ENAMS

Electrical **N**oise **A**rea **M**easurement **S**ystem

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Inhalt

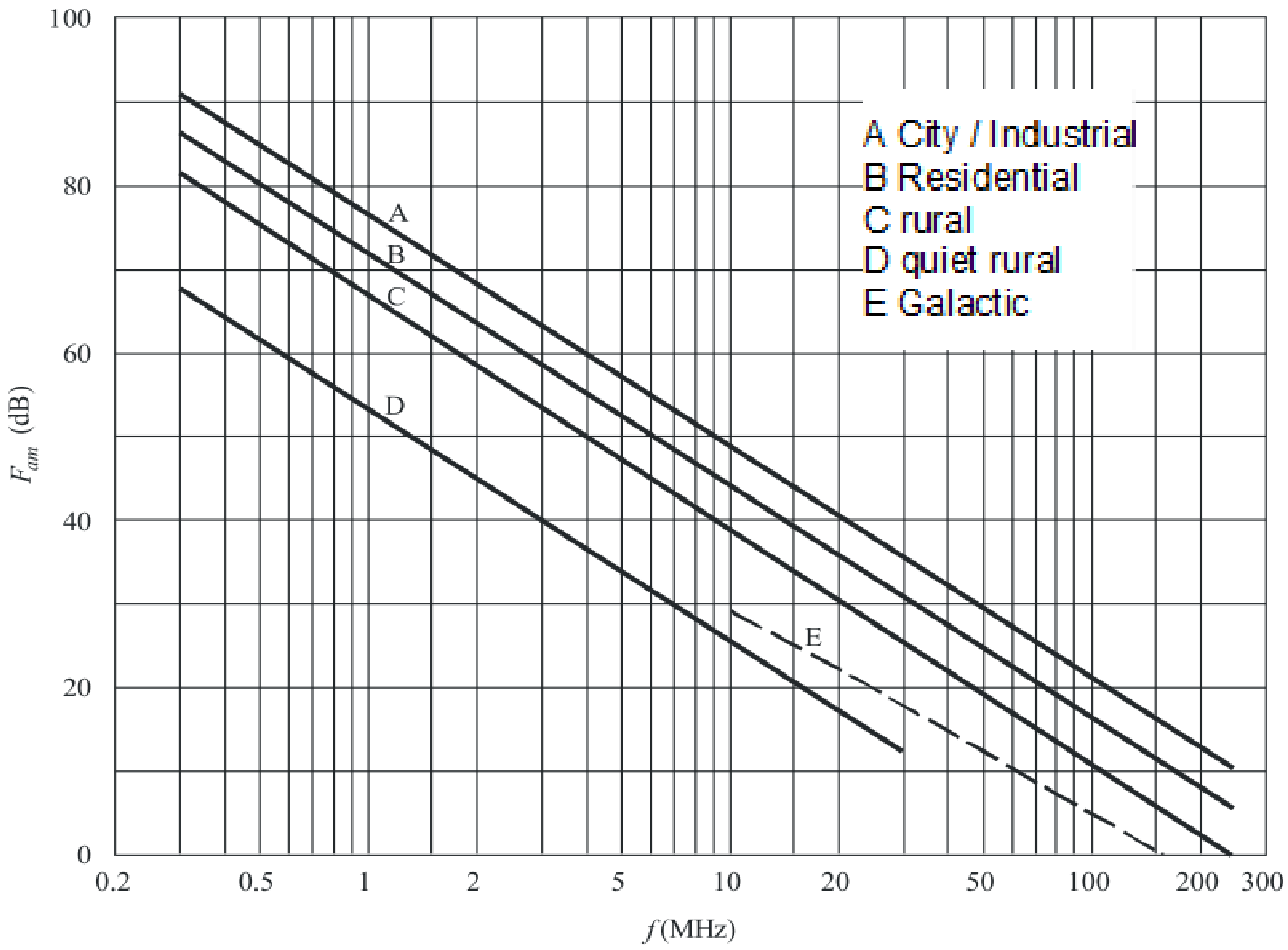
What is ENAMS ?

ENAMS is an interference field strength measurement system, i.e. an automatic receiving system distributed over Germany (and some European and non-European countries) for the detection of the interference level in the frequency range of 66 kHz - 31 MHz.

Why do we need ENAMS ?

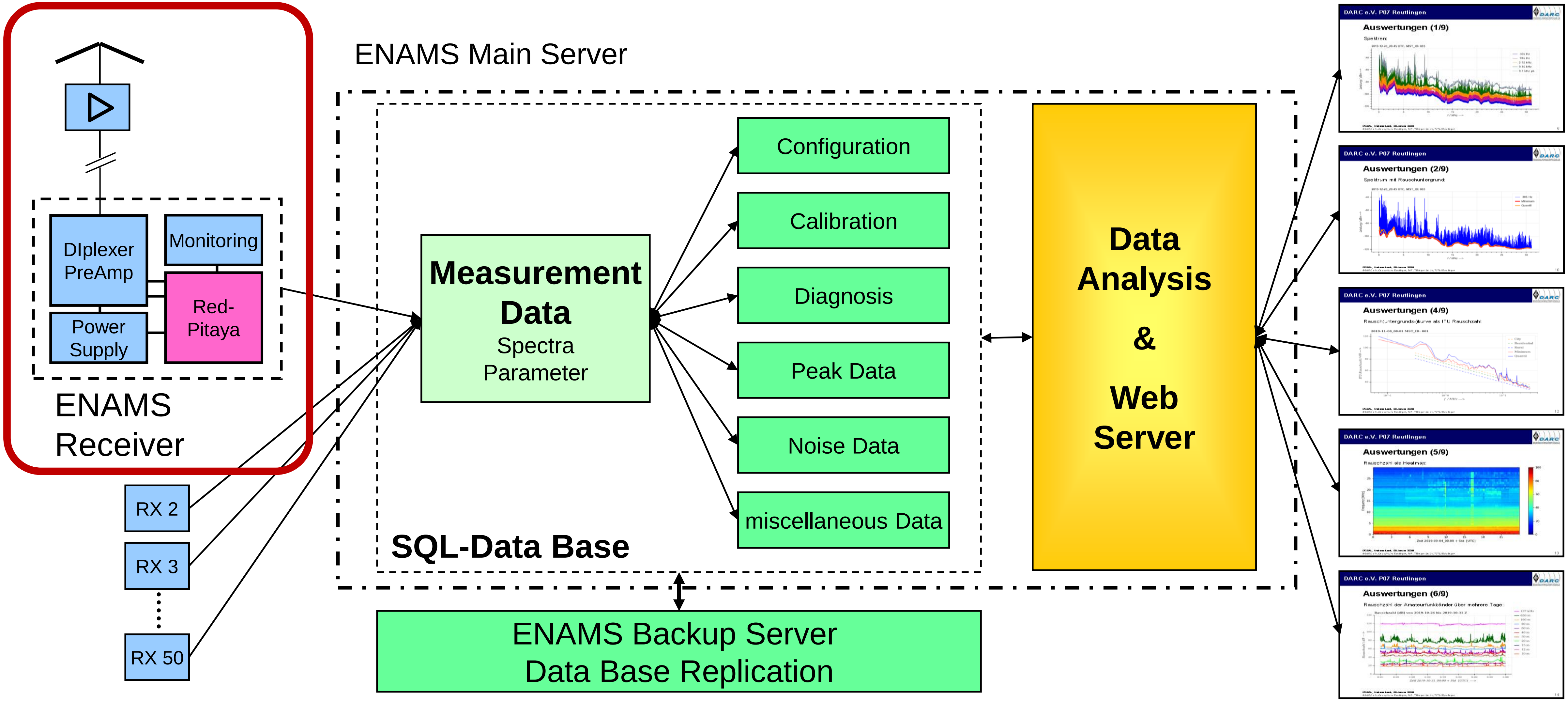
The ENAMS project was started by the DARC e.V., because the general interference measurements by the German Federal Network Agency (BNetzA) were no longer carried out after 2011 and the increase of the general interference level in the last years by the strong spreading of interfering electronics in residential and commercial areas is no longer documented.
With ENAMS amateur radio is thus in a position to measure the interference level relevant to it and to bring it into the in the discussion about limit values. In some cases, unsuitable measurement systems and procedures, which leads to false results, were used. Therefore it is in the responsibility of amateur radio to present the correct measured values and interference situations.

ENAMS – ITU Noise Measurements

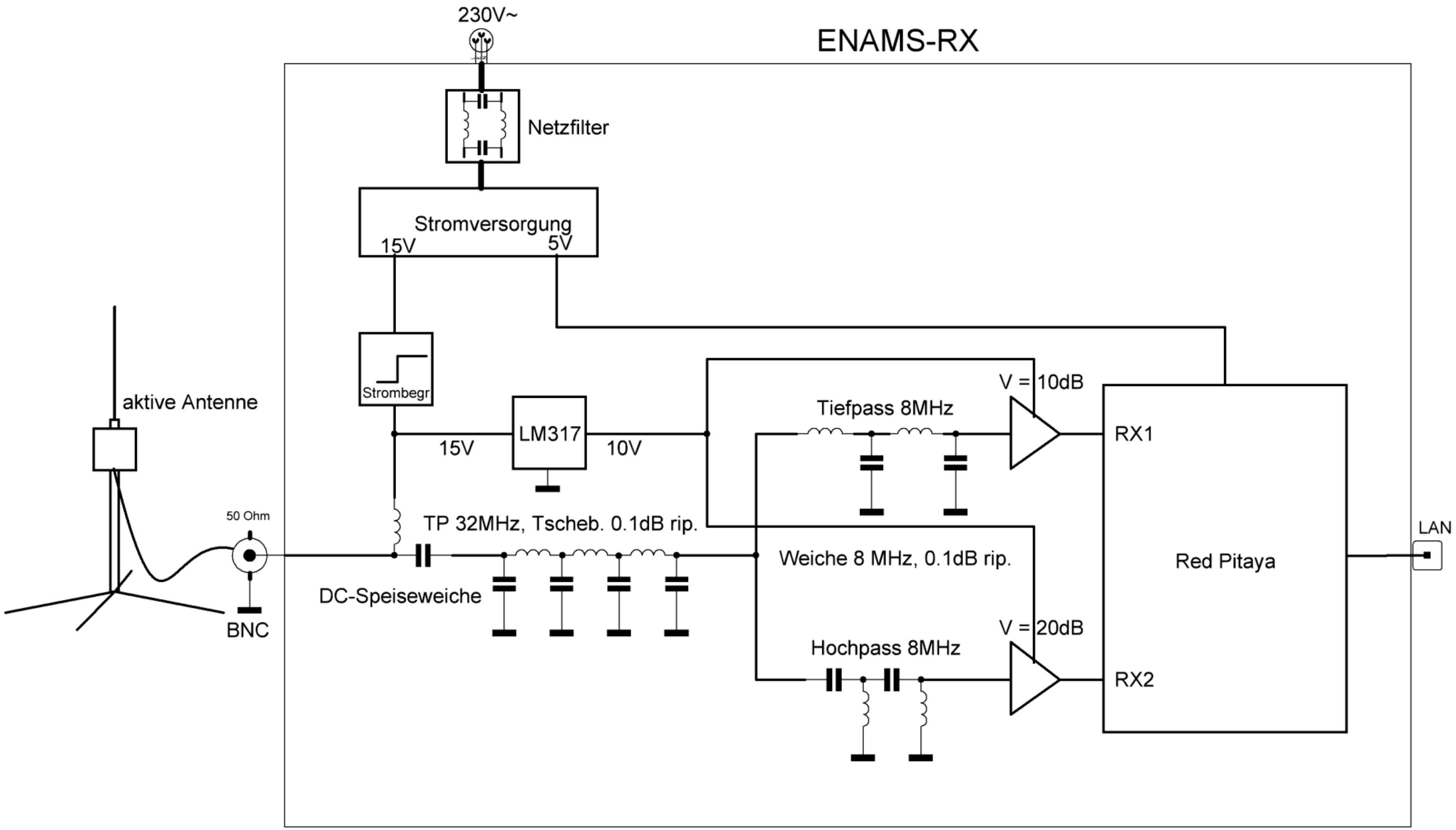


- First systematic measurements in the 1950s with vertical monopole antennas on the ground
- The ITU diagrams (P-372) with the noise categories quiet rural, rural, residential and city/industrial were created from individual measurements of the interference levels
- The diagrams in double-logarithmic representation form the basis of all interference observations up to now
- The diagrams show the average noise floor of all existing disturbances, natural or man-made, as noise figure of a lossless adjusted λ/4 monopole

ENAMS – System-Diagram



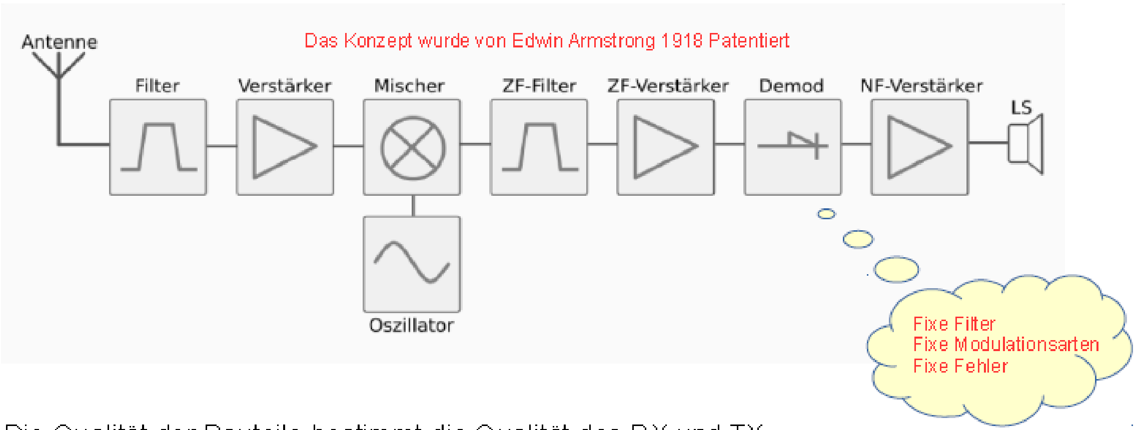
ENAMS Receiver Block Diagram



J. Logemann, DL2NI, CQ DL 08/21

Kein SDR-RX: Der Superhet

Klassischer RX: Hardware Defined Radio



- Die Qualität der Bauteile bestimmt die Qualität des RX und TX
- **Schwer zu ändern:** HW Filter, fixe Modulationsarten (meist nur AM, FM, SSB, CW)
- Die Alterung der Bauteile verändert die Eigenschaften des RX

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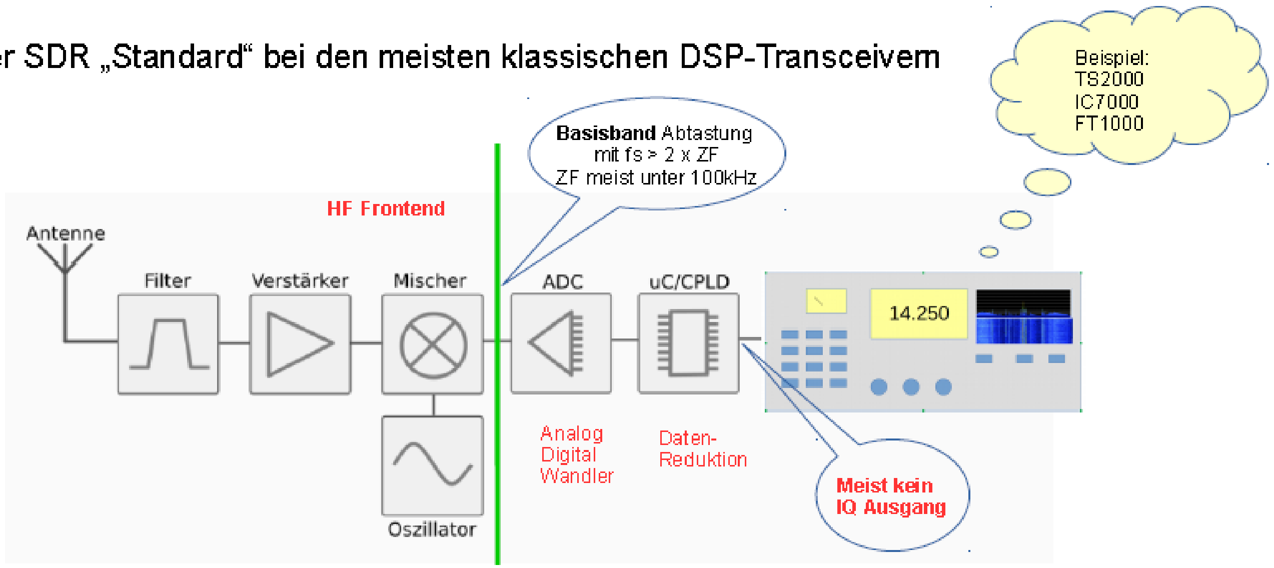
Noch kein „echter" SDR

Der SDR „Standard" bei den meisten klassischen DSP-Transceivern



- Hier wird bereits im Transceiver bei einer relativ niedrigen ZF digitalisiert
- Die Geräte haben eine „normale" Frontplatte – oder auch nicht ->TS2000X
- Teilweise auch mit Wasserfall und Spektrum Anzeige, aber mit geringer Anzeirebandbreite
- **Vorteil:** Digitale Filter, weitere Modulationsarten wie RTTY und CW Decoder direkt integriert
- **Nachteil:** Nur über Firmwareupdates änderbar

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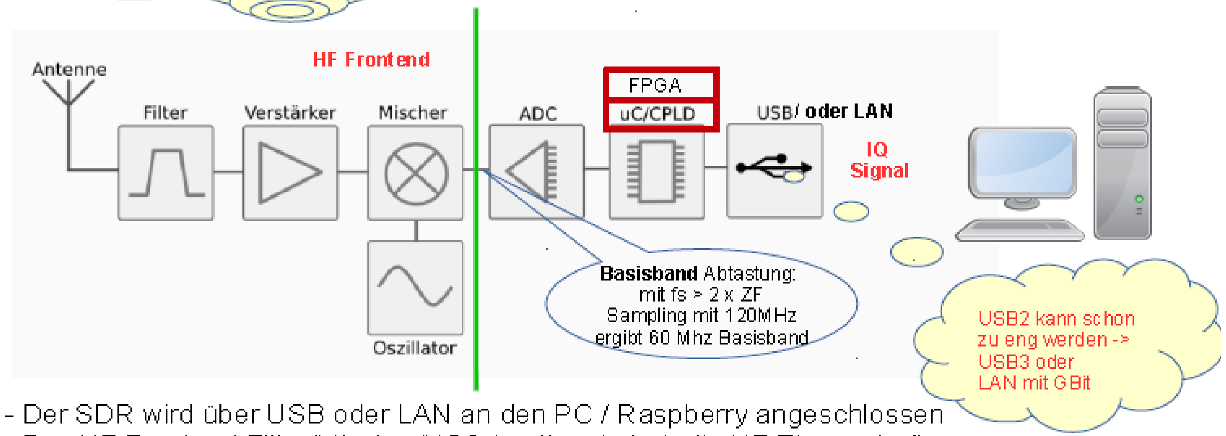
SDR Measurement Receiver (based on Red Pitaya)

Fast schon ein „echter" SDR

Braucht einen PC.
Hat aber noch einen echten HF Teil.
Geht dafür bis einige Ghz !!!

RTL Stick 1.7 Ghz (ohne cpld)
Hack-RF 6 GHz (cpld)
Lime SDR 3,8 GHz (fpga) Dual RX/TX
PlutoSDR 6 Ghz (fpga) Linux intern
Und viele Andere ...



- Der SDR wird über USB oder LAN an den PC / Raspberry angeschlossen
- Das HF Frontend Filter/Mischer/VCO bestimmt stark die HF Eigenschaften
- Verwendet werden Analog Digital Converter (ADC) bis 80 Mhz Basisbandbreite
- Die eigentliche Signalverarbeitung erfolgt im PC / Raspberry → sehr Flexibel
- Sehr viele Open Source Programme verfügbar

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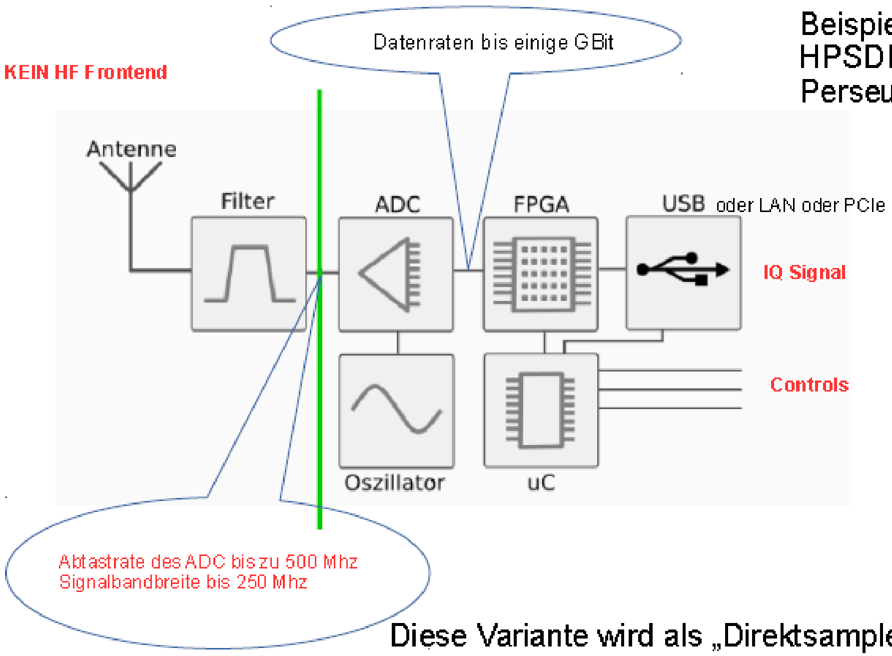
Der „echte" SDR



Beispiel:
HPSDR (Mercury, Hermes), Perseus, Kiwi-SDR ...

Mit Bedienteil:
z.B: IC7300
36 kHz ZF !

Web Frontend:
z.B: KIWI

PC Programme:
Windows
Linux Programme
GNURadio
...

Diese Variante wird als „Direktsampler" bezeichnet

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SDR Measurement Receiver (based on Red Pitaya)

- Digitale Mischung:

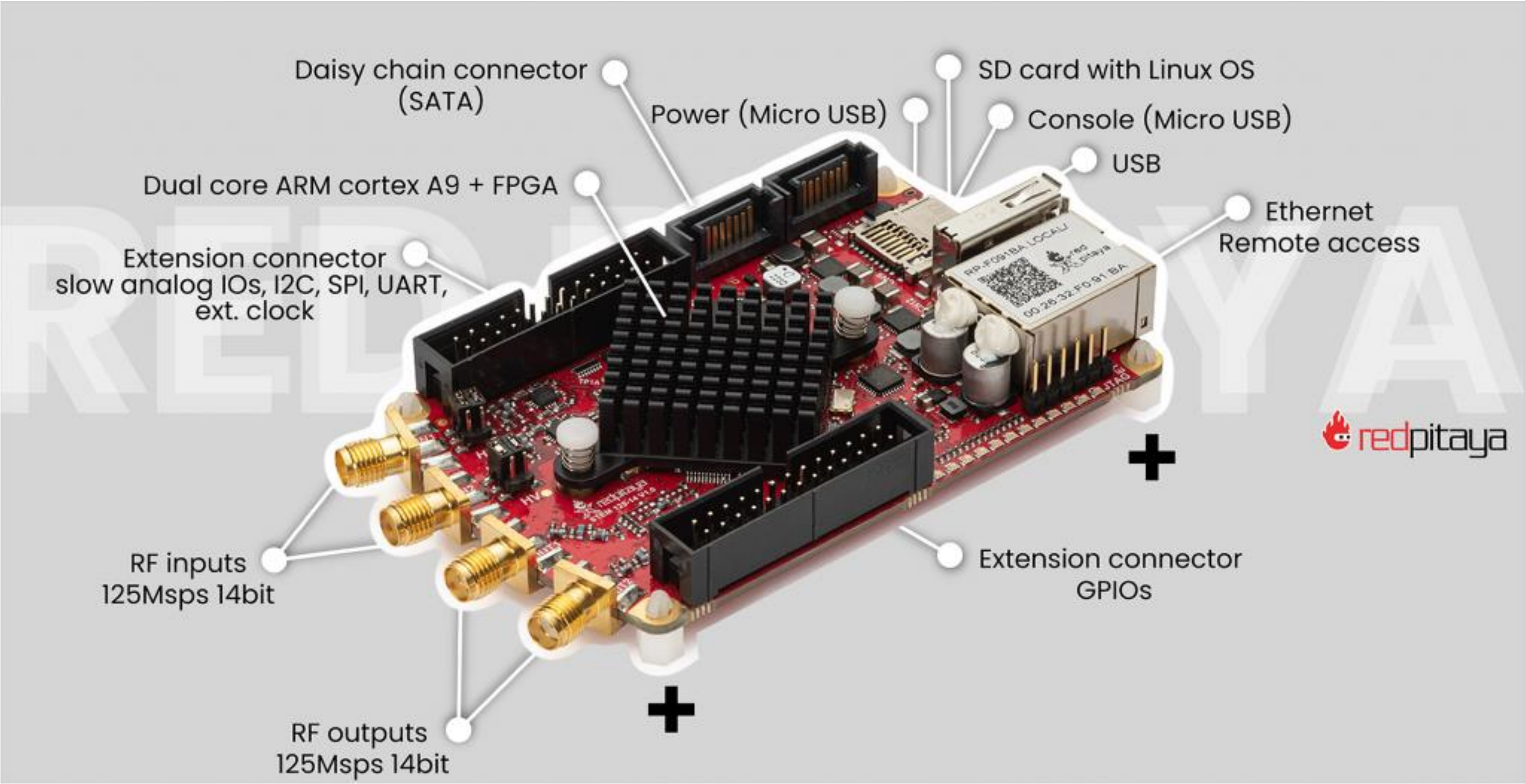
$$\cos(f_{RX}) * \sin(f_{LO}) = ½\{ \sin(f_{RX} - f_{LO}) + \sin(f_{RX} + f_{LO}) \}$$
$$\cos(f_{RX}) * \cos(f_{LO}) = ½\{ \cos(f_{RX} - f_{LO}) + \cos(f_{RX} + f_{LO}) \}$$

- Digitale Mischung
  - fungiert als (Abwärts-)Mischer und liefert die Differenz- und Summenfrequenz f_{RX} und f_{LO}
  - erzeugt ein I/Q-Signal der Differenz- und Summenfrequenz

- Nachfolgende Stufen:
  - Tiefpassfilter (ein oder mehrere)
  - Dezimierer (Nyquist-Theorem: Abtastrate mind. 2 x Maximalfrequenz = Grenzfrequenz TP)
  - Demodulator

Bei ENAMS ist der Demodulator durch eine FFT ersetzt, da das Leistungsspektrum gemessen werden soll

SDR Measurement Receiver (based on Red Pitaya)



Kenndaten:

Processor	Dual-Core ARM Cortex-A9
FPGA	Xilinx Zynq 7010
RAM	512MB (4Gb)
System memory	Micro SD up to 32GB

RF Inputs

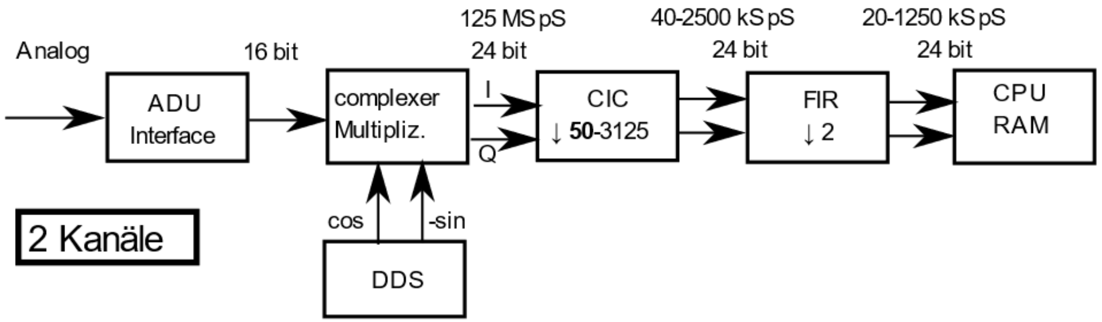
Channels	2
Sample rate	125MS/s
ADC resolution	14bit
Full voltage range	+-1V / +-20V
Input coupling	DC
Bandwidth	DC-60MHz

RF Outputs

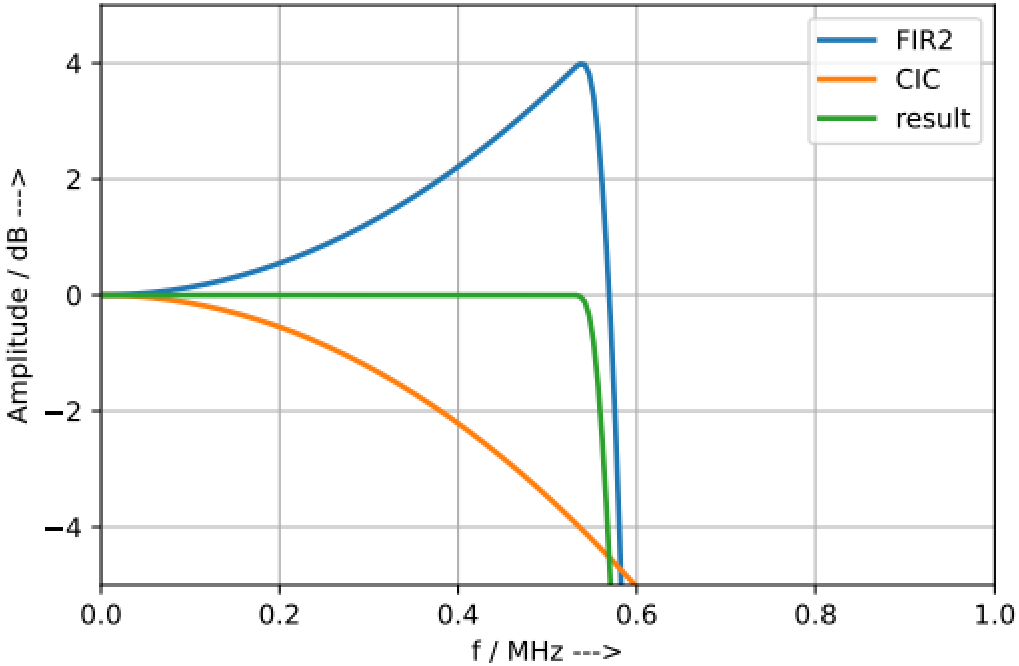
Channels	2
Sample rate	125MS/s
DAC resolution	14 bit
Full voltage range	+-1V
Load impedance	50 ohm
Shortcut protection	Yes
Rising/falling time	2V / 10ns
Bandwidth	DC – 50MHz

SDR Measurement Receiver (based on Red Pitaya)

Red Pitaya SDR receiver by Pavel Denim

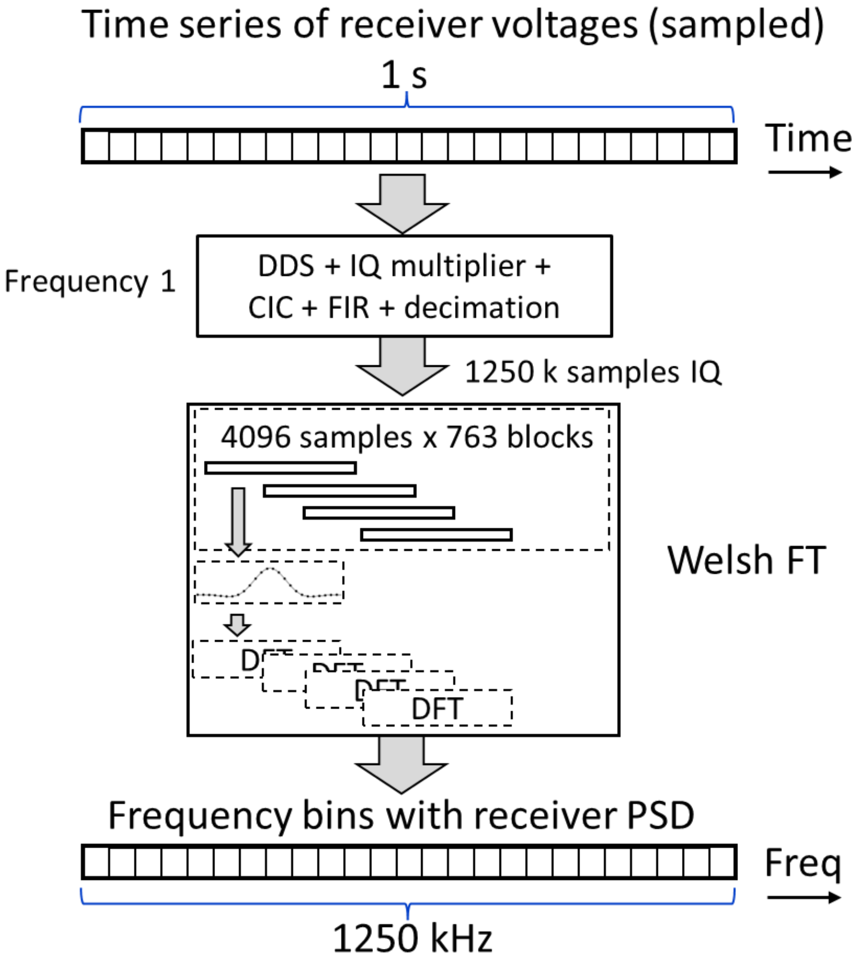


Modified Filter Parameters for large bandwidth



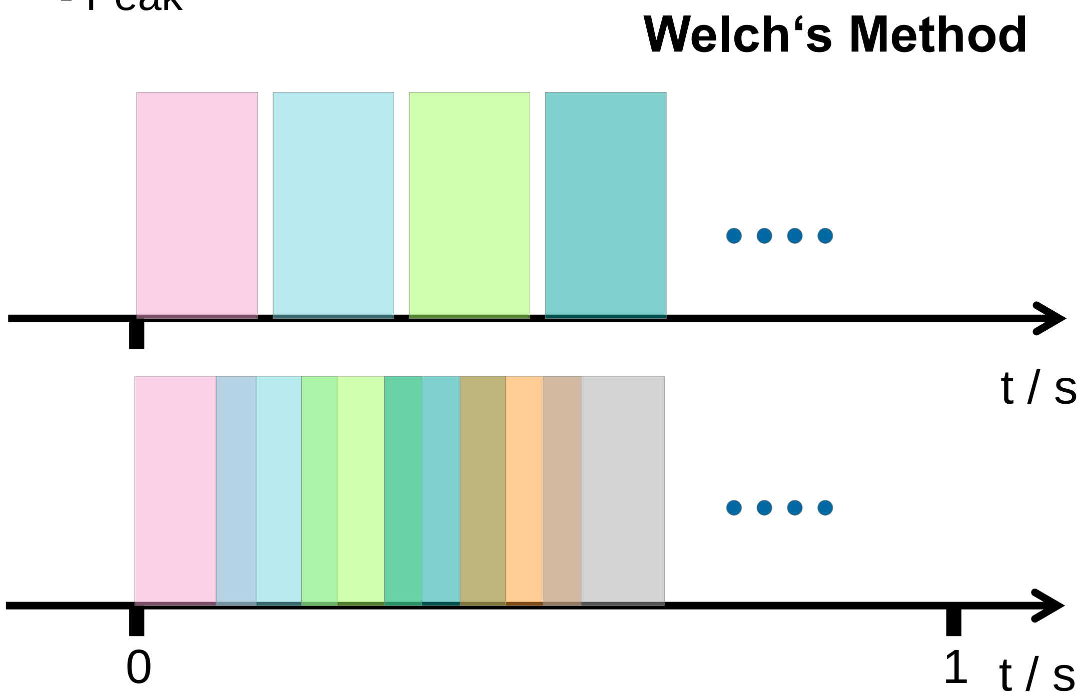
M. Hartje, DK5HH, CQ DL 09/21

ENAMS SDR Measurement Procedure

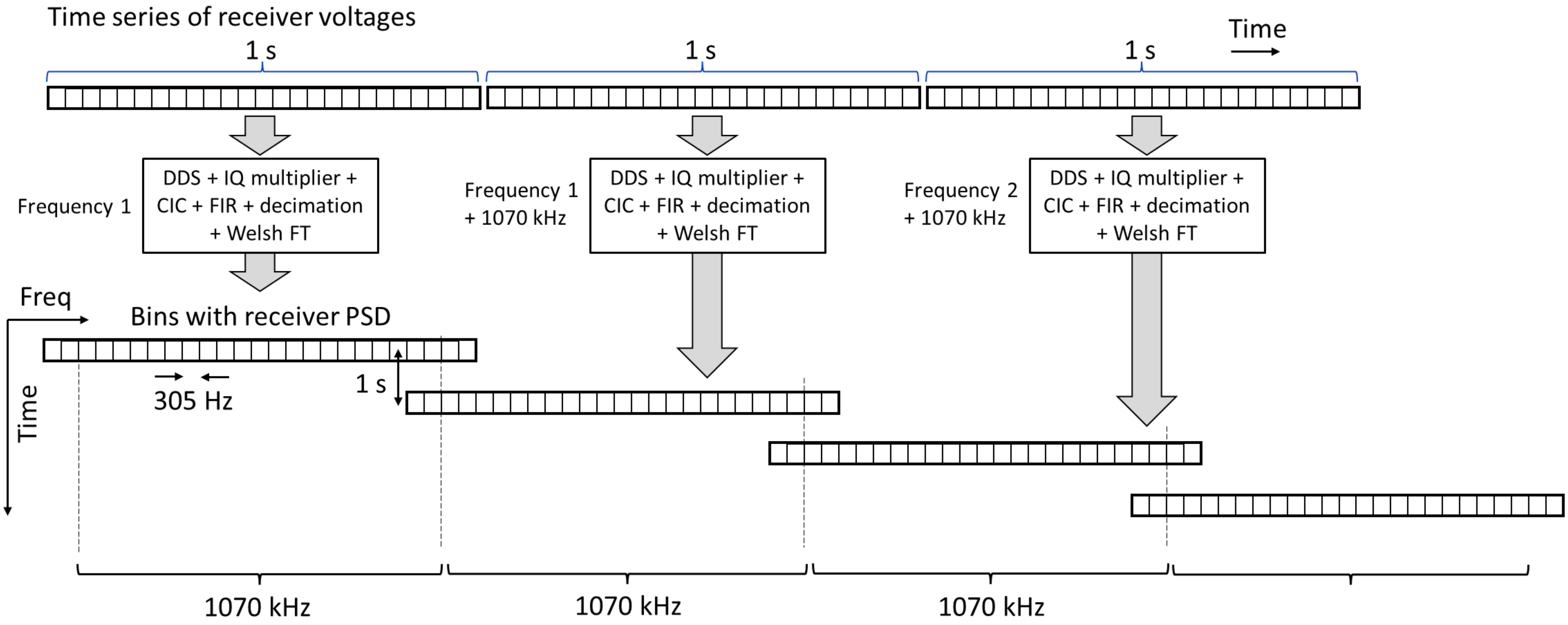


Time division of the recording with overlapping

- Weighting with window function
- FFT of each section
- Evaluation of all FFT sections together over time
  - RMS
  - Peak

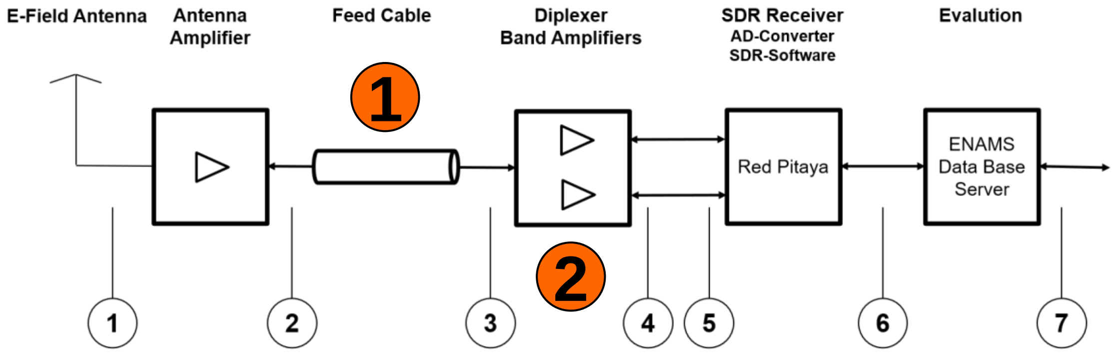


ENAMS HiRes Measurement Principle



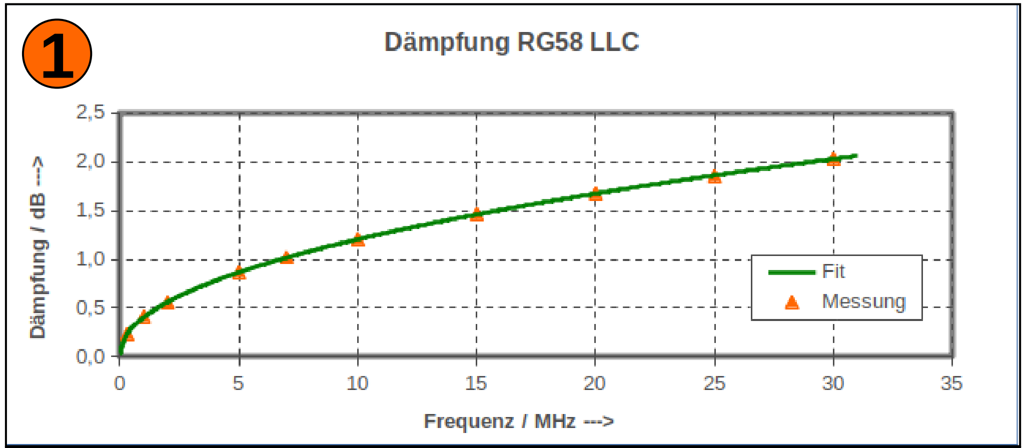
Analyse der Meßgerätefähigkeit und Meßtoleranzen

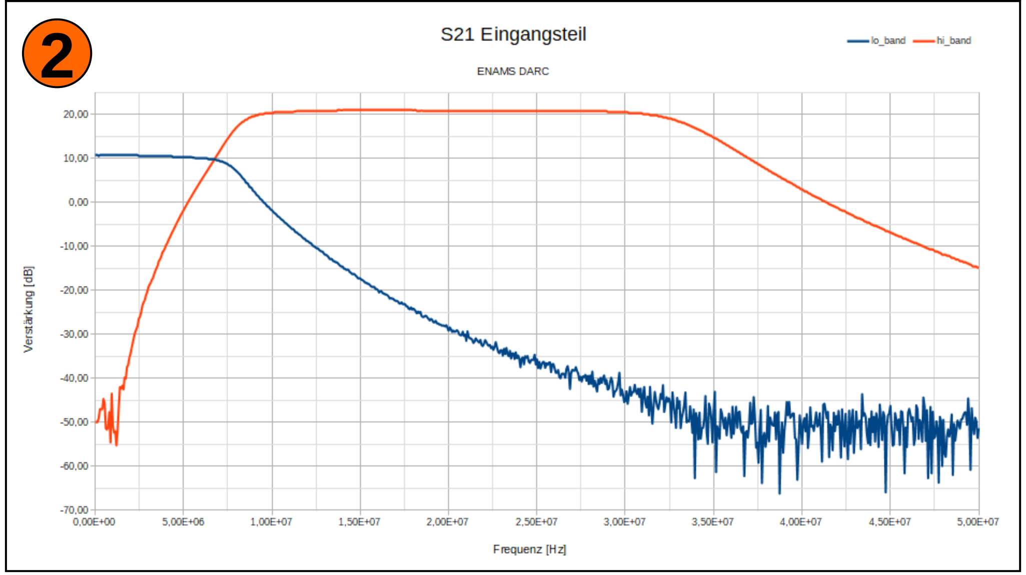
- Untersuchung der Linearität, des Frequenzgangs, Temperaturabhängigkeit und Bauteiletoleranzen pro Systemelement und für das ganze System
- Analyse der Empfängerrauschzahl und Empfindlichkeit des Empfängers
- Die Übertragungsmessfunktion:



$$P_{50\Omega} = C_{SDR}(E_{Ant}, f, T, M) \cdot V_{Filter}(E_{Ant}, f, T, M) \cdot D_{Kabel}(E_{Ant}, f, T, M) \cdot k_{Ant}(E_{Ant}, f, T, M) \cdot E_{Ant}(f)$$

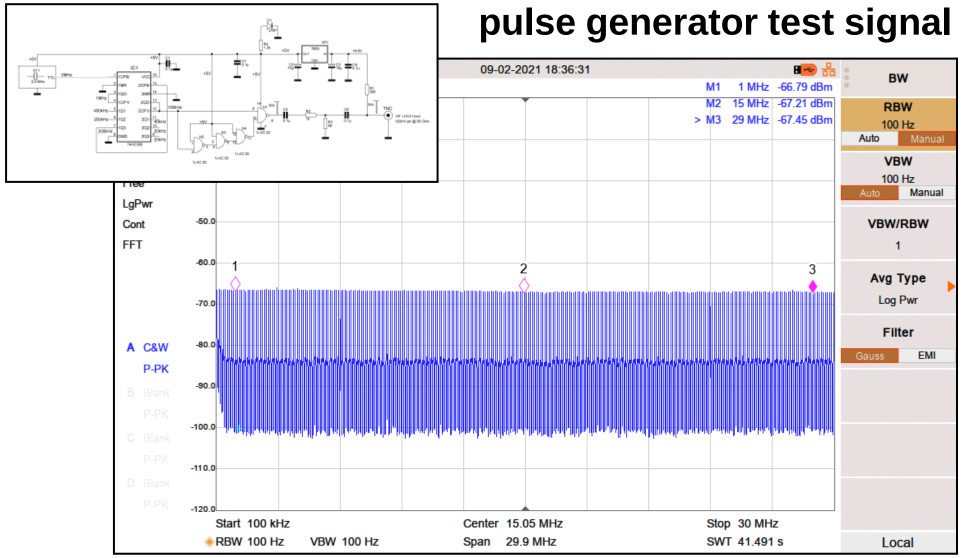
$$log(P_{50\Omega}) = log(C_{SDR}) + log(V_{Filter}) + log(D_{Kabel}) + log(k_{Ant}) + log\big(E_{Ant}(f)\big)$$

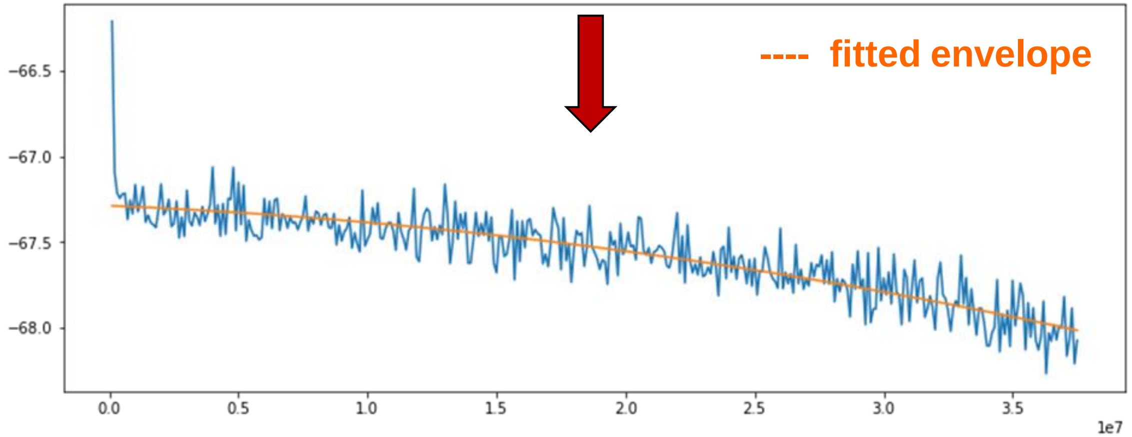


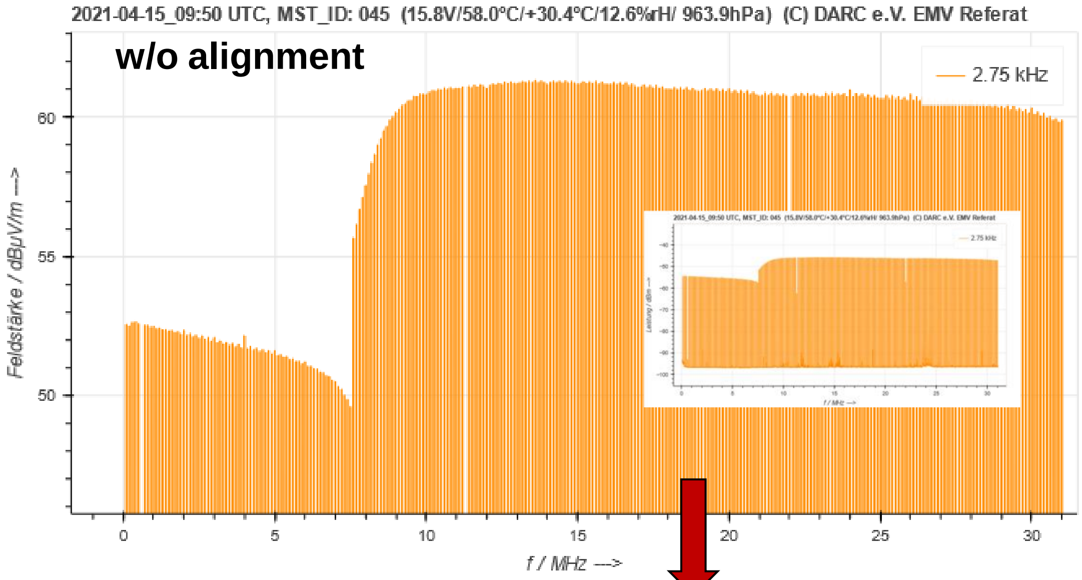


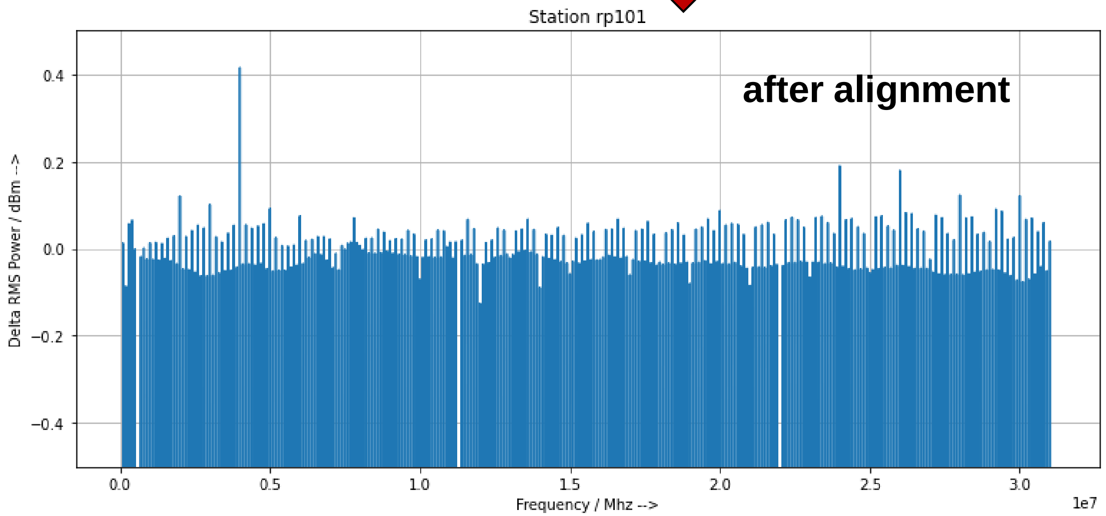
Das Abgleichverfahren

pulse generator test signal









DG8AL, Andreas Lock, 01. April, 2023

Receiver Characteristics

- Minimum bandwidth: 305 Hz (larger bandwidth w/ convolution w/ window function)
- Dynamic range: ≈ 106 dB
- Linearity: better than 0.2 dB at dynamic range > 90 dB
- Sensitivity: approx. –120 dBm
- Min. Discernible Noise Figure 20dB (@ 30MHz)
- Gain per receiver, frequency response of diplexer and damping of feed cable are compensated individually by software (see alignment procedure)
- Temperature dependency and component tolerances contribute to the overall tolerances
- The electrical measurement tolerance for the individual receiver is better than ± 0,2 dB, the tolerance for the whole ENAMS system (all 50 receivers) is better than ± 2,5 dB

Vielen Dank für die Aufmerksamkeit !

Fragen