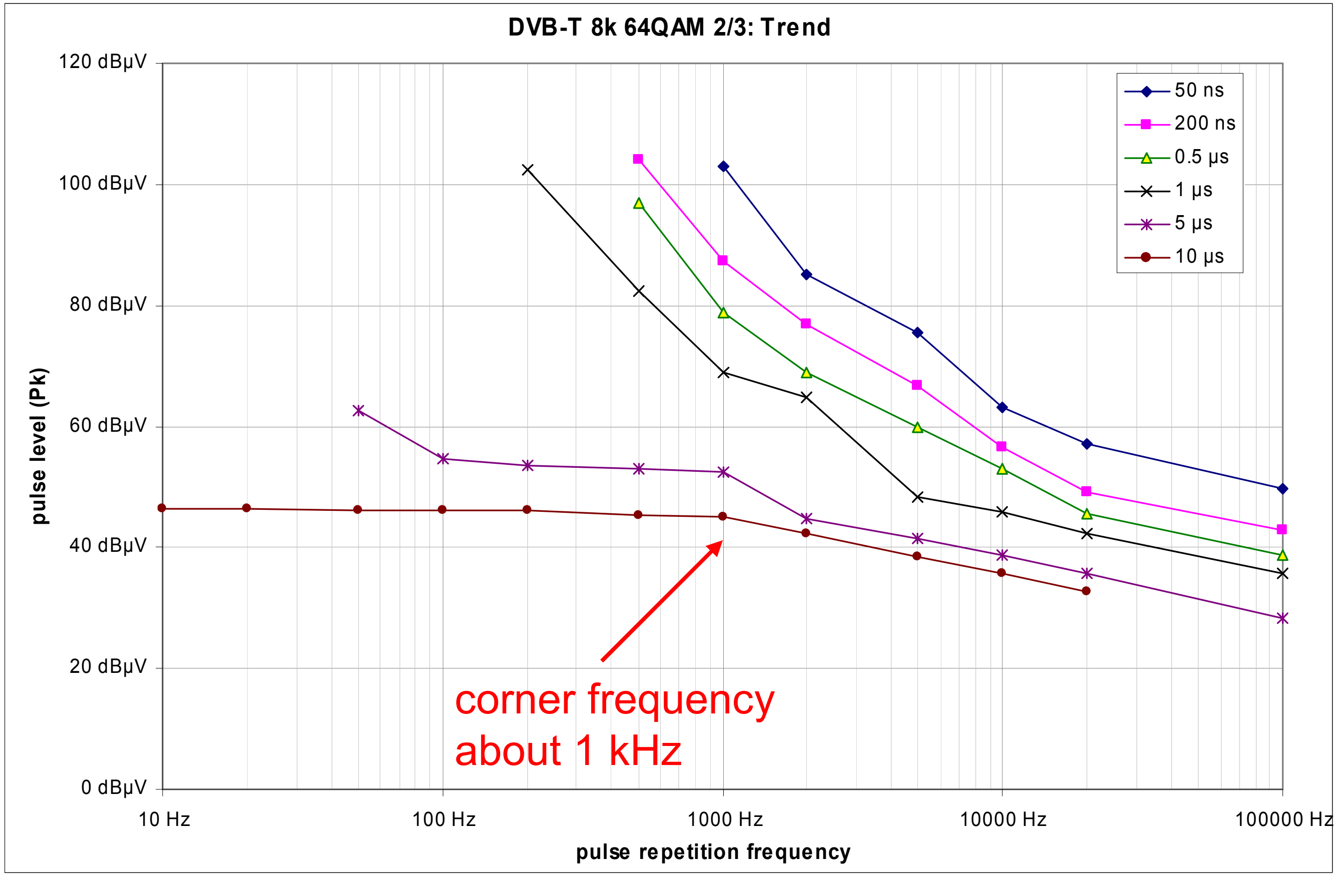
Investigation of weighting characteristics

Band C/D: DVB-T in Spain, Interference Signal Type 1



Investigation of weighting characteristics

Band C/D: DVB-T with 64-QAM, Interference Signal Type 2



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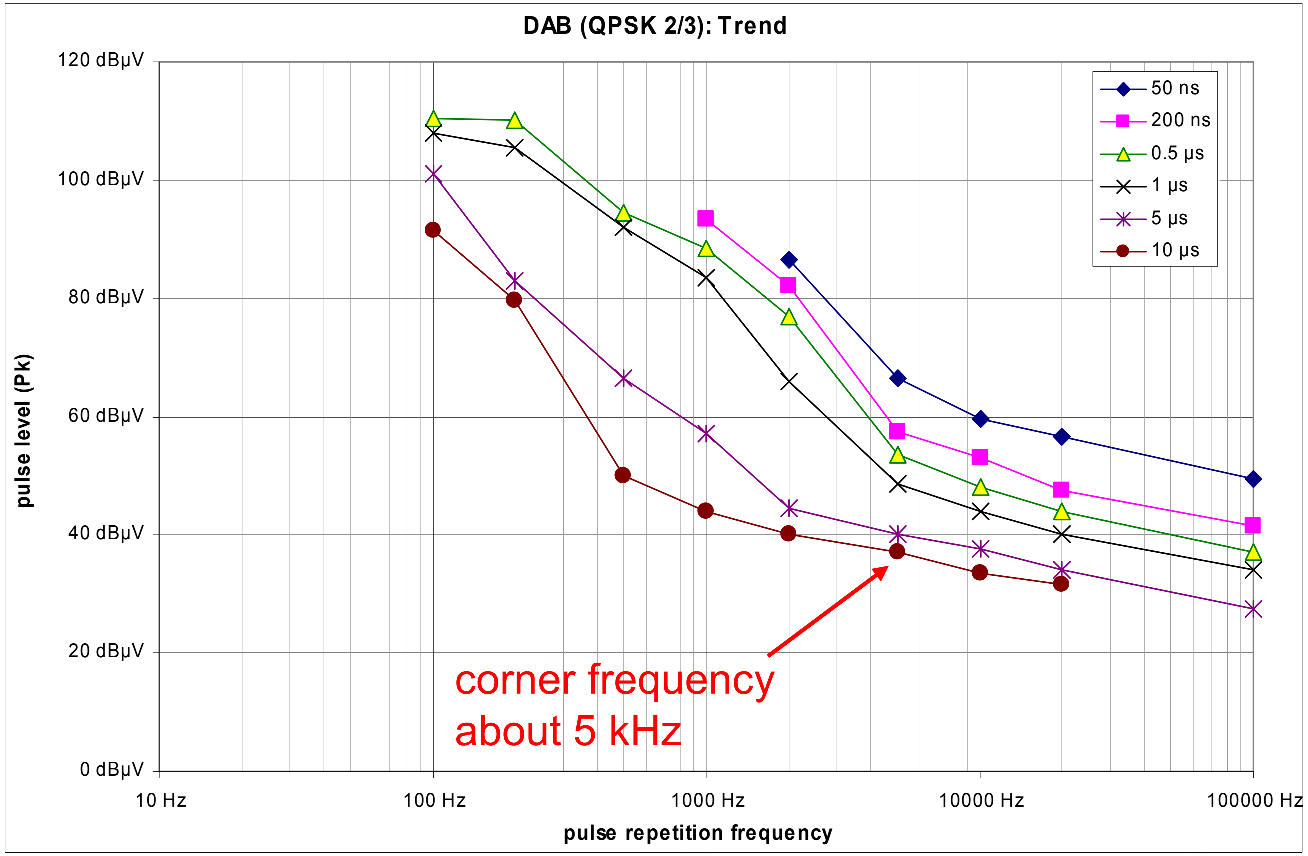
Band C/D: DAB (Digital Audio Broadcasting), OFDM, Interference Signal Type 2



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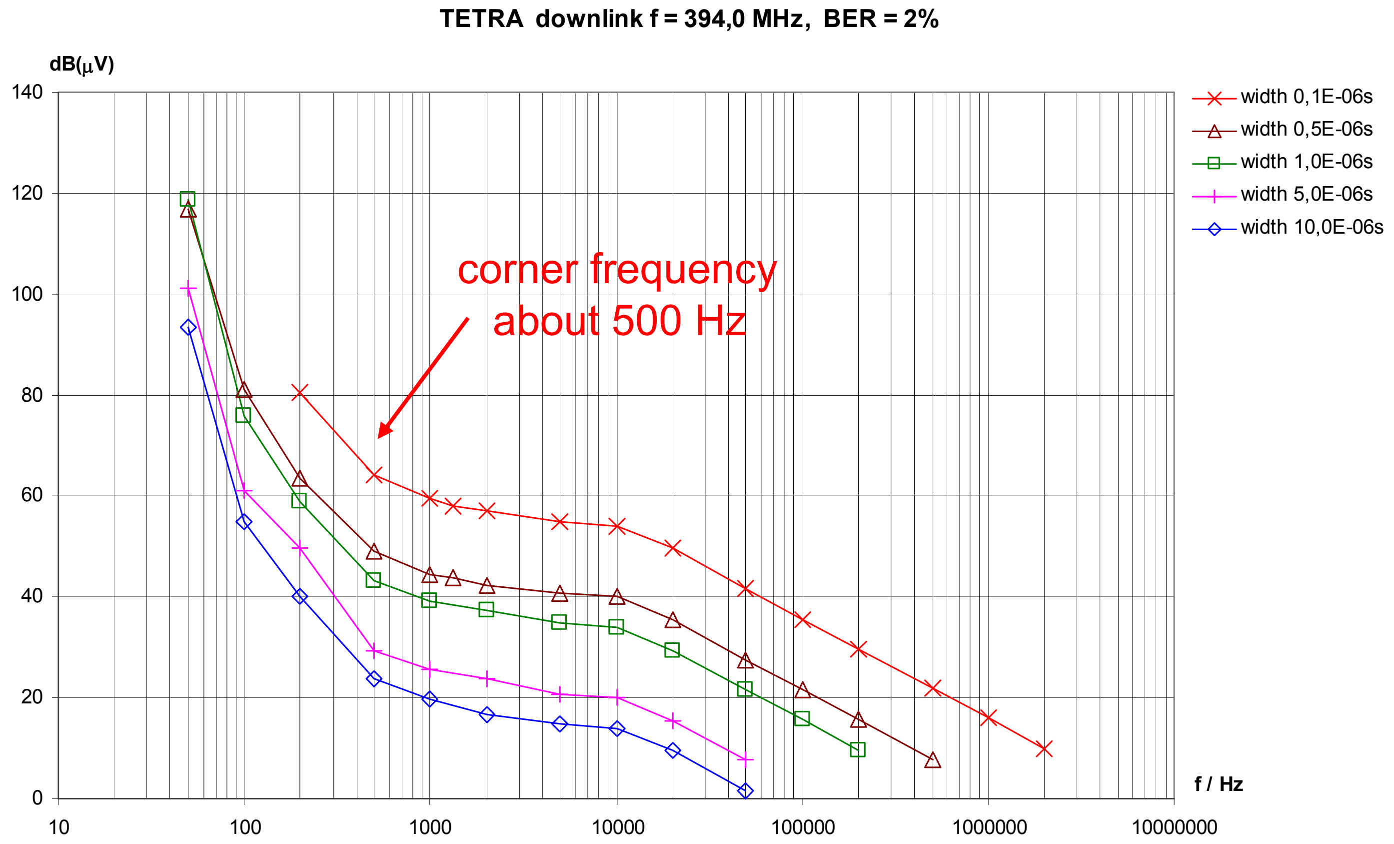
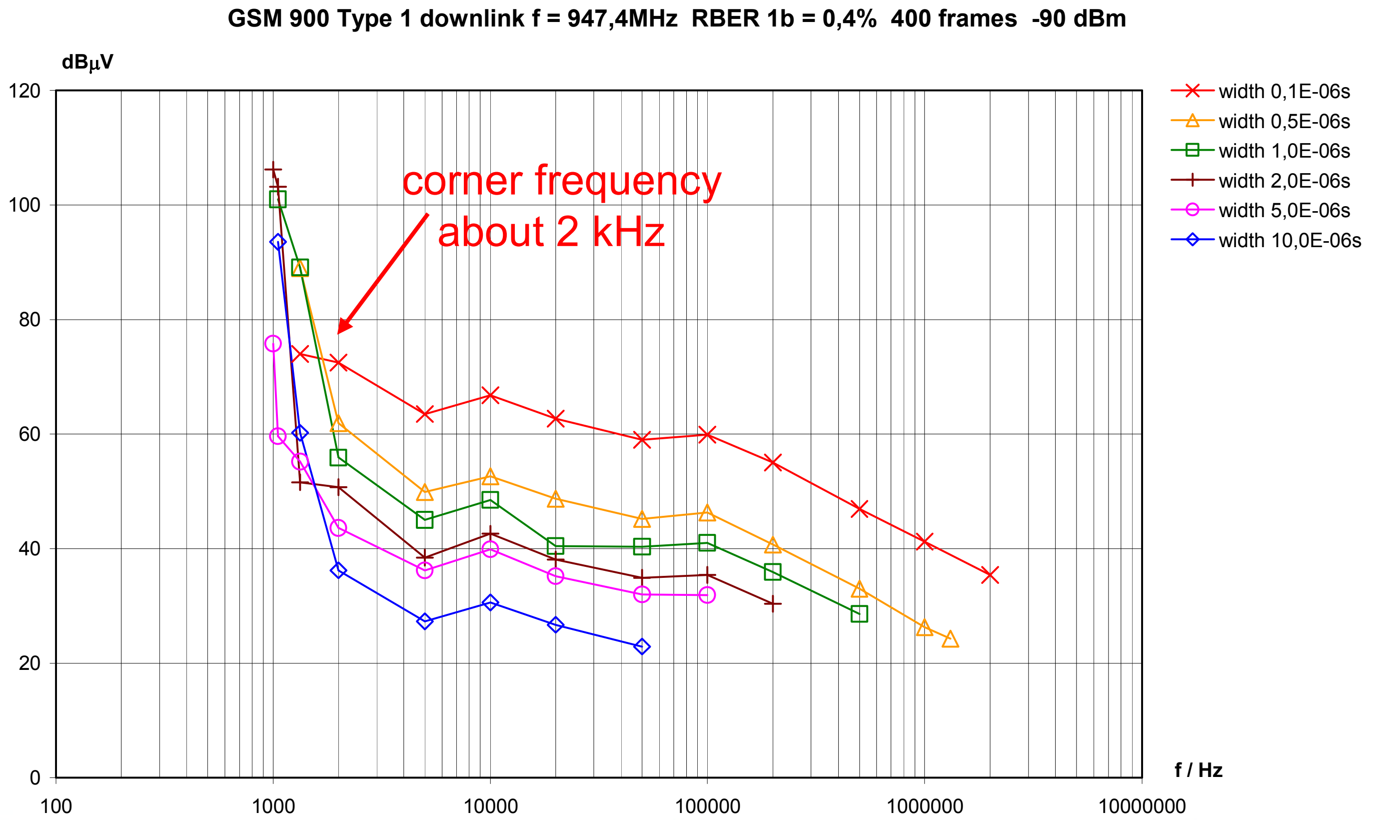
Investigation of weighting characteristics

Band C/D: TETRA, narrowband system, π/4-DQPSK, Interference Signal Type 1



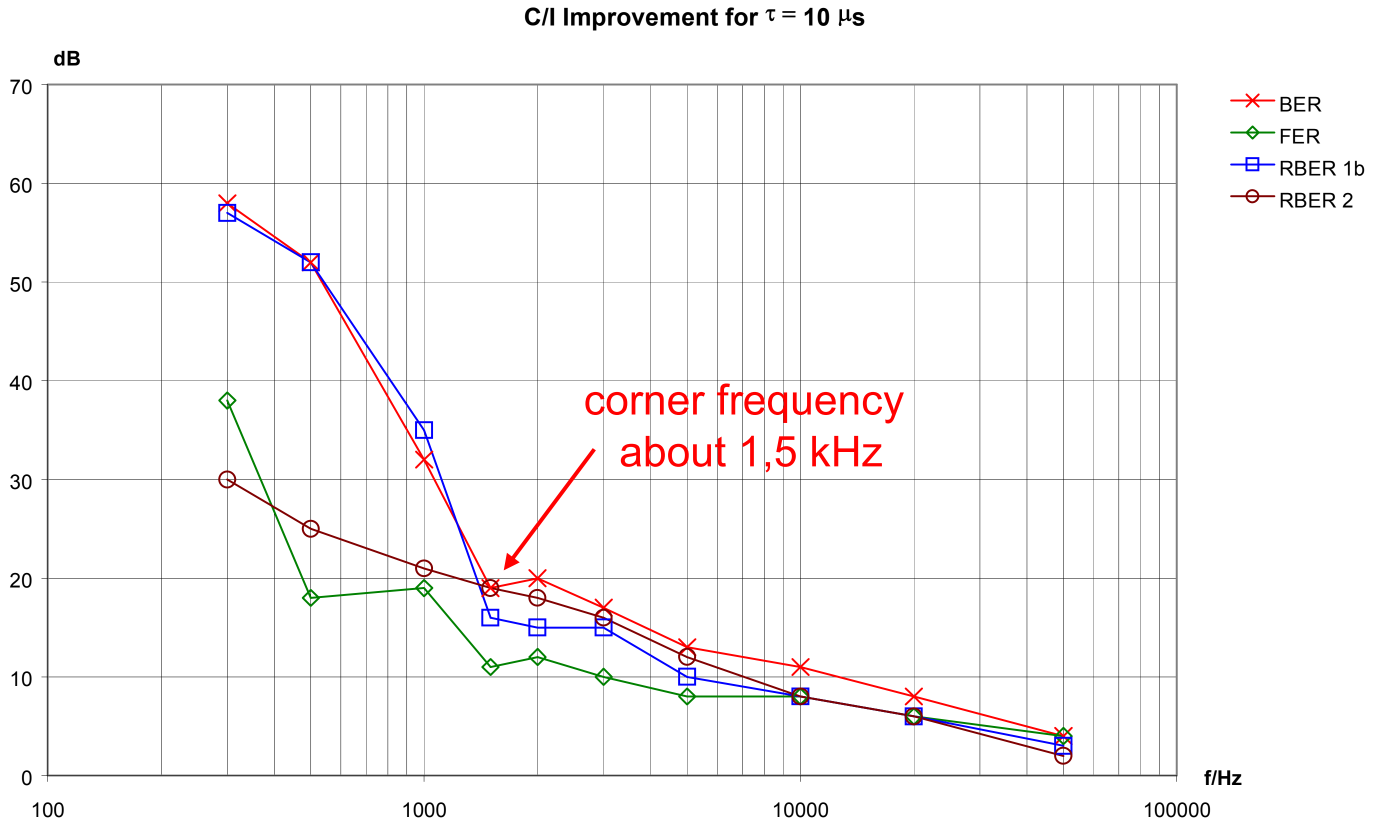
Investigation of weighting characteristics

Band C/D: GSM 900, GMSK modulation with TDMA, Interference Signal Type 1, RBER1 and RBER2 are used



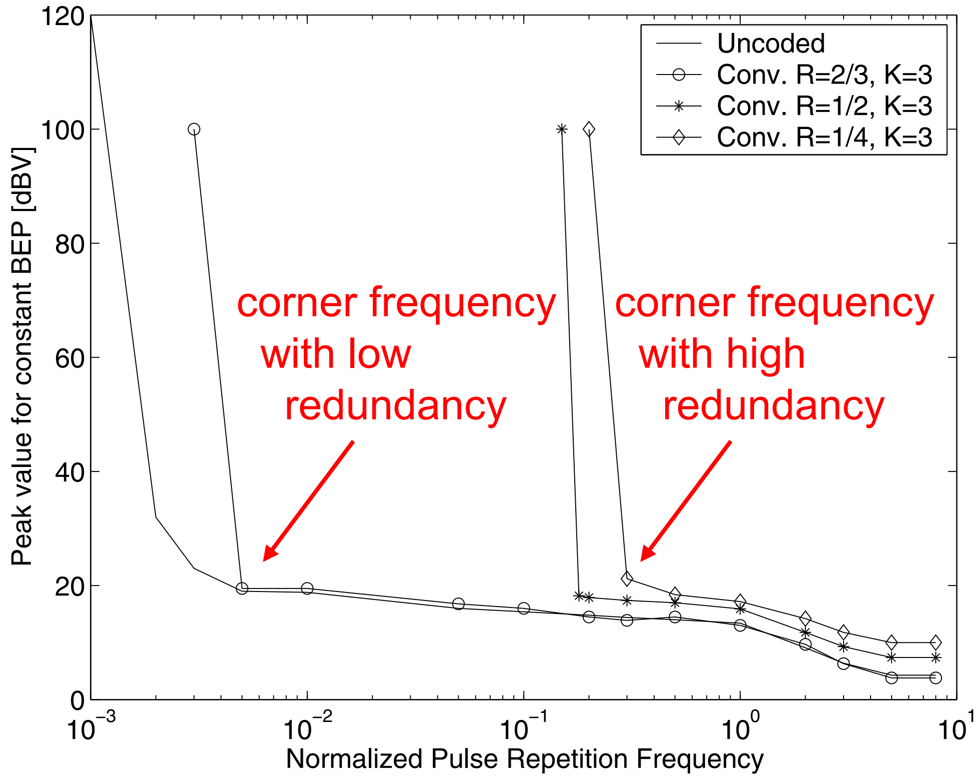
Investigation of weighting characteristics

Band C/D: GSM 900, arithmetic simulation with COSSAP (Neibig/Bosch)
RBER1 and RBER2 are used



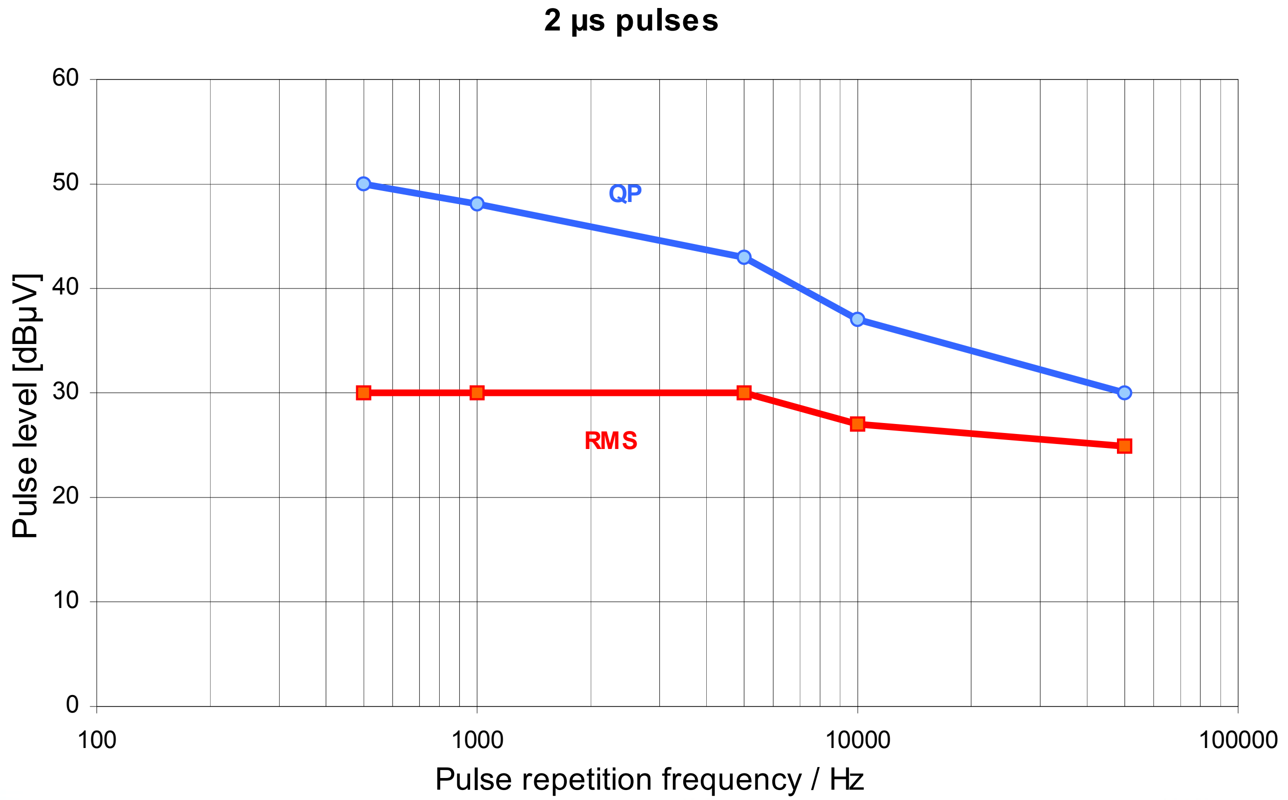
Investigation of weighting characteristics

Band C/D: Arithmetic simulation by Stenumgaard (Sweden)
BPSK modulation with convolution coding similar to DVB-T
R = Code Rate, K = number of shift register steps



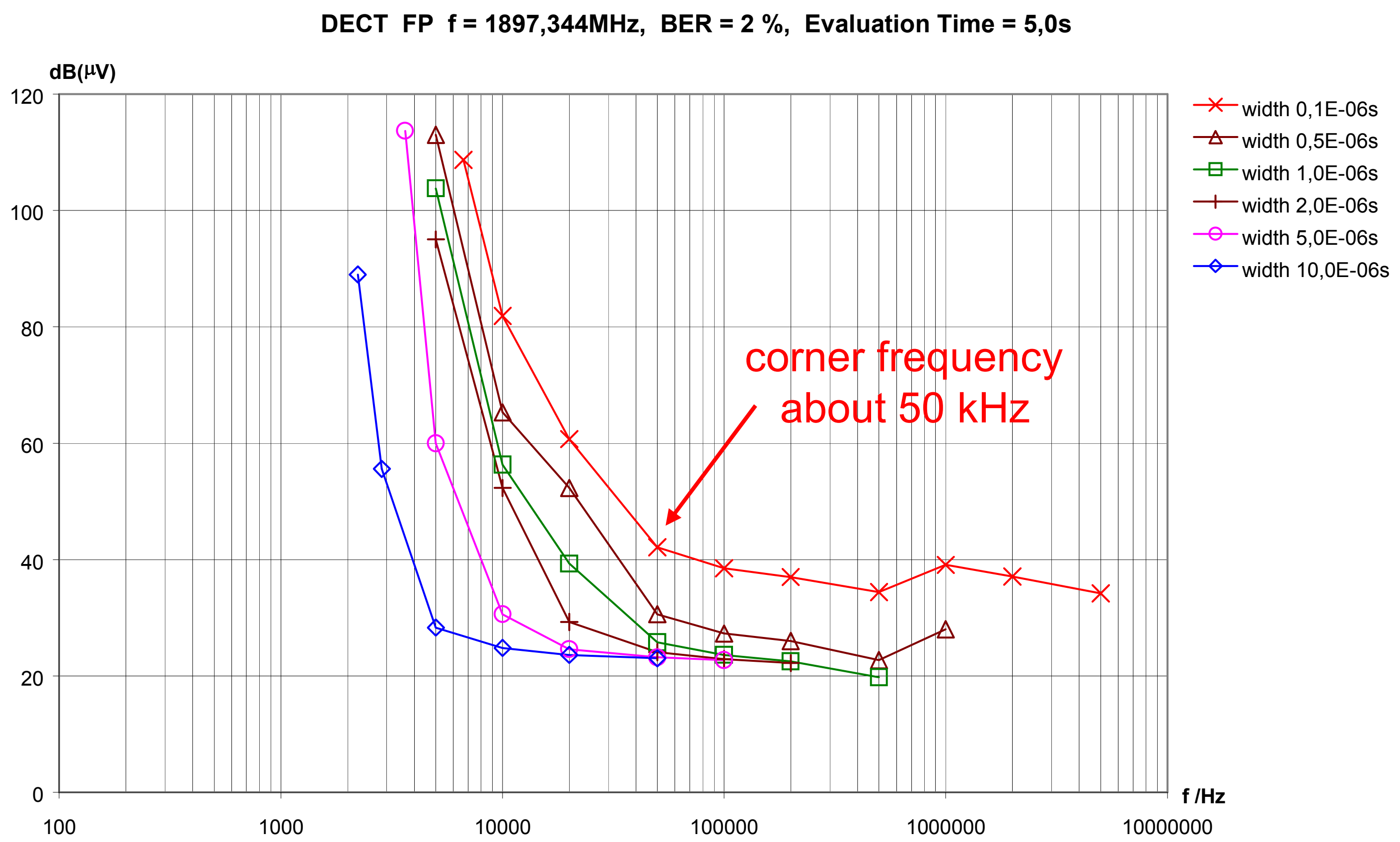
Investigation of weighting characteristics

Band C/D: FM (analogue modulation; keeps on air beyond 2010)
Disturbance level measured with RMS and QP for constant S/N
Interference Signal Type 2



Investigation of weighting characteristics

Band E: DECT, ADPCM (Adaptive Differential PCM) GMSK
Interference Signal Type 1



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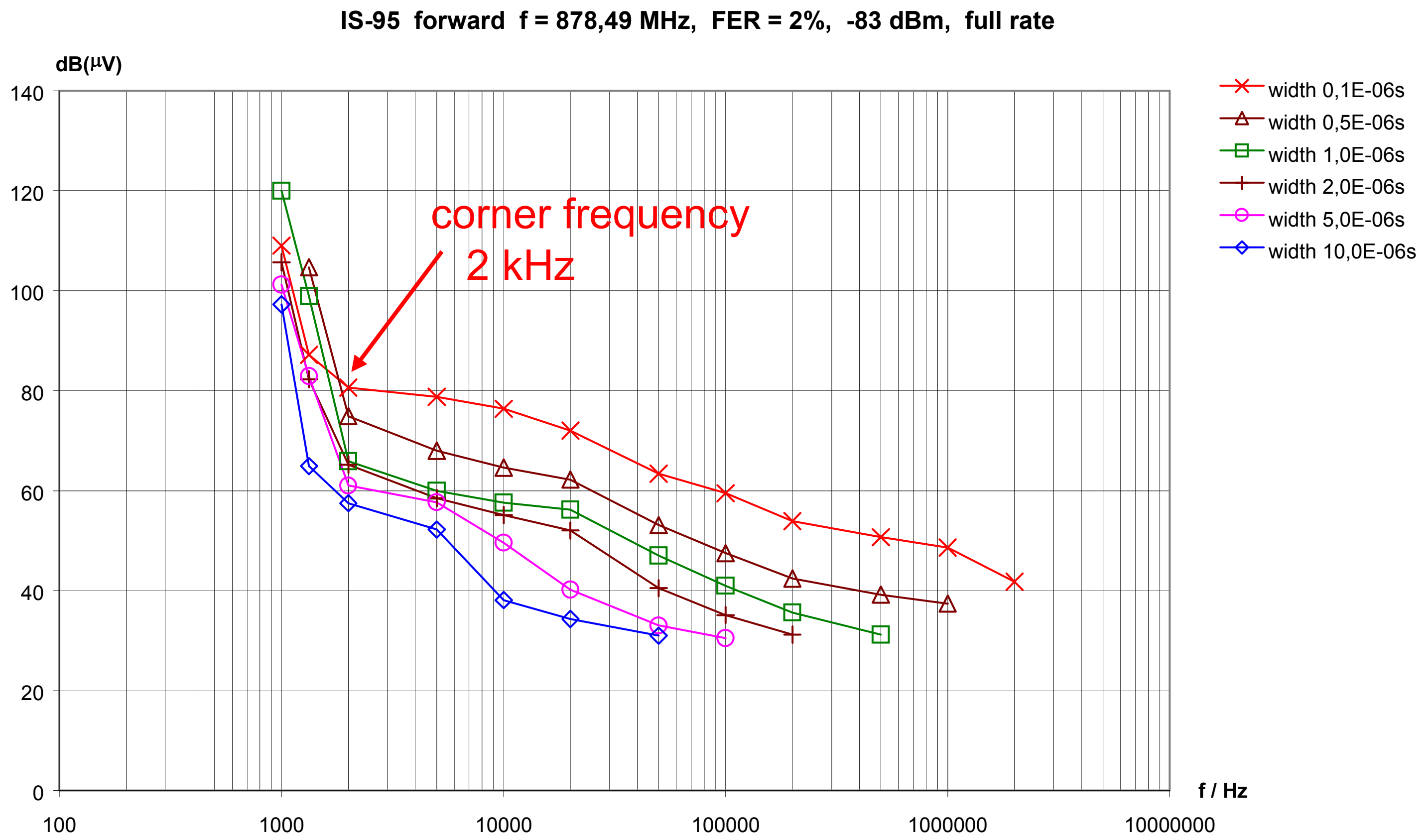
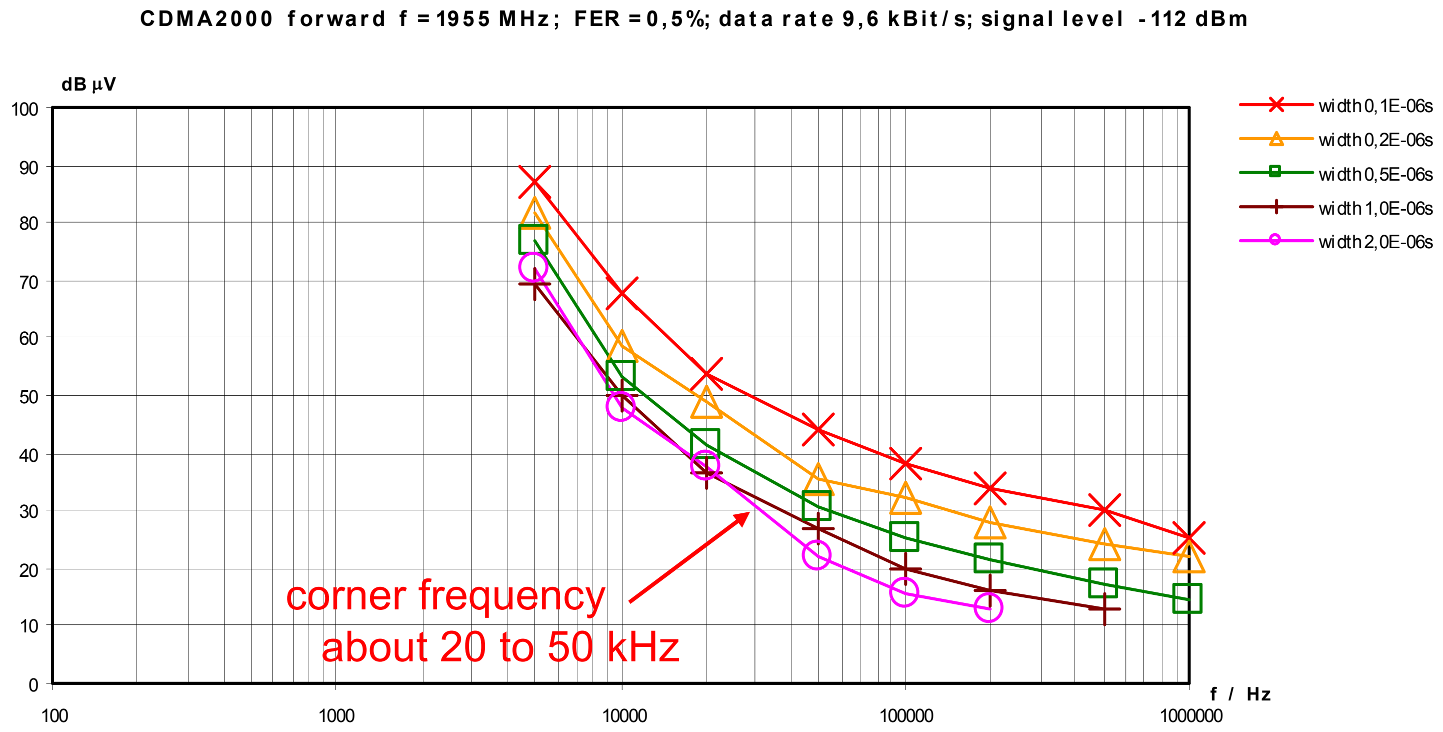
Investigation of weighting characteristics

Band E: CDMA with QPSK modulation (IS-95 and J-STD 008)
Interference Signal Type 1



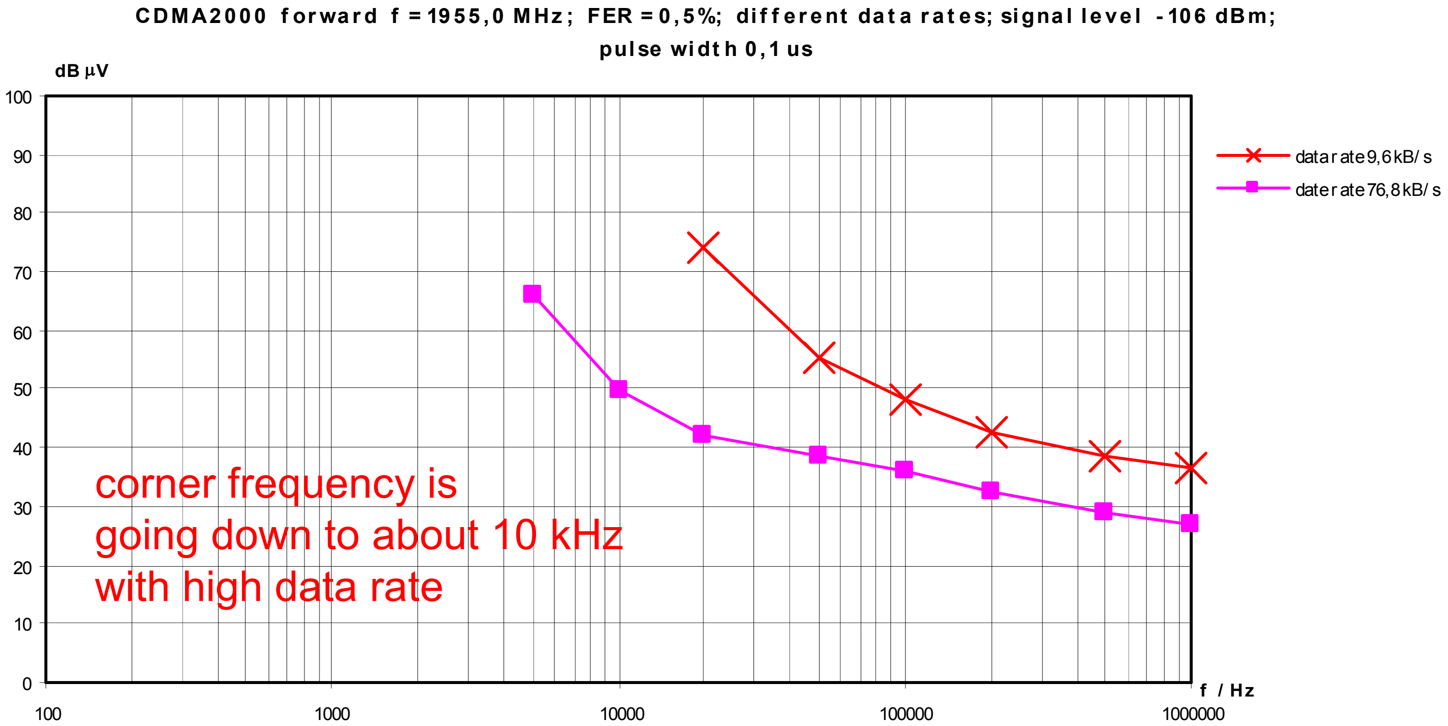
Investigation of weighting characteristics

Band E: 3G system CDMA2000 with low data rate
Interference Signal Type 1



Investigation of weighting characteristics

Band E: CDMA2000 comparison with low and high data rate
Interference Signal Type 1



Evaluation of weighting characteristics

Determination of corner frequency between RMS and AF detection
Band A und B: 10 Hz; Band C/D: 100 Hz; Band E: 1000 Hz

System	Reference	f_c in kHz	Comment
DRM	2, 10	0,1/0,005	10 Hz chosen for feasibility
DVB-T	2, 11	0,1 - 10	f_c depending on w_p, modulation and coding
DAB	2, 9	5	f_c partially depending on w_p
TETRA	9	0,5	narrowband system, mainly used below 1 GHz
GSM 900	7, 8, 9	1,5	above f_c very close to rms
FM	(2) unpubl.	< 0,5	weighting characteristics follows rms down to 0,5 kHz
GSM 1800	7, 8, 9	1,5	above f_c very close to rms
DECT	9	50	above f_c flatter than rms
IS-95	9	2	very similar to J-STD 008; above f_c close to rms
J-STD 008	9	5	very similar to IS-95; above f_c close to rms
CDMA2000	9	50	data rate 9,6 kb/s; above f_c, curves are very close to rms
CDMA2000	9	10	data rate 76,8 kb/s; above f_c, curves are very close to rms

Construction – CISPR-RMS Detector

Measurement bandwidth:

Band A: 200 Hz, Band B: 9 kHz, Band C/D: 120 kHz, Band E: 1 MHz

Weighting functions for the shortest possible pulse width

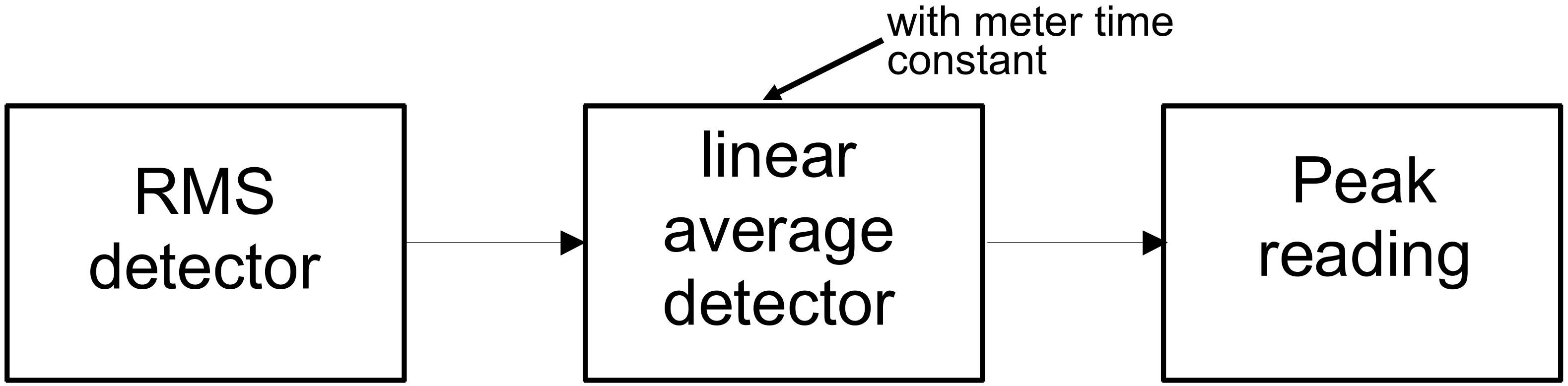
Construction – CISPR-RMS Detector

1. RMS detector that **continuously determines r.m.s. values** during periods of time equal to the reciprocal of the corner frequency *fc*
(example: 1 ms for Band E with corner frequency = 1kHz)

2. Followed by a linear Average detector with meter time constant

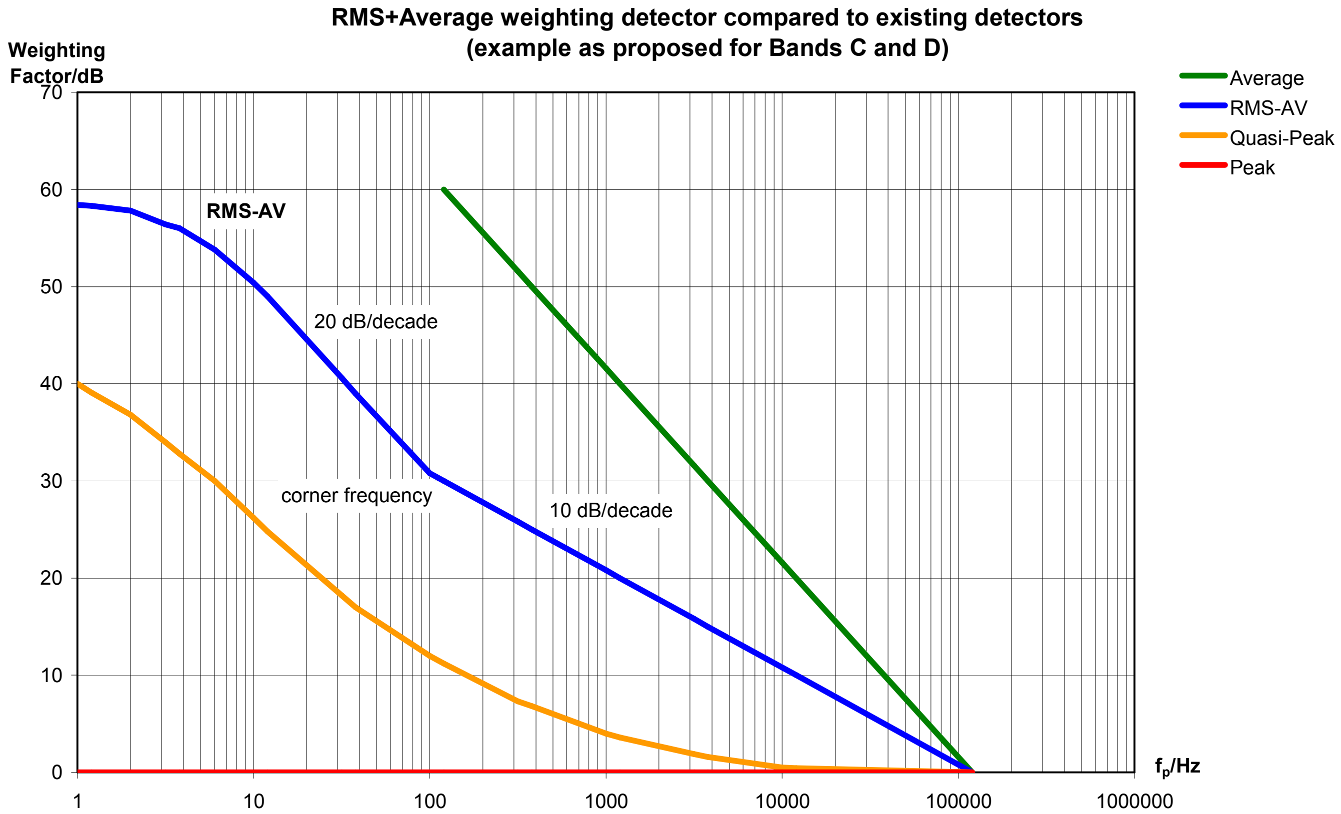
3. Moving coil-instrument for Average detection with meter time constant has unsteady indication if f_p < 5 Hz

4. Peak reading takes the maximum of the alternating value



Consequences for measurement of typ. disturbances

The weighting function of the CISPR-RMS detector lies in between Average und Quasi-Peak detector (example Band C/D)



Consequences for measurement of typ. disturbances

There is a realistic hope to have only one limit value for one detector in the future. Limit values for the RMS-Average detector may about 4 dB above the current limits for Average detection.

EUT	*f* in MHz	Average value in dB(µV)	RMS-Average minus Average in dB	Quasi-peak minus Average in dB
Hairdryer	1,0	32,75	+3,39	+11,81
Hairdryer	35	33,80	+8,49	+26,84
Washing machine 1	0,768	20,67	+4,74	+21,79
Washing machine 1	124	13,68	+3,80	+19,91
Washing machine 2	0,71	26,98	+1,71	+9,22
Washing machine 2	116	18,90	+3,92	+22,04

Standardization Update – CISPR-RMS Detector

After long development (start in 1991):

- Background material to weighting detector measurements has been published in **Amendment 2:2006 to CISPR 16-3:2003**
- Specification of RMS-average measuring receiver has been published in **Amendment 2:2007 to CISPR 16-1-1:2006**
(replaces the existing RMS measuring receiver)
- Round Robin Test in CISPR/I/WG1 to CISPR 13 took place,
Round Robin Test in CISPR/I/WG2 to CISPR 32 took place
- Topic of new working project in CISPR/I (CISPR/I/232/CD):
Draft CISPR 13 A3 Ed.4: “Introduction of the RMS-average detector as an alternative to quasi-peak and average detector limits“
→ CD has been confirmed, next stage CDV (Committee Draft for Vote)

Standardization Update – CISPR-RMS Detector

The RMS Detector was already under discussion when CISPR 1 was published in 1972, the introductory note states:

> "The majority of interference shows itself in the form of repeated impulses. The early work of the CISPR led to the conclusion that the best measure of the effect of this type of interference would be made by apparatus employing a quasi-peak type of voltmeter. Subsequent experience has shown that an ***r.m.s. voltmeter might give a more accurate assessment*** but the quasi-peak detector has been retained for the following reasons:
> (1) the variation of indication with prf agrees reasonably well with that of an r.m.s. meter ... within the audio-frequency range
> (2) extensive practical experience ... over a period of many years with the qp type of instrument
> (3) a large number of interference measuring sets employing this type of voltmeter .. in existence"

Nowadays the majority of disturbance sources may not contain repeated pulses, but still a great deal of equipment contains broadband emissions (with repeated pulses) and pulse-modulated narrowband emissions.

Conclusion

If the CISPR-RMS detector will be accepted by CISPR a long development process ends

- **The new detector may**
  → replace Quasi-Peak and Average detectors in the frequency range below 1 GHz
  → have a more appropriate weighting in the range above 1 GHz

- **Speed up measurements**
  → A long measurement time is not necessary for the majority of measurements (similar to Average detector)
  → Instrument time constant for pulse repetition frequencies < 10 Hz
  → further experience are necessary

- **Application also for spurious emissions reasonable**

Thank you for your attention !