Experiment No. 5 – Tasks **(Version from 27.11.2017)**

Digital RF-Receiving Technology and EPR

Use the previous experiment descriptions in order to familiarize yourself with the basics of the EPR.

1. Frequency mixing and modulation

As a signal source for the mixing and modulation experiments, use both channels of the RIGOL Dual-Channel Arbitrary / Waveform Generator DG1022.

Manual DG1022:

The mixture is handled by a Hewlett-Packard Model 10514A mixer. Carry out the experiments according to point 14. Mixer of the manual.

Manual HP10514A:

Observation of the input frequencies in the time domain is done with Handy-scope HS3. In conjunction with the PC and a monitor you use this as a 2-channel oscilloscope.

Manual TiePie HS3:

For the spectral representation and measurement of the mixed products use a combination of the hardware RSP1 (Radio Spectrum Processor) with the software HDSDR.

Datasheet_RSP1:
Manual RSPHDSDR:
Pegel-Spannung-Leistung:
Messwerte einer Sinusschwingung:

No more than 40 mA of current should flow into any of the connections of the HP10514A mixer, otherwise it will be destroyed!

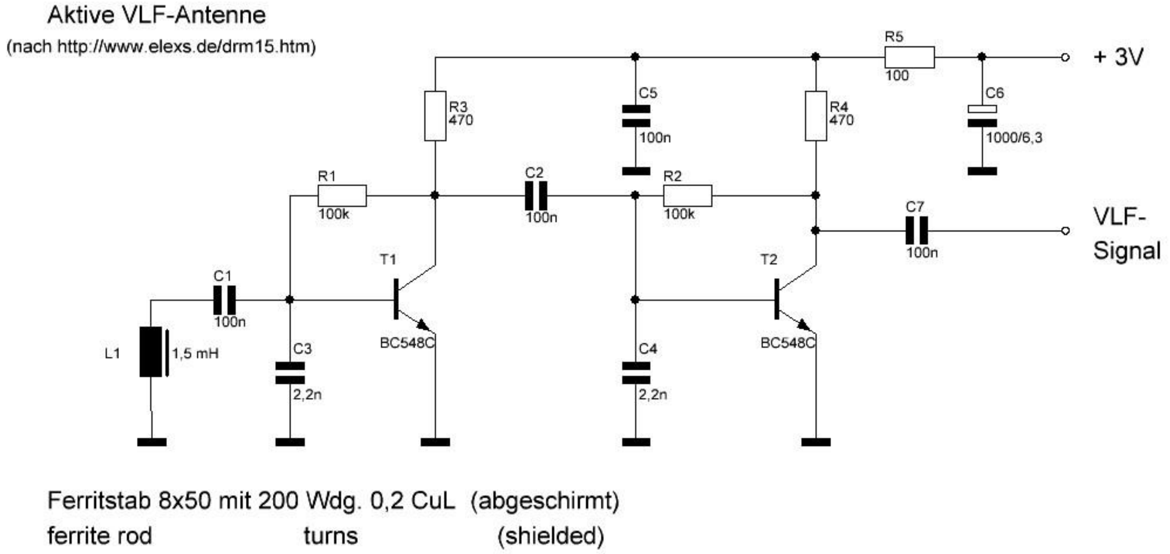
For safety's sake, always keep below 5 mW of power in the 50 Ohm system. This corresponds to a maximum level of about 1.4 Vpp or 0.5 Vrms, regardless of which socket.

Follow the instructions of the mixer according to point 14. *Mixer* and connect one channel of the DG1022 to the input L. A sine signal with 10 MHz frequency at the 50 ohm output is required. The amplitude is set to 0.5 Vrms = 1.414 Vpp (5mW).The second channel of the DG1022 also supplies to the input R with 50 ohm source resistance a sine wave with a level of 1 mW (0.22 Vrms) and the frequency of 200 kHz.

Observe the output X (and the input signals) in the time domain with the TiePie HS3.

Before connecting the RSP1 for the spectral measurements, the attenuation at the **PRL T5075** attenuator is set to at least -60 dB. Lower the levels of the signals at L and R so that the mixing products are harmonic free. Check the details in Figure 3 for mixer efficiency. Experiment independently with other frequencies and modulated signals. The documentation of the results is provided with written descriptions of the measurement setup and with screenshots of the oscilloscope and the HDSDR.

2. Receiving and analyzing signals in the VLF range from 10 kHz to 150 kHz



To receive the specified frequency range, use the active VLF antenna in the laboratory window. The BNC connector of the corresponding cable is marked with **VLF**. Turn on the attenuator PRL T5075 at least 40 dB attenuation before connecting the plug. Do not change the location of the antenna. Rotate the antenna only around the vertical axis to achieve alignment with the various VLF transmitters.

VLF-band plan: http://www.db9ja.de/bandplan-bis500khz.html

Locate the DCF77 timestamp transmitter and analyze the received signal.

Wikipedia DCF77: https://de.wikipedia.org/wiki/DCF77

Capture the three transmitters DCF49, DCF39 and HGA22 of the radio control system EFR. Analyze the received signals.

EFR-System: http://www.efr.de/efr-system/

3. Receive FM broadcasts and selected signals in the VHF and UHF area and their assignment

Use the wire antenna attached to the wall of the lab. The corresponding BNC connector is marked with **VHF/FM**. Switch on the attenuation element PRL T5075 at least 40 dB attenuation before connecting the plug. Switch on the attenuation element PRL T5075 at least 40 dB attenuation before connecting the plug.

Work with the maximum observation bandwidth of the RSP1 in the FM radio band.

UKW-Rundfunk: https://de.wikipedia.org/wiki/UKW-Rundfunk

Look for 144.434 MHz for a CW signal. DB0LBV, what could that be?

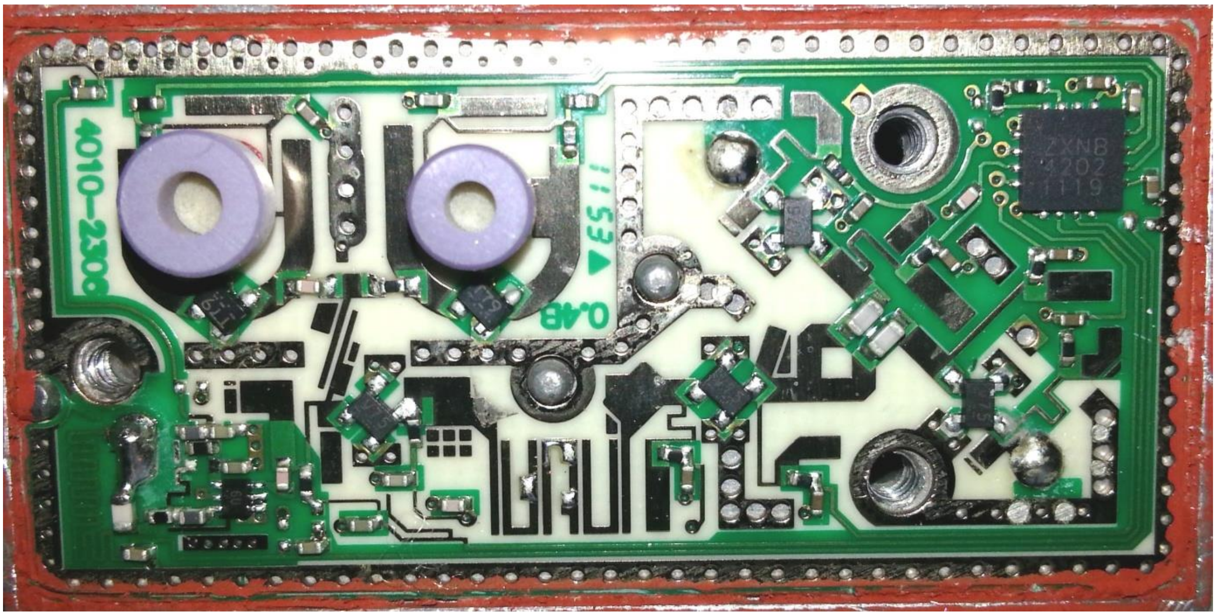
Take further experiments with PMR transceivers. What channel frequencies are used? What is the bandwidth and type of modulation?

PMR-Funk: https://de.wikipedia.org/wiki/PMR-Funk

Locate the data transfer of a wireless thermometer to 433 MHz. What do you observe?

4. Determination of the resonance frequency and recording of the dispersion curves of different DPPH samples

A modified low noise block LNB "OSLSO" is used for the measurements on the DPPH and Ultramarin samples:



Both Local Oscillators LO with 9.75 GHz and 10.6 GHz are simultaneously operated and mixing. The sample to be measured is applied to the dielectric resonator DR with the high frequency, which is the small violet ring cylinder on the right. At the output of the LNB, the dispersion signal can be measured in the region of 800 MHz.

According to the basic equation of EPR, we find the magnetic flux density required for resonance

$$hf_{B_1} = g\mu_B B_0$$

On the left side are the Planck constant and the resonance frequency of the high frequency alternating field, on the right side the Landé factor, the Bohr magneton and the magnetic induction of the external field leading to the resonance. The B1 field is perpendicular to the B0 field.

The strength of the magnetic flux density is determined with the output voltage of the power supply PS2000 and displayed in Millitesla. To control the PS2000, be sure to start the software on the notebook as an administrator. **Right mouse button "run as administrator"!**

There are different sequence files available for different field gradients. It is also easy to program other sequences. Determine the respective gradient in Gauss per second Gs / s.

Before starting the sequence, the voltage is manually set close to the first voltage value in the file on the notebook. The sequence must be programmed to sweep the resonance. Then we observe in the HDSDR software the dispersion signal of the resonance as a clear change of the frequency.

Optimize the settings for displaying the waterfall diagram and the spectrum for documenting the measurement as a snapshot with the key combination SHIFT / Print. The best display can be reached with Options / Visualization / only upper display. With F2, the display can be paused. The HDSDR snapshot is copied to IrfanView: Image / create new (blank) image ... and paste with CTRL + V. Now the measurement result can be saved and further processed.

It is recommended to rotate the image to the left in the 90 ° protocol for your documentation and to digitize it with the program engauge.exe. As a result, you can export a * .csv file that can be displayed, dimensioned, and labeled as usual with Origin. The y-axis now shows the frequency of the high-frequency alternating field over the external magnetic field B0 (X-axis) with the course of the dispersion signal of the resonance.

Measure the DPPH samples one by one with the weights of 100 µg, 10 µg and 1 µg.

5. Determination of the resonance frequency and recording of the dispersion curves of different Ultramarin samples

Measure the dispersion curves of the UM samples with the dilution levels:

Pure (undiluted), 1:10, 1: 100 and 1: 1000

6. Measurement of the DPPH sample 10µg with a calibrated LNB as observation system

Use a calibrated PLL LNB with the Local Oscillator Frequency of exactly 9.75 GHz as the receiver. Compare the result with the one obtained under 4. using the direct mixing method.

Are there differences in the measured resonance frequency?
How accurate is the display of the magnetic flux density?