TRAINING PROJECT LABORATORY REPORT

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ABSTRACT

This is a report for training project laboratory in electrical engineering info-communication BSc course. This laboratory consist of two parts, both will be covered by this report. The first part is circuit realization and measurements around a radio direction finder receiver. The second part is measurements, calculation and software tools realization in Space technology laboratory.

1 PART1 – RADIO DIRECTION FINDER RECEIVER

From week 1 to 7 I was working on the radio direction finder receiver. Our task is to realize the circuit following the schematic. The printed circuit board(PCB) is prepared in advance.

1.1 Components

SURFACE MOUNTED COMPONENTS All resistors, capacitors, inductors and transistor are packaged using surface mount technology(SMT). Which makes them tricky to hand solder on the board. When to much soldering is applied a short circuit could happen between pads underness components. A multimeter is very useful for troubleshooting.

THROUGH HOLD COMPONENTS Audio jack, potentiometer and crystal oscillator are through hold components which provided a firm connection to the PCB.

1.2 Circuit design

The circuit is designed in KiCad

1. The radio receiver:
   The main blocks:
   - 9 turns from 210 cm CuZ copper wire as antenna,
   - radiofrequency (RF) amplifier,
   - RF band pass filter,
   - bipolar junction transistor (BJT) based mixer,
   - local oscillator,
   - audio frequency low pass filter,
   - audio amplifier.
2. The test transmitter:
   Collpitts type oscillator, where the quartz frequency is some 100 Hz different from the receiver local oscillator frequency, in order to make audio signal and it can be heard.

1.2.1 Schematic

The schematic diagram of the receiver is in Fig. 1.

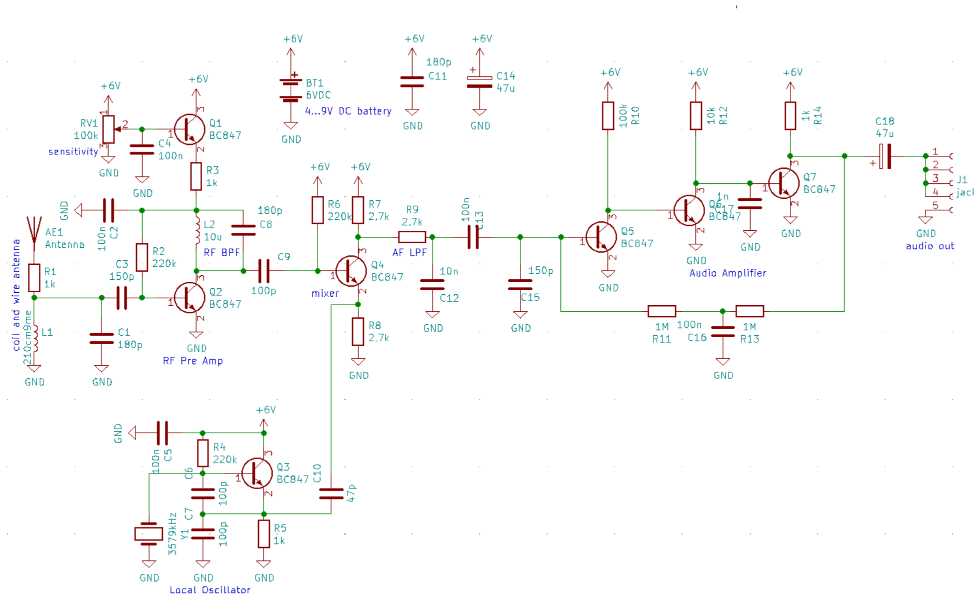


Figure 1: Schematic

1.2.2 *Printed Circuit Board*

The designed PCB can be seen in Fig. 2. There are THT and SMD type components.

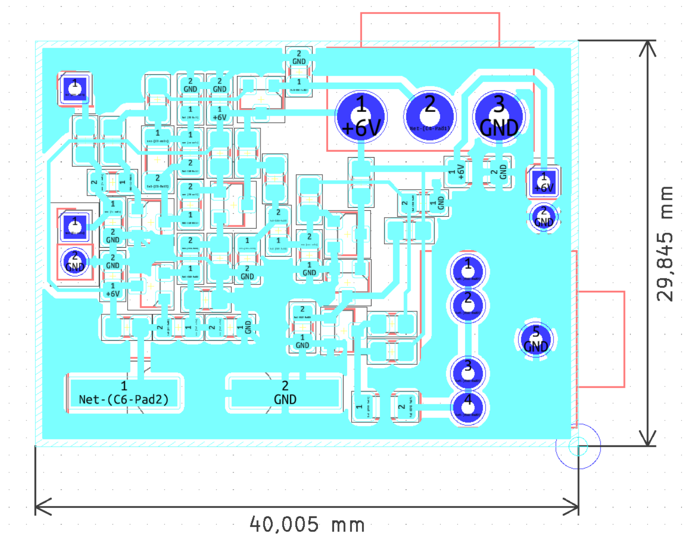


Figure 2: PCB

1.2.3 *Component placement*

The components with its reference is in Fig. 3.

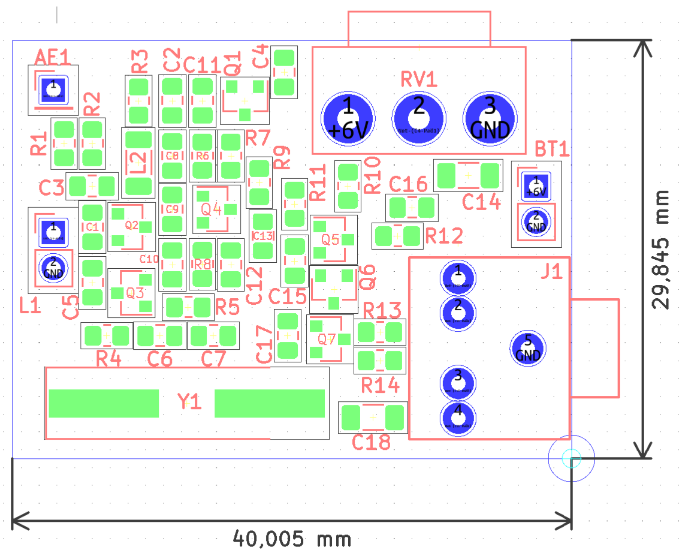


Figure 3: Components Placement

1.3 Measurements

The task is to measure the following parameters of the realized circuit and make test and measurement report based on the measurement results.

1. Bias DC voltages to the reference GND point on all pins of all semiconductors.
2. Voltage curve in time of the local oscillator output (emitter): peak-to-peak voltage and frequency.
3. Receiver audio (time domain) output signal on the AF output connector: variable resistor low, middle, high position: peak-to-peak voltage, frequency, curve. During this measurement, a single test transmitter will be run near to the receiver.

1.3.1 *Bias DC voltage of transistors*

DC voltage is measured reference to ground. And potentiometer is set to a low position during measurements.

Transistor	Voltage
Q1	807mV
Q2	72.4mV
Q3	2.79V
Q4	1.94V
Q5	96.5mV
Q6	97.2mV
Q7	96.9mV

Table 1: Transistor voltage measurement

1.3.2 Voltage curve in time domain of the local oscillator output

In this measurement 10x probe gain is used. I used the quick measure function on the oscilloscope.

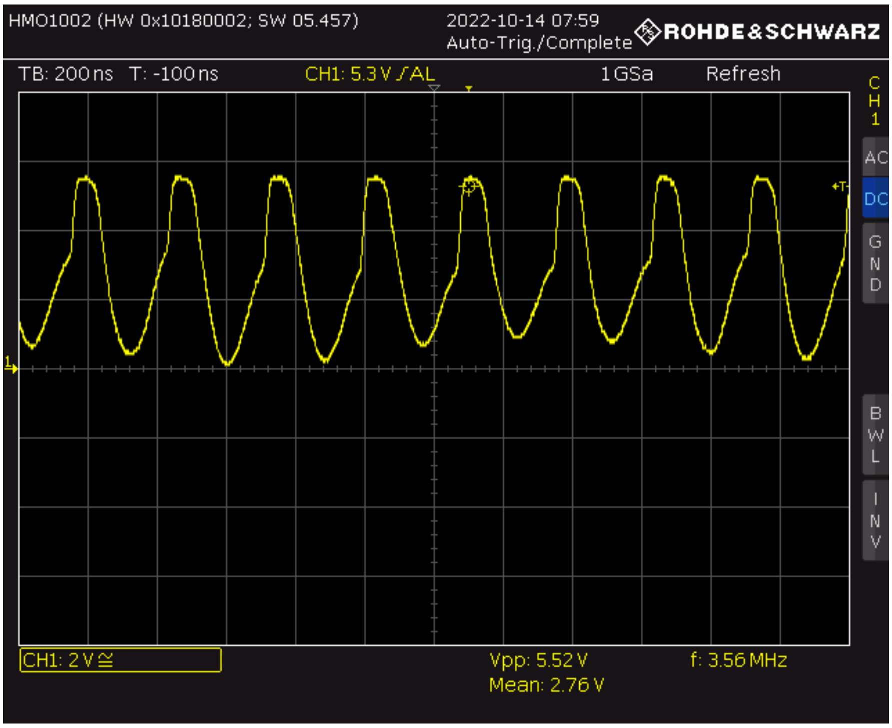
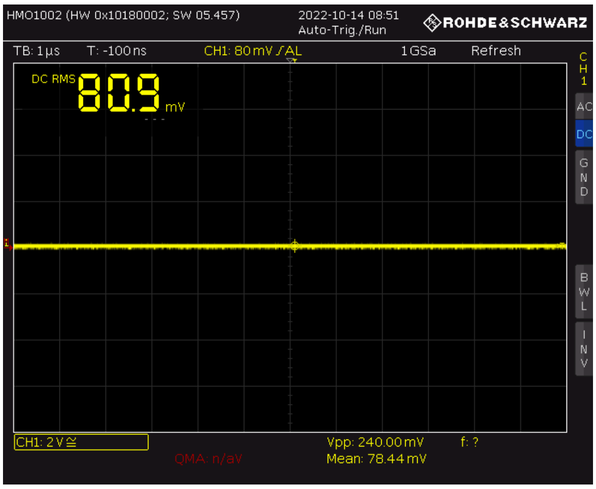


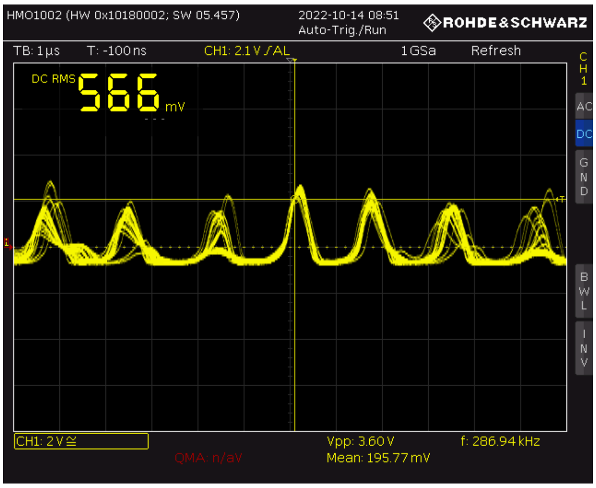
Figure 4: local oscillator output

From the schematic 1 we can see that a crystal oscillator with 3.579MHz frequency is used. Our measurement result matches this value within 0.5% of error.

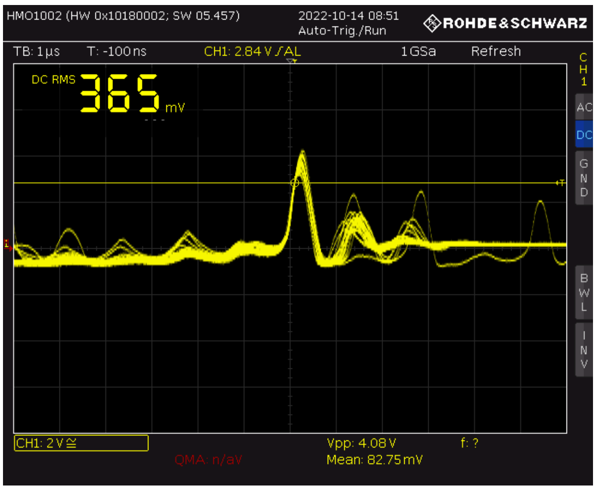
1.3.3 *Receiver audio (time domain) output signal*



(a) Low



(b) Mid



(c) High

Figure 5: Receiver audio output signal in time domain

2 PART2 – 58GHZ ATTENUATION

From 8 to 14 week I worked for Space technology laboratory supervised by Dr. László Csurgai-Horváth. Our topic is to research about oxygen and rain attenuation on 58GHz radio signal.

2.1 Introduction on 58GHz band

Signal around 60Ghz band has a unique advantage. Around this frequency signal propagation is effected by oxygen molecule in the air. This phenomenon is called oxygen attenuation. Because such phenomenon, signal can not propagate for long distance. In urban area where high bandwidth communication is required this property can increse frequency reuse rate which will conserve frequency band resource.

2.2 Experiment setup

Two antennas are placed on the roof of building V1 and building E. An indoor unite was set in the laboratory for data logging.

GEOMETRY Geolocation of antennas are measured using GPS coordinate where distance and elevation angle can be calculated. GPS coordinates are:

- Building V1 antenna: 47.476647, 19.056420, 123.2m
- building E antenna: 47.477423, 19.057490, 146.8m

From above data we calculated distance $d = 118.0m$ and elevation angle $\theta = 11.537°$

HARDWARE SPECIFICATION Testing divices are consist of indoor and outdoor units. Both manufactured by Nokia Network. Hardware specification are defined in the user manual of these units [1]

- Frequency: 57.725GHz
- Polarization: vertical
- Antenna gain: 34dB
- Transmitter output power: 5dBm

2.3 Calculations

FREE SPACE LOSS Free space loss is the loss when signal travels through open space with no other attenuation. This can be calculated using following equation [2]

$$a_{sz}^{[dB]} = 32.44 + 20\log f^{[MHz]} + 20\log d^{[km]} - G_{TX}^{[dB]} - G_{RX}^{[dB]} \quad (1)$$

Where:

- a_{sz} is free space loss in dB
- f is radio frequency in MHz
- d is distance between transmitter and receiver in km
- G_{TX} is transistor antenna gain in dB
- G_{RX} is receiver antenna gain in dB

OXYGEN ATTENUATION Oxygen attenuation or Atmospheric attenuation is the effect of signal propagation due to gas in the atmosphere. The following figure is given in ITU-R P.676 [3] which demonstrate signal attenuation with different frequency. A peak at around 60GHz is clearly visiable which is casued by oxygen molecule in the air.

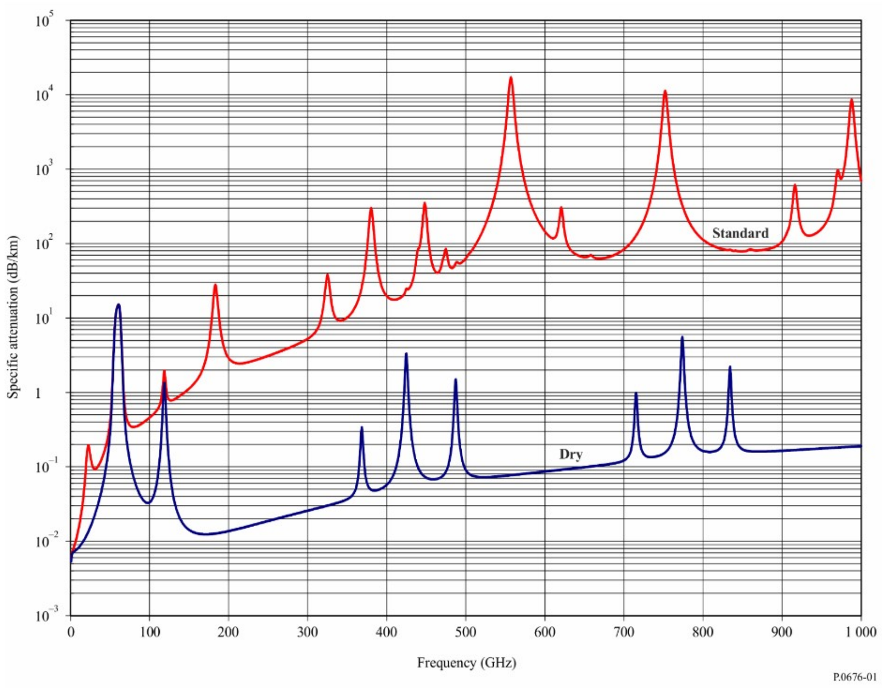


Figure 6: Atmospheric attenuation

Calculations for oxygen attenuation is quit complicated but for estimation purpose Matlab provided a built-in function `gaspl`

```
L = gaspl(range,freq,T,P,den)
```

arguments:

- range: Signal path length in multimeters
- freq: Signal frequency in Hz
- T: Ambient temperature in degrees Celsius
- P: Dry air pressure in Pa
- den: Water vapor density or absolute humidity in g/m^3

RAIN ATTENUATION Rain attenuation is our main research direction. We want to measure how rain will effect signal propagation on this particular frequency.

REFERENCES

[1] Nokia Network Oy. Nokia metrohopper radio product description. C33512.09.

[2] International Telecommunication Union. Itu-r p.525-4. calculation of free-space attenuation. [Online].Available:https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.525-4-201908-I!!PDF-E.pdf, 08 2019.

[3] International Telecommunication Union. Itu-r p.676. attenuation by atmospheric gases and related effects. [Online].Available:https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.676-13-202208-I!!PDF-E.pdf, 08 2022.