IEEE MTT-S Hyderabad Chapter
Sponsors Speaker Bureau Talk

Sir J C Bose Memorial Lecture Event
December 02, 2016

Next Generation Networks: Software Defined Radio - Emerging Trends

By

Prof. Dr. Ing. habil Ulrich L. Rohde

Brandenburg University of Technology, Cottbus, Germany

Bavarian Academy of Science, Munich, Germany

Indian Institute of Technology, Delhi, India

Oradea University, Romania

About Ulrich L. Rohde

Brandenburgische Technische Universität Cottbus - Senftenberg

Fakultät 1

Arbeitsgebiet Hochfrequenz- und Mikrowellenschaltungstechnik

Professor Dr.-Ing. habil Dr. h.c. mult. Ulrich L. Rohde

ROHDE&SCHWARZ

Rohde & Schwarz GmbH & Co KG is an international electronics group specialized in the fields of electronic test equipment, broadcast & media, cybersecurity, radio-monitoring and radiolocation, and radio-communication.

Founder: Lothar Rohde

Founded: November 17, 1933, Munich, Germany

Biography | Publications | Awards | **Contact**

Hochfrequenz- und Mikrowellenschaltungstechnik ▸ Contact

Contact

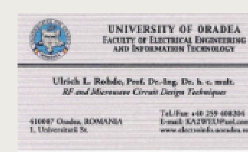
Prof. Dr.-Ing. habil Dr. h.c. mult. Ulrich L. Rohde

building 3A, room 252,
phone +49 (0) 355 69 50 62

ulrich.rohde(at)b-tu.de

- Business Card - Bundeswehr Universitaet München
- Business Card - University of Oradea
- Contact - University of Florida
- Contact - University of Oradea
- Contact - Technische Universität München

Business Cards



Ulrich's House: Antenna Garden for Radios

- First to write paper on Active Antenna
- First to report SDR technology (http://en.wikipedia.org/wiki/Software-defined_radio)
- Oldest living being to write paper in IEEE transaction, "Very Low Noise Transistor Amplifiers in the U.H.F. Band using the Parametric Conversion Mode - Sept 1962".

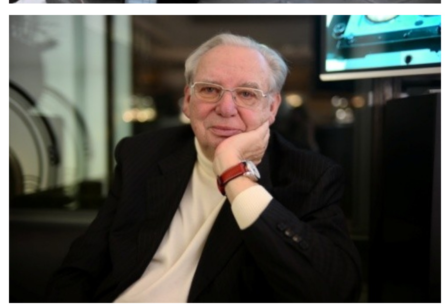
Radio House: Prof. Rohde spends most of his hobby time

Hobby: Antenna for Sailboat

Expensive/Intensive Hobby:
Pilot & US Coast Guard Captain Master License

- **Won more than half dozen time sailboat race**
- **Flew concord aero plane**
- **Provided training to several thousands folks Amateur Radio training/licensing**

Above hobby requires significant amount of knowledge about Antenna technology and propagation dynamics

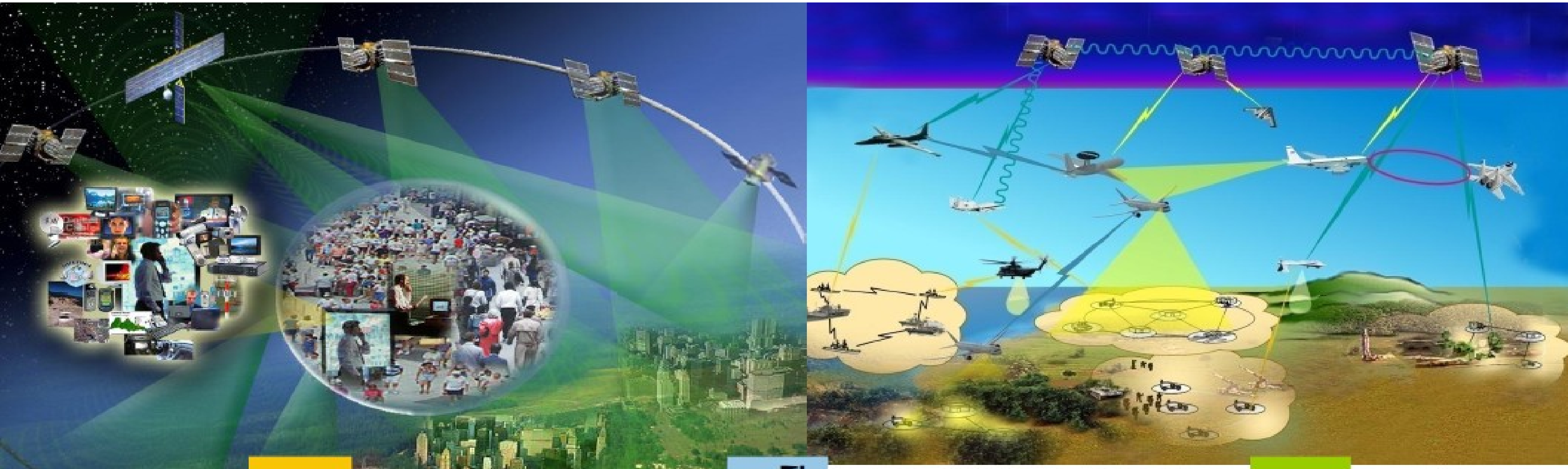


Outline

Presenation is in 2-Part:

- **5 minutes Video: Radio Monitoring using SDR**
- **Presentation: Next Generation Networks**
  - **Radio Monitoring Receivers**
  - **Software Defined Radio**
  - **Analog Frond End: Pros & Cons**
  - **Requirement of Radio Monitoring Receivers**
  - **5G (5th Generation) Cellular Network**
  - **Conclusion**

High Performance Receiver Needed Everywhere !



More Users !

Newer Applications !

Higher Data Rates !

Spectrum Congestion

Looking for ?

Microwave High Performance Monitoring Receiver Solution 20MHz-100GHz ?

Radio Monitoring Receivers

High Dynmaic Range Microwave Monitoring Receivers

- Searching for faults in professional radio networks
- Comprehensive spectrum analysis
- Monitoring of user-specific radio services
- Monitoring on behalf of regulating authorities
- Handoff receivers, i.e. **parallel demodulation** of narrowband signals and simultaneous broadband spectrum scanning=High Dynamic Range
- Critical Parameters: Noise Figure, IP2, IP3, and instantaneous dynamic range

Best solution: ⇨ Software Defined Radio

SDR (Software Defined Radio)

- Definition:

  A Software Defined Radio (SDR) is a communicaton system,   where the major part of signal processing components, typically realized in hardware are instead replaced by digital algorithms, written in software“ (FPGA).

SDR

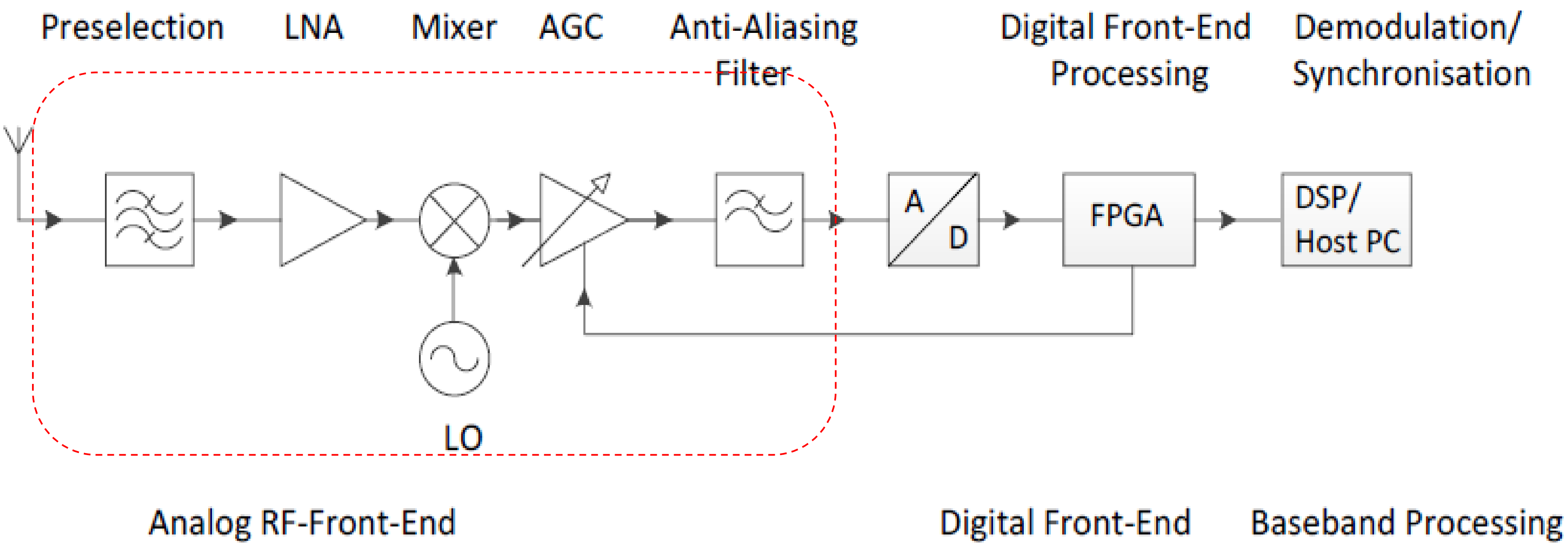
- Want to make all parameters digitally tunable
  - What Parameters?
    - **RX/TX Frequency**
    - **Bandwidth**
    - **Impedance Match**

- First Reported Publication (February 26-28, 1985):

  Ulrich L. Rohde, Digital HF Radio: “A Sampling of Techniques, presented at the Third International Conference on HF Communication Systems and Techniques”, London, England, February 26-28, 1985, Classified Session (U.S Secret).
  http://en.wikipedia.org/wiki/Software-defined_radio

Typical Microwave Receiver

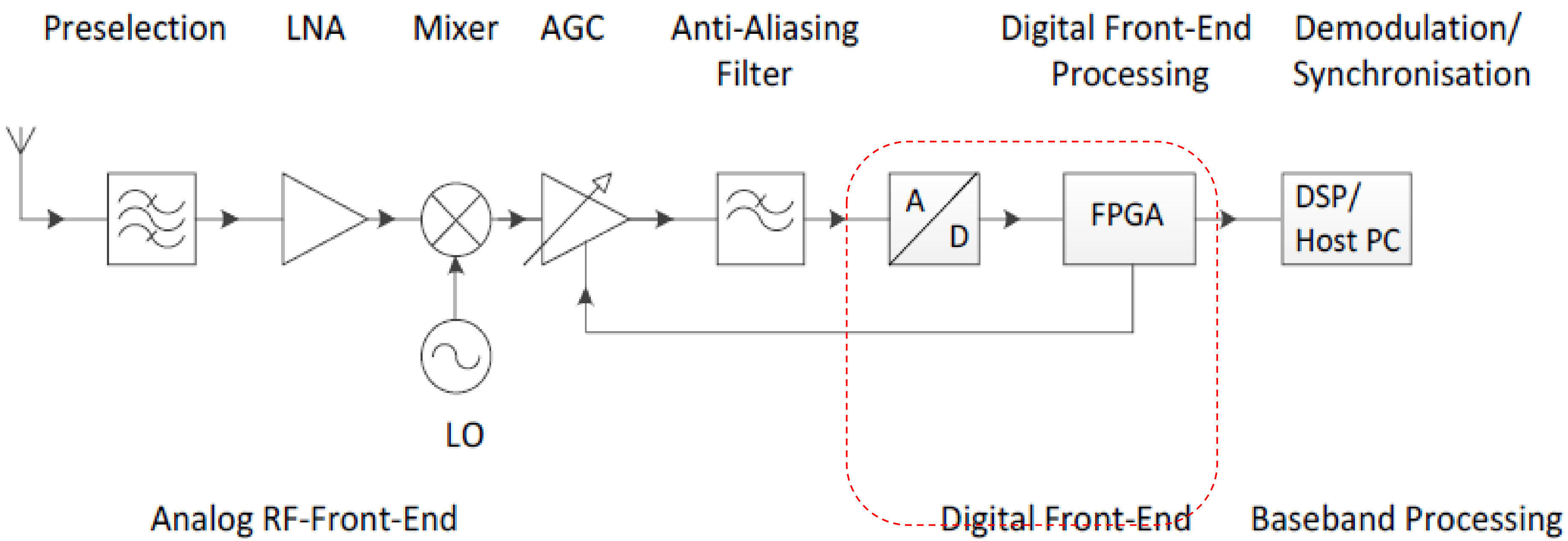
Principal Arrangment for Typical Microwave Receivers



The analog front end is downconverting the RF signals into an IF range <200MHz

Microwave Receiver, Cont‘d.

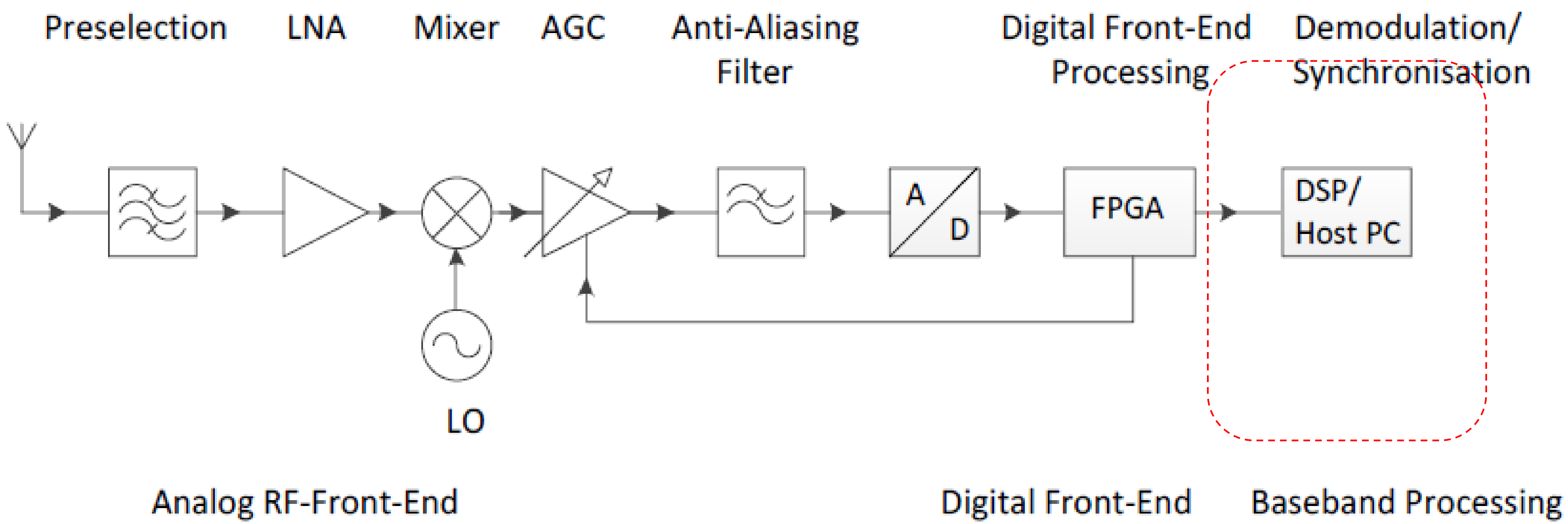
Principal Arrangment for Typical Microwave Receivers



The digital front end consists of an Analog to Digital converter and a digital down- converter to reduce the sample rate down to the bandwidth needed by the application. Sampling rate of AD converters are rising up to 250Msps with resolutions of 14 or 16 bits.

Microwave Receiver, Cont‘d.

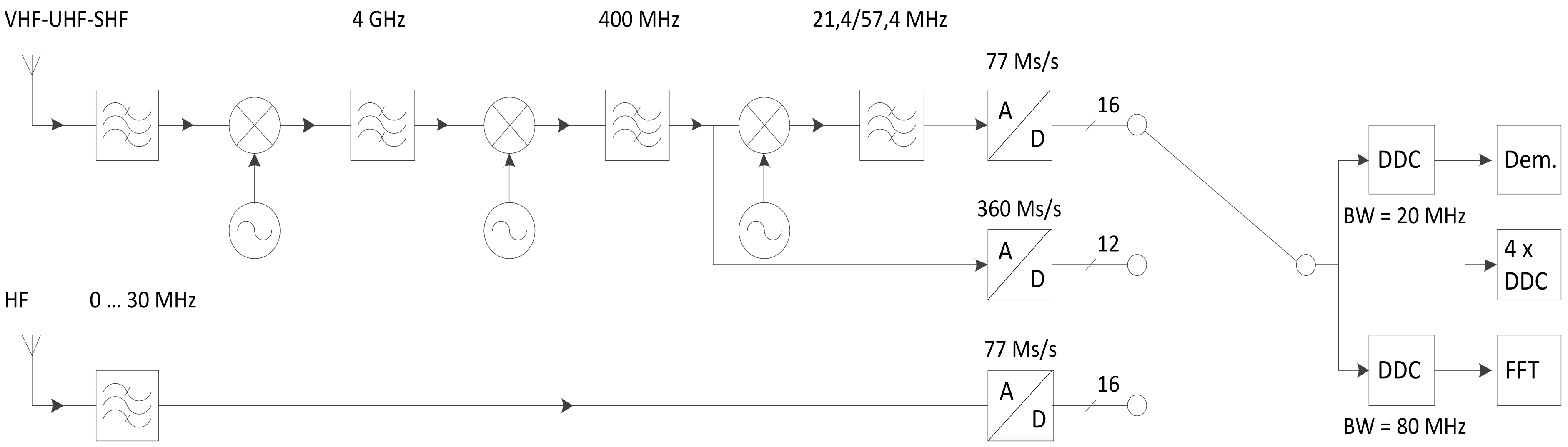
Principal Arrangment for Typical Microwave Receivers



The baseband processing takes over the base band filtering, AGC, demodulation, and the signal regeneration..

Typical Analog Front End

Possible Drawbacks on the Analog Front End



- Wide band microwave receivers need tripple conversion to prevent image reception
- Several expensive and switchable filters are required for pre- and IF-selection
- Intermodulation and Oscillator Phase Noise are the main issues
- Low noise and high dynamic range are contradictionary

Image Rejection Mixer

Solution to eliminate tripple Conversion

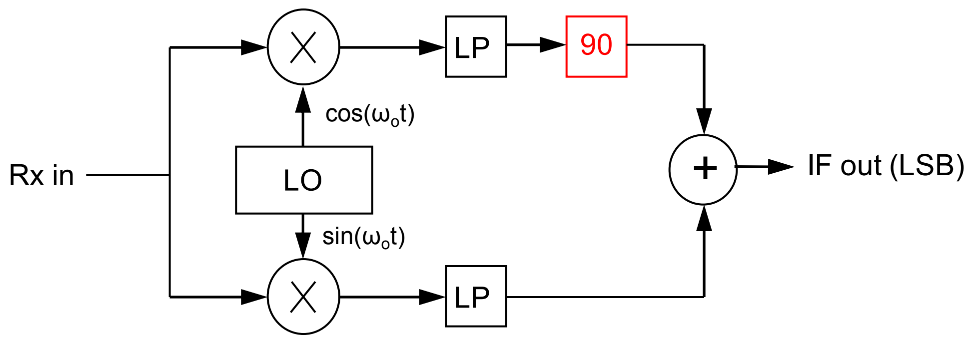
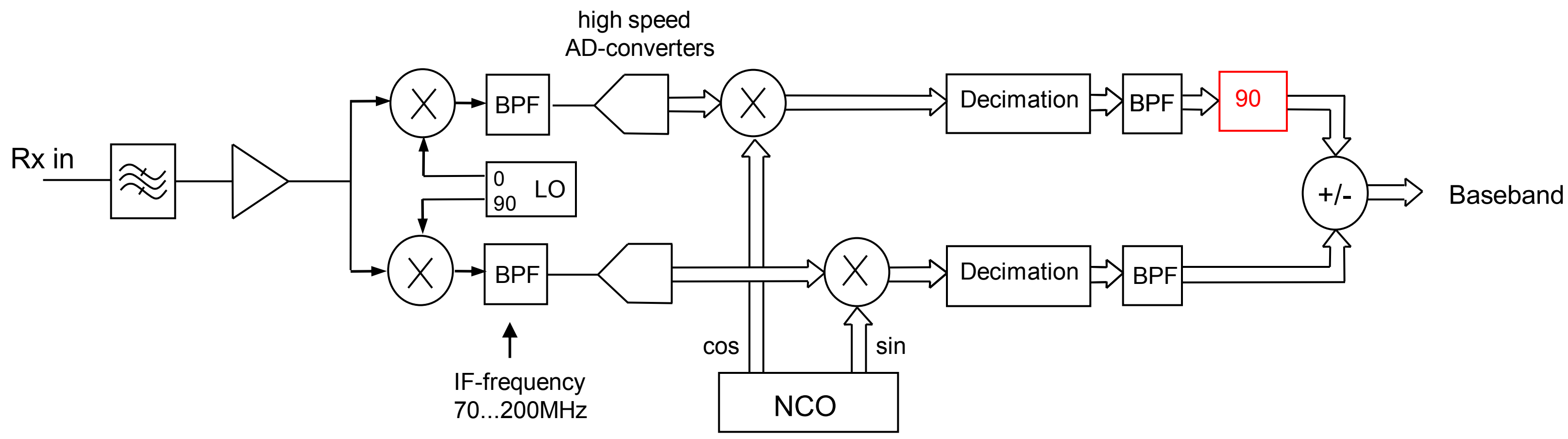


Image Rejection Mixer

- **An analog Image Rejection Mixer is capable to attenuate the Image by 30...40dB**
- **Criterions for the image attenuation are amplitude and phase errors in both branches**
- **The most critical element is the 90 phase shifter, mainly for wide band IF**
- **The SDR technology allows to move the phase shifter from analog into the digital part, where it can be realized nearly ideal by means of a Hilbert Transformer**

Image Rejection Mixer

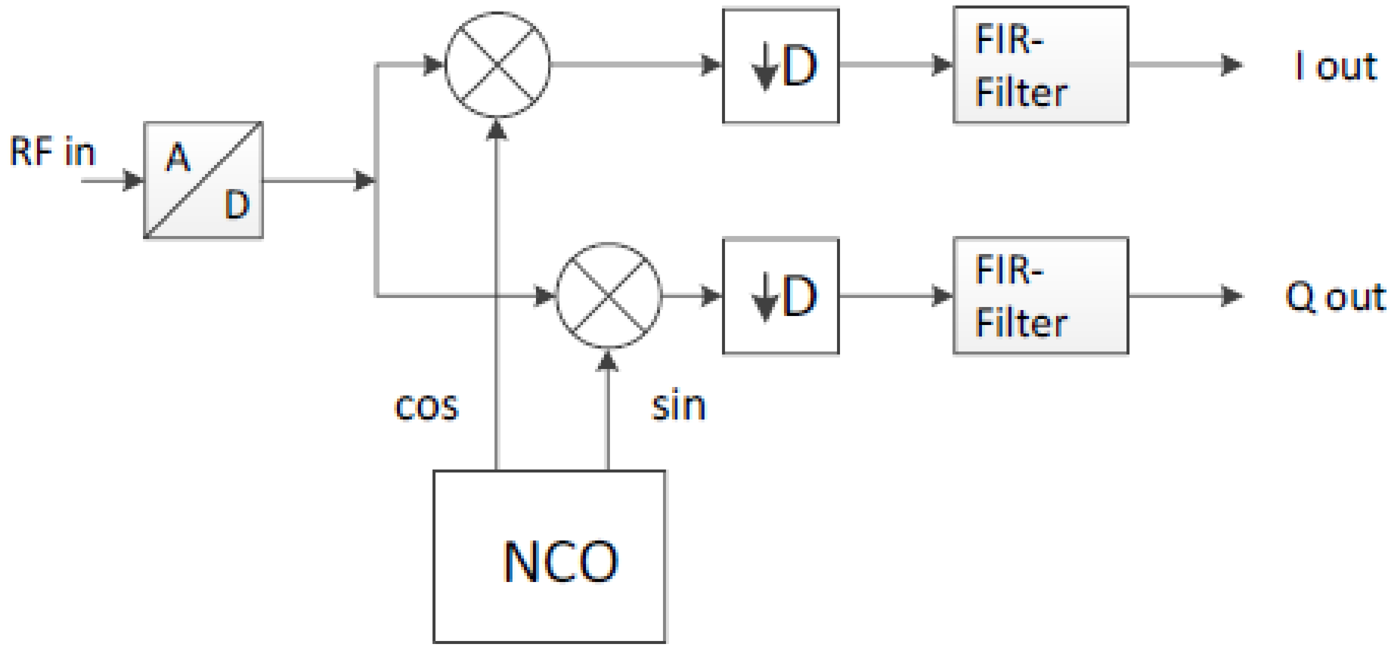
Solution with a distributed Image Rejection Mixer



- **The preselector filters may be wider, as they are no longer used for image rejection**
- **The digital parts, following the AD converter, can be realized in a FPGA**
- **In a wide band receiver, the LO can be tuned in steps from up to 10MHz which is simplifying the PLL loop filter design. The fine tuning will be done by the NCO**
- **The image rejection can be further improved by calibration algorithms in the digital part to values up to 80dB**

Down Converters

Digital Down Converter

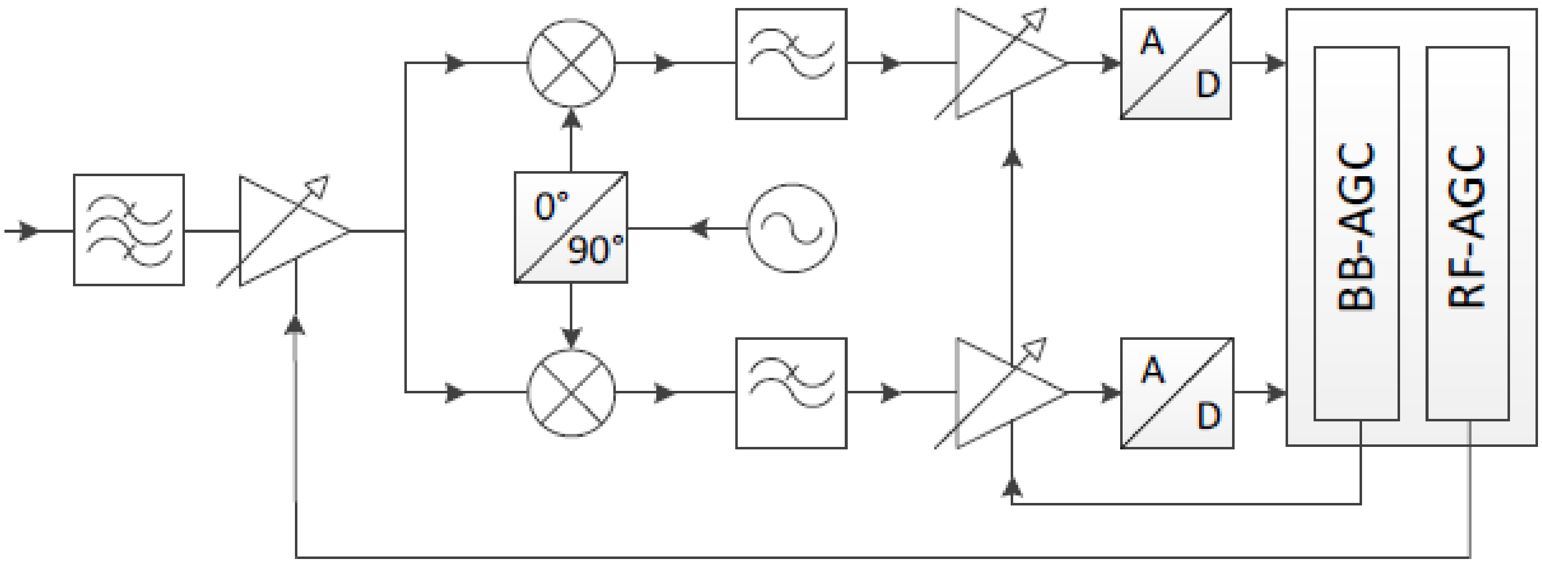


The digital down converter includes:

- a numerically oscillator (NCO)
- a complex IQ-mixer to convert the IF down to approx. 0Hz (zero-IF)
- several decimation filter stages for reducing the sampling rate
- final lowpass FIR-filters (Finite Impulse Response)

Automatic Gain Control

Automatic Gain Control



The broadband AGC serves to protect the AD converter from overvoltages. The RF-AGC can be used to set the receiver sensitivity just below the external noise.

The digital processing part is free from distortions, therefore the final AGC can be placed near the analog output.

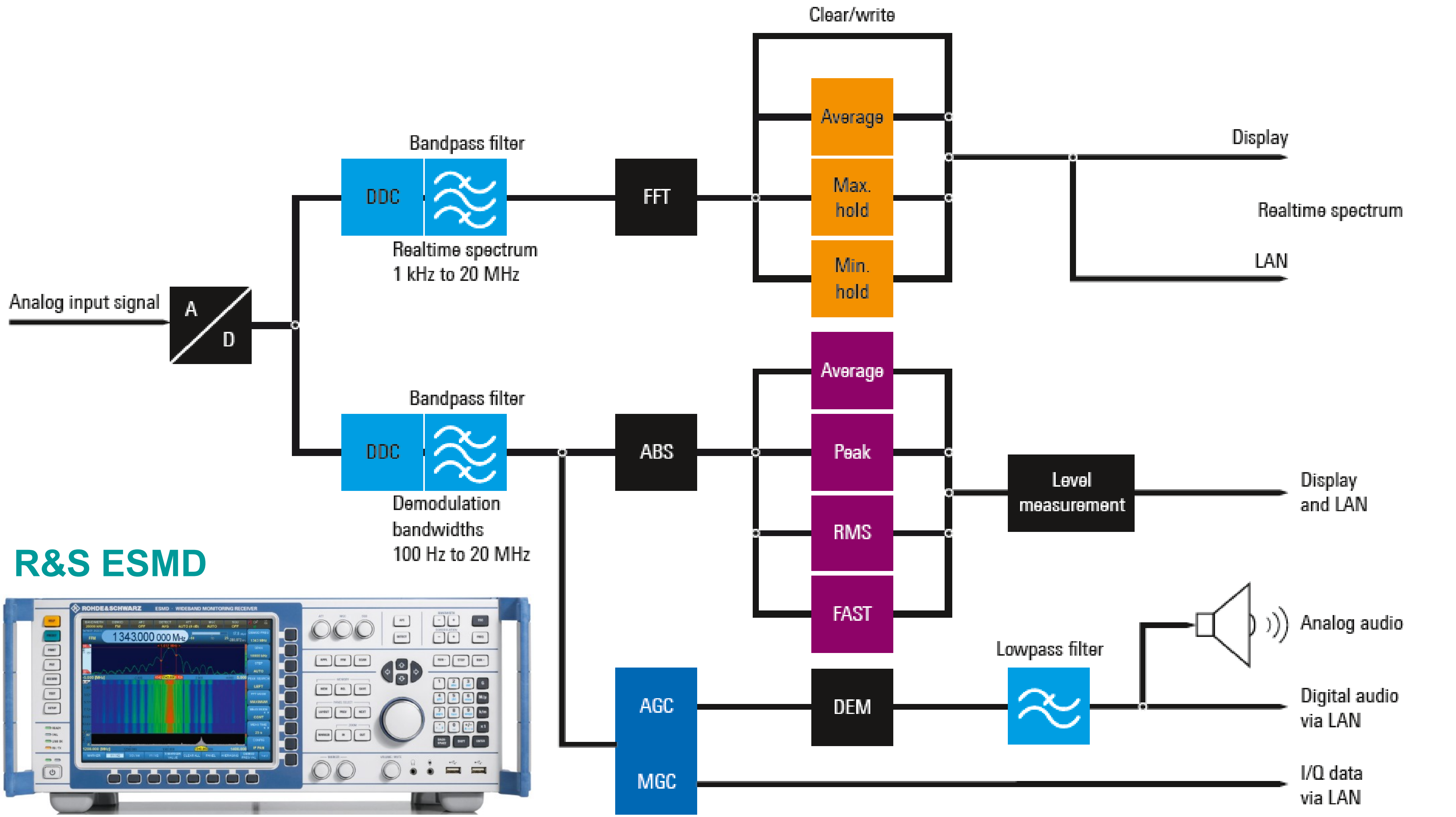
Radio Monitoring Receiver

Requirements on a Monitoring Receiver

- **Fast detection of unknown signals**
- **Search for activities over wide frequency ranges**
- **Monitoring of individual frequencies, lists frequency ranges**
- **Measurement of spectral characteristics of very short or rarely occurring signals**
- **Storage of activities**
- **Triggering of further activities after a signal is detected**
- **Demodulation of communications and/or transfer of demodulated signals for processing**
- **Integration into civil and military dedicated systems**
- **Homing, i.e. localization of signal sources and direction finding**
- **Simple coverage measurements**
- **Measurements in line with ITU recommendations**

Widebnad Monitoring Receiver

R&S ESMD Wide Band Monitoring Receiver



R&S ESMD

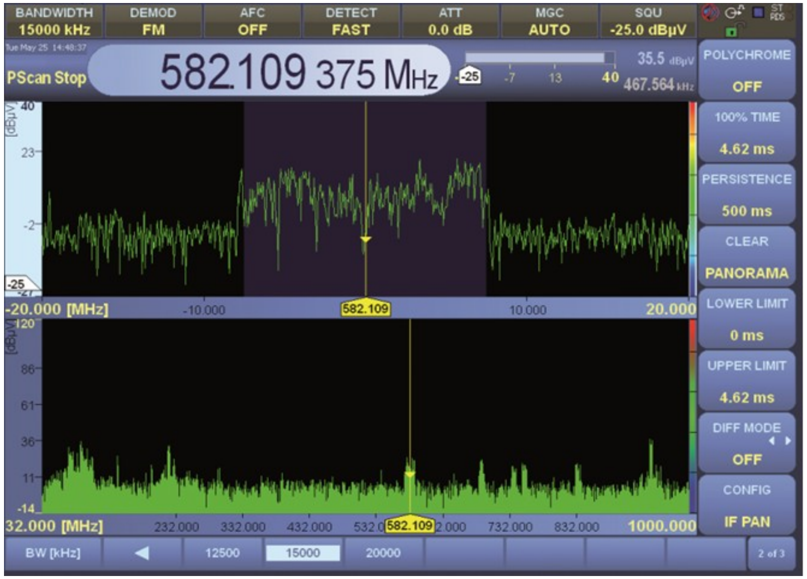
High Dynamic Range

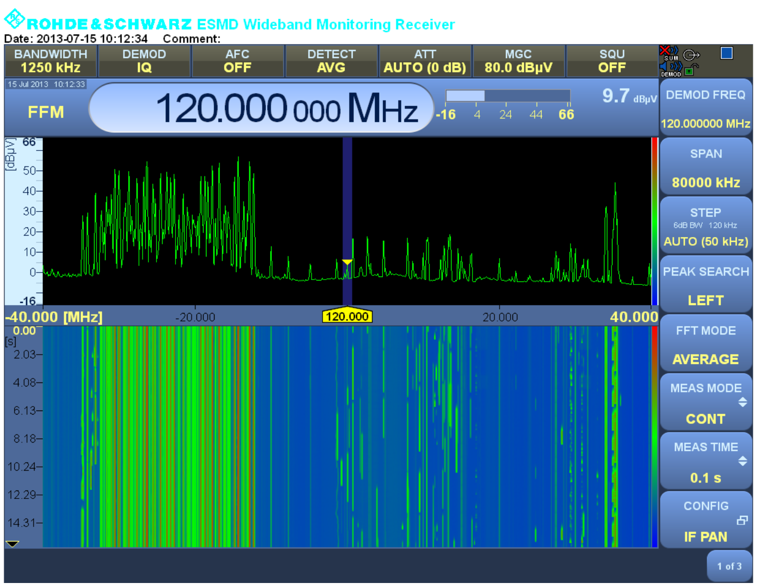
Spectrum Analysis in Receiver

Spectrum Analysis in Communication Receivers

Narrowband Analysis

Wideband Analysis

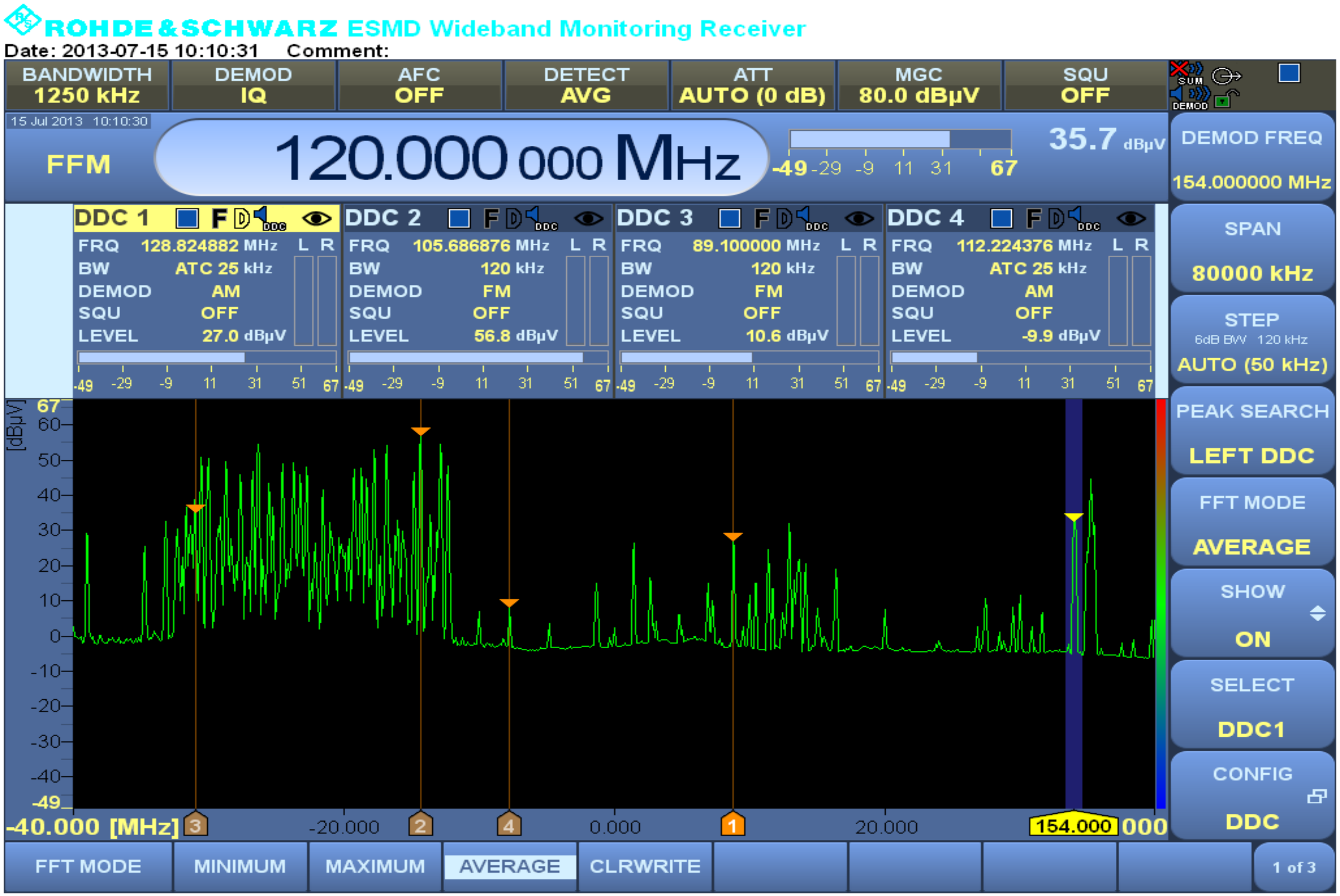




Aircraft Radio Communication Receiver can be monitored and demodulated in the presence of strong FM Radio signal

Spectrum Analysis in Communication Receiver

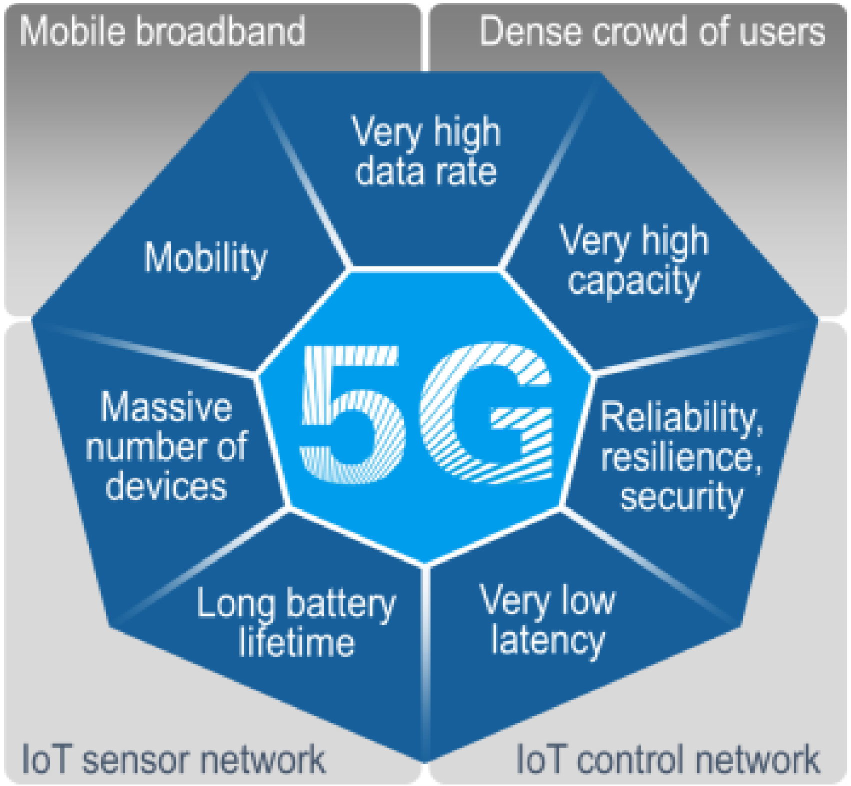
Multichannel (4) Operation



All 4-Channels can be anlayzed

5G: Emerging Cellular Networks

5G drivers



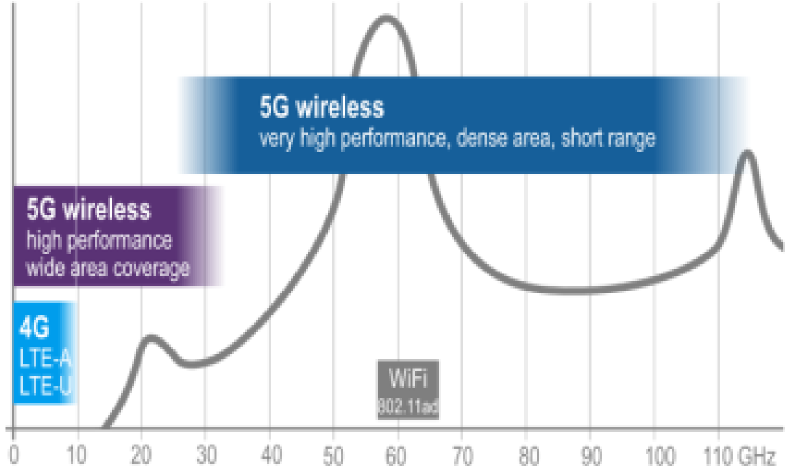
Mobile operators have just commercialized LTE and few of the features that make LTE a true 4G technology have made it into live networks. **So why is industry already discussing 5G?**

- Constant user demands for higher data rates and faster connections require a lot more wireless network capacity, especially in dense areas.
- The industry is expecting demand for 100x higher peak data rate per user and 1000x more capacity, and better cost efficiency defined these as targets for the 5th generation of mobile networks (5G).
- Internet of Things (IoT) provides new challenges to be addressed. It is anticipated that millions of devices will "talk" to each other, including machine to machine (M2M), vehicle-to-vehicle (V2V) or more general x-2-y use cases.

Beyond doubt there is a need to improve the understanding of potential new air interfaces at frequencies above current cellular network technologies, from 6 GHz right up to 100 GHz, as well as advanced antenna technologies such as massive MIMO and beam forming, very long battery lifetimes (years instead of days) and very low response times (latency) call for another "G" in the future !!!

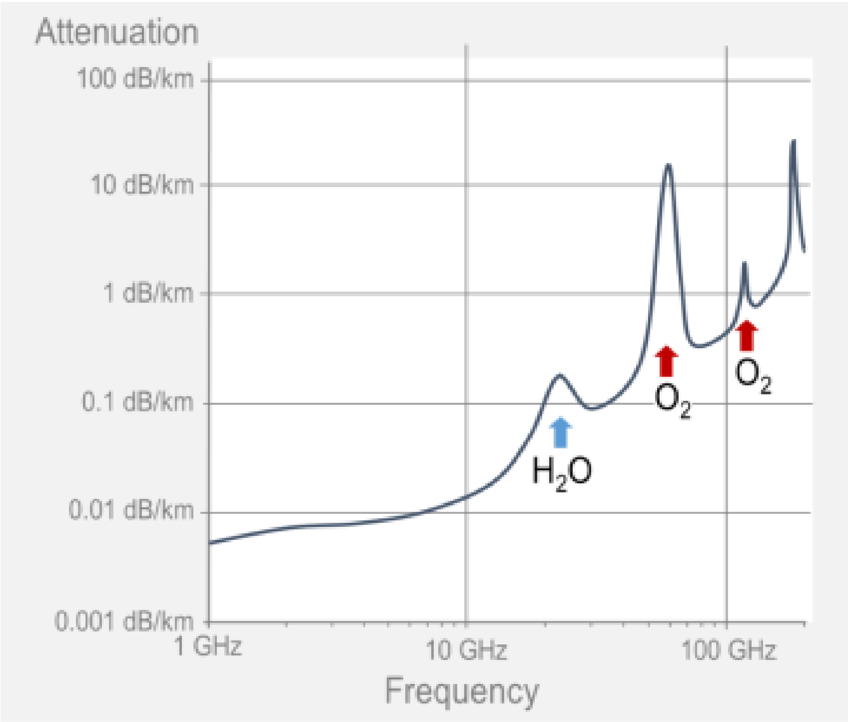
5G: Emerging Cellular Networks

The need for higher bandwidth and thus higher data rates for 5G makes it necessary to adopt significantly higher carrier frequencies compared with today's cellular network implementations below 6 GHz.



- The path loss is significantly higher so that highly directional beam fforming will be required in the mm-wave domain.
- Oxygen and water absorption (e.g. rain or humidity loss) needs to be taken into account for specific bands below 70 GHz and above 100 GHz and above a range of 200 m.
- The attenuation of most obstacles is stronger, e.g. even foliage loss, but reflections too.
- Line-of-sight (LOS) conditions cannot always be ensured therefore non-line-of-sight (NLOS) communications is essential (and possible).

5G Channel Sounding

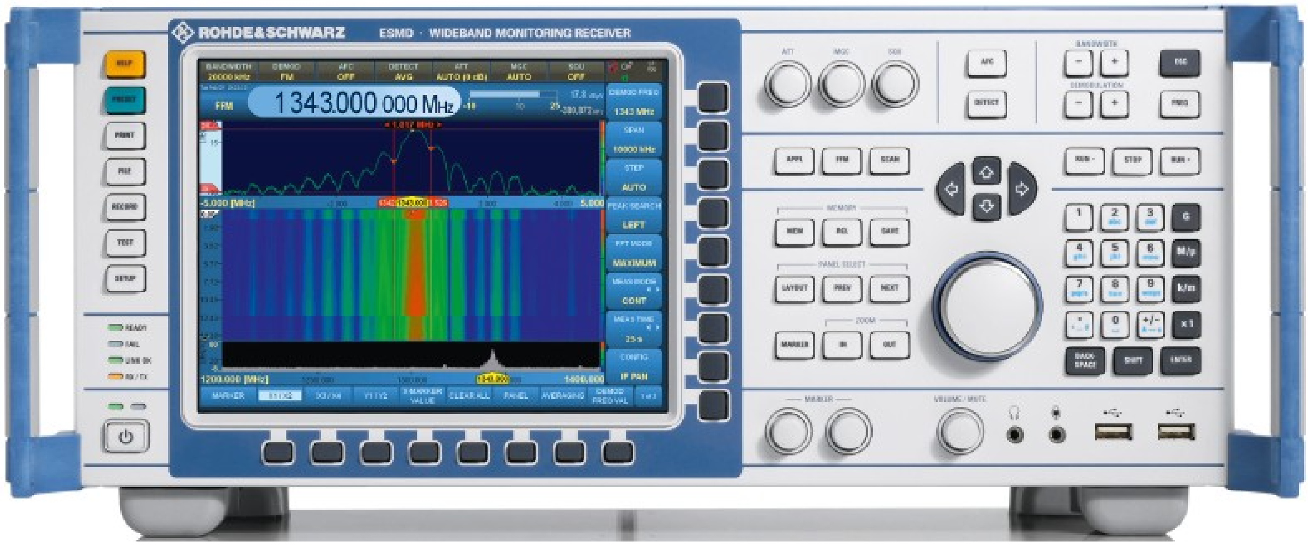


Channel sounding is a process that allows a radio channel to be characterized by decomposing the radio propagation path into its individual multipath components. This information is essential for developing robust modulation schemes to transmit data over the channel.

Conclusion

- **Software Defined Radio:**
  - **High Dynmaic Range Microwave Monitoring Receivers**

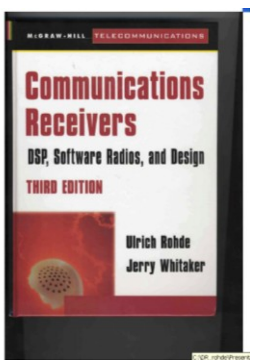
R&S ESMD

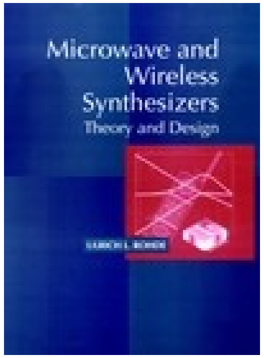


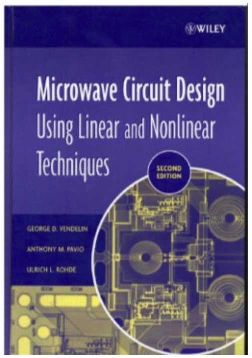
Proof of Available High Dynamic Range

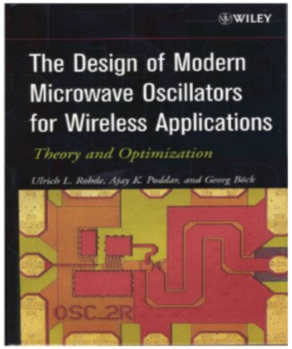
References

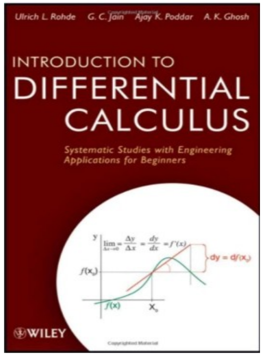

Ulrich L. Rohde “radio house”

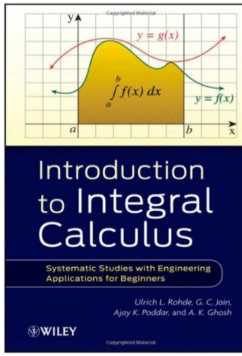












Thank You