EE 316 - Electronic Design Project

RF Transceiver

Second Project Report
25 May 2018

Objective

Radio Frequency (RF) transmission lines are commonly used and consists of several frequency bands defined in the spectrum used for the wireless data and voice communication systems. Various applications of communication have been assigned to certain frequency bands in the spectrum not only for data transmission channels but also radar, geo positioning and navigational purposes. In these distributed lines careless use of transmission cause interferences and these interferences cause dangerous consequences. Band allocation is highly preferred and used by the government responsibilities to prevent unwanted interferences and consequences. Therefore, the main aim of this project is to construct a short-range (min:5m) RF data transmitter operating at 2.2MHz center frequency and receiver devices within the transmission limitations.

Group Members

Common efforts **:** Short distance RF transmission frequency band analysis.
Erman OLÇAY **:** AM radio receiver circuits and Serial data transmission.
M. Emre ŞAHİN **:** Tuned amplifier circuits and AM Modulation, Demodulation

Revision History

Week-10: The transmitter modulation is inverted to prevent unnecessary outputs from antenna. Also, receiver Schmitt-Trigger Op-Amp changed with inverting op-amp for receiving message correctly at the receiver since it has been inverted in the transmitter.

Week-10: The receiver amplifier has been changed and replaced with higher gain and higher output impedance model.

Week-11: 12v to 5v regulator added to use one power supply and changed the amplifiers operate with 12v DC supply to get more powerful output from transmitter antenna.

Week-11: Because of the laboratory size limitations, the magnetic loop antenna design discarded and changed with 10m cable wire model which could work well in the short-range applications.

1. Introduction

On RF Data Transceiver project, we had to solve five major design challenges in constructing RF Transmitter and receiver circuits.

1. **Constructing Sinusoidal at 2.2Mhz:** On our project it was required to operate the carrier frequency at 2.2MHz. Therefore, Colpitts oscillator has been constructed with the calculated inductor and capacitor values.

2. **Eliminating the Noise in Amplification process:** Since the AM Modulation is very vulnerable to the noise effects therefore we have constructed our amplifiers with tuned amplifier models with center frequencies at the carrier frequency. Thus, it is possible to amplify only the modulated signal with very small portion of the noise using tuned amplifier.

3. **Deciding the proper antenna design:** Antenna is the one of the major challenges on the project since the operating frequency is at 2.2Mhz the wavelength of the carrier 136 meters long. Therefore, for the monopole antenna the required antenna length is one fourth of the wavelength 34 meters. In the laboratory conditions we have no chance to build such antenna however any long wire could work in the short-range applications.

4. **Component Compatibility with Project:** Since RF Transmission will be in high frequencies, many electronic components will not work properly in this project. However, with the operation principle of the RS-232 the constant 5v output in idle mode cause the circuit to transmit whole time when the user did not send any data from the computer. So, to prevent unnecessary transmission when the channel is idle, the modulation process has been changed as it not to modulate while the computer does not send any data in the first place. This change has lead also the receiver Schmitt-trigger to be changed as inverting comparator.

5. **Theoretical calculations mismatch with the Practice:** When the calculated inductor and capacitor values are used the results may not be same as it was expected due to the non-ideal characteristics and environmental effects. Therefore, some of the capacitor and inductor values have been varied with trial and error methods to obtain exact required characteristics.

1.1. Colpitts Oscillator

Oscillators convert unidirectional current flow from a DC source into an alternating waveform which has desired frequency, as decided by its circuit components.

Colpitts Oscillator is in the category of Harmonic Oscillators and typically has tank circuit and feedback with gain devices such as the bipolar junction, field effect transistor and operational amplifier. Tank circuit has two capacitors and a parallel inductor. Colpitts Oscillators can generate sinusoidal output signals with very high frequency with very wide range broadbands [3].

1.2. AM Modulation and Demodulation

The data and voice signal should be modulated, and it had to be carried with available modulation techniques to transfer from source to receiver [12]. Ordinarily used and respectively easy in modulation and demodulation techniques of signal modulation is Amplitude Modulation (AM). Ever since of its first usage in 1901, the AM is still being used in broadcast transmission areas, VHF transmissions for many airborne applications, HF radio links, transmission of data in short range wireless links [1]. AM transmitters are quite simple rather than FM transmitters and the receivers of AM devices are simple to build cost efficient. Also, AM waves can travel long distance with ranges of allowed frequency band. However, effect of noise, bandwidth/spectrum efficiency and power wastage are main problematic limitations in AM systems [1].

The modulation is just simply multiplication of the message signal and carrier sinusoidal signal.

The demodulation is also very simple since it does not require synchronous demodulation, but it can be demodulated only using envelope detection process.

1.3. Tuned Amplifier

Tuned amplifiers are capable to amplify a signal over the narrow band frequencies which is tuned by the designer while rejecting the rest. Since tuned circuits allow only desired bandwidth, tuned amplifiers commonly used for amplification of Radio Frequency (RF) signals which have generally single center frequency with a bandwidth including the message information. Tuned amplifiers generally use reactive components like inductor and capacitor and these components are efficiently minimize the power loss. When the capacitor and inductor connected in series, it offers low impedance with allowing high current through itself. However, in the parallel scenario, they offer high impedance characteristics [4].

1.4. Schmitt-Trigger Comparator

Comparator circuits are widely used in electronical circuits. These circuits are simply compares two input levels and changes the output as desired. One of the most efficient comparator is Schmitt trigger comparator.

The Schmitt trigger is a comparator application which switches the output negative when the input passes upward through a positive reference voltage. It then uses positive feedback of a negative voltage to prevent switching back to the other state until the input passes through a lower threshold voltage, thus stabilizing the switching against rapid triggering by noise as it passes the trigger point. That is, it provides feedback which is not reversed in phase, but in this case the signal that is being fed back is a negative signal and keeps the output driven to the negative supply voltage until the input drops below the lower design threshold [4]. In the Figure 1, typical calculations and circuit are shown.

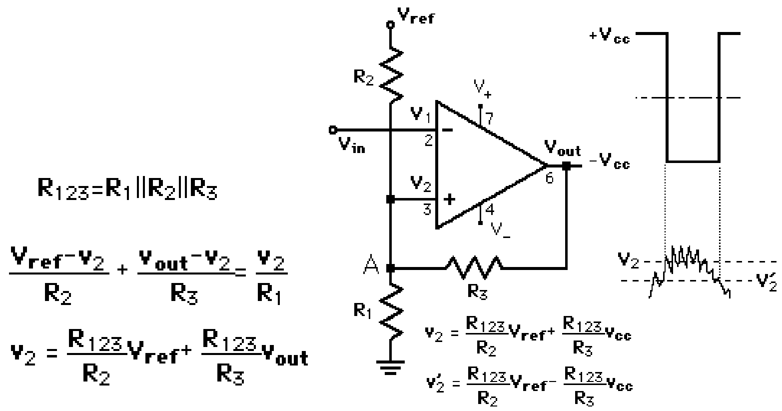

Figure 1. Schmitt-Trigger Circuit and threshold calculations [3].

1.5. Antenna

Antennas are used to radiate the RF signal over long distances. There are several antenna designs available however for every operating frequency changes the antenna shape drastically since the main design factor is the wavelength of the operating frequency. For simple dipole antenna the length of the poles is one fourth of the wavelength. Furthermore, for the monopole antenna this length is same ($\lambda/4$). Generally, antennas have small impedance however they have capacitive effect due to the magnetic field surface current of the conductor. Therefore, it is needed to be matched with the circuit to decrease reactive power and increase active power.

1.6. RS-232 Standard

The RS (Recommended Standard) 232 is almost 20-year-old technology on serial data communication area which is used with computer platforms generally. This standard applied at its simplest from with three wire connection method it may go complex up to 25 wires with fully implemented connection [3].

The speed of the connection expressed with Baud rate and it means the bits change amount per second which has similar meaning with the frequency subject. Predefined speed criteria on this project is 9600 baud this rate can be roughly transformed to frequency in Hz with 1:1 ratio which corresponds to 9.6 kHz.

Transmission method of RS-232 has four data sets combined [12]:

a. Start bit
b. data bits
c. Parity bit
d. Stop bit

In the beginning of the transmission start bit is required to be detected from the receiver part which means the message signal is started to be received.

Data bits are the main components of the communication since it contains the data as it could be understood from its name.

Parity bit is used to perform error checks over the received signal; a very basic example for this aspect is to XOR every bit in data bits which is also called Odd Parity.

Finally, when the end of the data is reached the stop bit is transmitted to define that the transmission is ended.

2. Technical Description

In the radio channel transferring the message signal requires the message signal to be modulated with specified modulation principle, in our case the Amplitude modulation principle is used. Therefore, the required Carrier signal generated with the oscillator circuit. The carrier signal frequency is decided as 2.2MHz.

Design of the RF Data Transceiver project consists two main structures: A Transmitter and a Receiver design. Main purposes and principles that explained below obeying the block diagram seen in **Figures 1 and 2**.

2.1. Transmitter Part

2.1.1. Colpitts Oscillator

This Oscillator generates a sine wave using DC voltage supply; the generated signal is tuned to 2.2MHz with the tank circuit which is our carrier frequency.

2.1.2. Computer and RS-232

The message signal generated by computer in RS-232 standards using the terminal.exe application and transferred to AM Modulator circuit to be modulated. This transfer is done using USB to TTL converter in RS-232 Standard.

2.1.3. AM Modulator

The message signal should be modulated with carrier signal in this part with AM Modulator principles to be radiated through the channel. The modulated signal is needed to be amplified before transmitted through the channel, so it is transferred to the Tuned Amplifier.

2.1.4. Tuned Amplifier

The modulated signal which has 2.2MHz carrier frequency should be amplified by eliminating the noise it includes, by the tuned amplifier, the amplified signal transferred to transmitter antenna.

2.1.5. Transmitter Antenna

The antenna broadcasts the modulated signal towards the receiver part of the project through the 2.2MHz channel. The dimensions of the antenna at this frequency is quite large if we require to design it properly however since we need short range application an approximate dimension would operate as well.

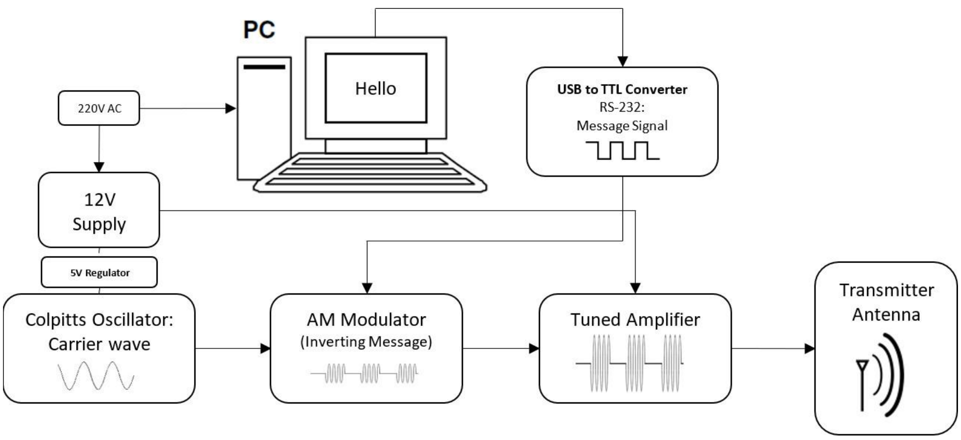

Figure 2: Transmitter Block Diagram [11].

2.2. Receiver part

2.2.1. Receiver Antenna

Receiver antenna receives propagated signal with unnecessary frequency components including also with the undesirable noise.

2.2.2. Tuned Amplifier

The received signal which has 2.2MHz carrier frequency should be amplified filtering the noise and other frequency components. Using tuned amplifier, it is possible to tune the amplification process only to the signal has the carrier frequency.

2.2.3. Envelope Detector for AM Demodulation

Amplified signal is demodulated using an Envelope detector circuit which is very beneficial in this modulation technique. The envelope of the received signal obtained. Obtained signal carries the message signal information but it also has some ripples occurred during the envelope detection process.

2.2.4. Schmitt-Trigger Comparator

The envelope of the received signal still has some impurities and ripple behaviors to remove these effects, the Schmitt trigger circuit is used. The principle could be explained simply as the input voltage of the comparator circuit exceeds a desired value the output of the comparator is fixed until the input signal falls below the threshold. The Schmitt-trigger is decided to be inverting comparator since the modulation process is inverting.

2.2.5. RS-232 and Computer

Finally, the output of the Schmitt-trigger circuit is the message signal itself and going to be transferred to the Computer platform using the TTL to USB converter module in RS-232 Standards.

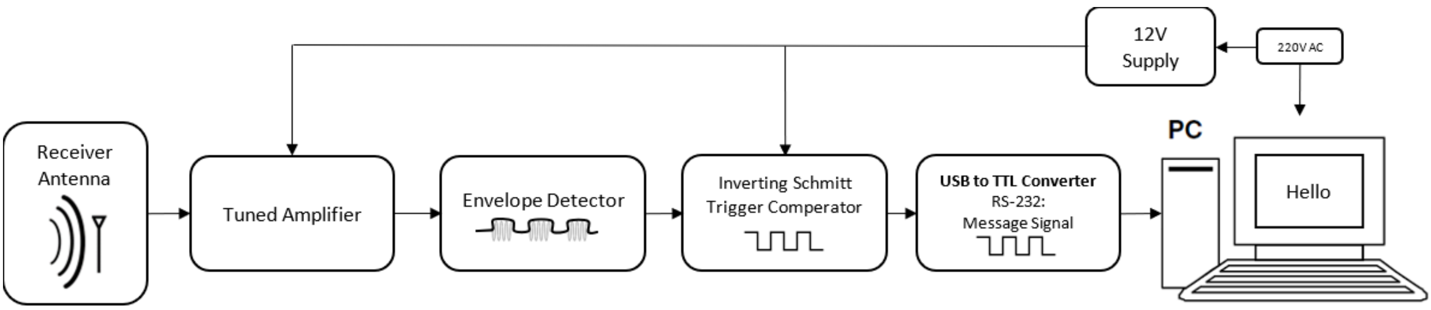

Figure 3: Receiver Block Diagram[11].

2.1. Transmitter Circuit

2.1.1. Construction of the Carrier Signal: Colpitts Oscillator

Colpitts oscillator is used to generate carrier signal for AM transmitter circuit and the circuit is shown in **Figure 4**. Colpitts oscillator is necessarily used since it generates required sine wave using a DC supply. The adjustment of the carrier signal frequency could be easily done simply by changing the inductor and capacitor values of the tank circuit exists. Calculation of the frequency is obtained with the equation 1 given below. [8]

Equation 1: $$f_c = \frac{1}{2\pi\sqrt{LC}}$$

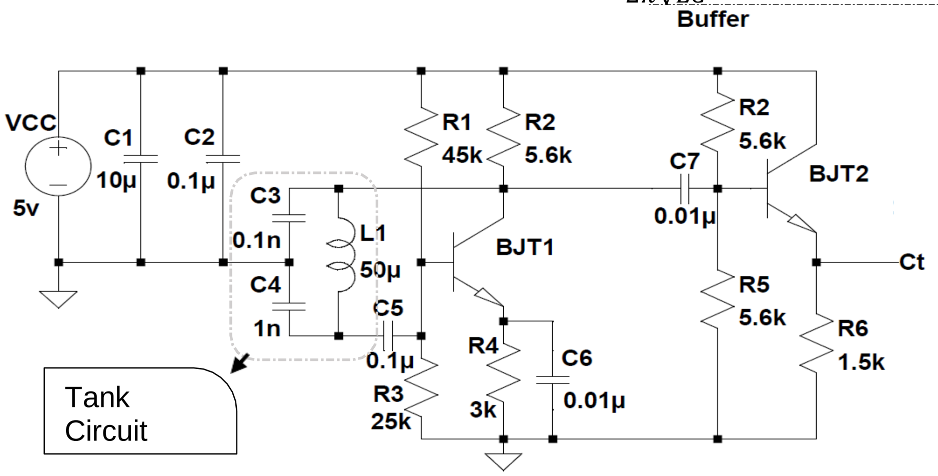

Figure 4. Colpitts Oscillator with Buffer **[11]**.

The buffer prevents the current to be drawn from the tank circuit in Colpitts Oscillator and ensures the current be drawn from the Supply Source.

Colpitts Oscillator Design Parameters		
Description of design parameter	**Value**	**Unit**
Input voltage	**5**	**Vdc**
Output voltage	**3.3**	**V(Vp-p)**
Output frequency	**2.2**	**MHz**
Output Current	**4.2**	**mA**
Oscillation Start duration	**5**	**μs**

Table 1. Design parameters for the Colpitts Oscillator [11].

2.1.3. Constructing Message Signal: Computer, USB to TTL Converter and RS-232

The message signal produced by Terminal.exe and transferred by computer in RS-232 standards with 9600 baud rate to AM Modulator circuit to be modulated. This transfer should be done with USB to TTL converter. Regular USB to TTL converter shown in Figure 5. The message signal (Mt in Figure 5) will be taken from Data Transmit port in Figure 5. "Advanced Serial Port Terminal" software will be used to create message signal. [7]

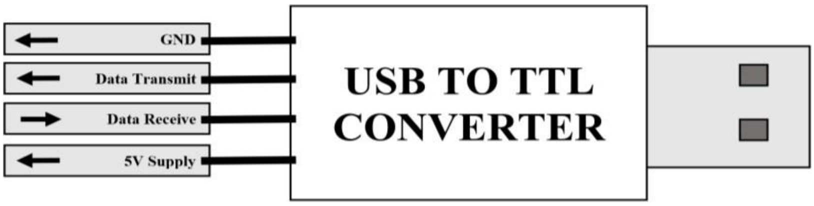

Figure 5: Basic USB to TTL Converter Schematic [11].

2.1.4 Inverting AM Modulator

AM Modulator circuit is fundamental part for transmitting. The circuit modulates message signal with carrier signal [1] [2]. This modulation process is inverting because the operation principle of the RS-232 the constant 5v output in idle mode cause the circuit to transmit whole time when the user did not send any data from the computer. So, to prevent unnecessary transmission when the channel is idle, the modulation process has been changed as it not to modulate while the computer does not send any data in the first place.

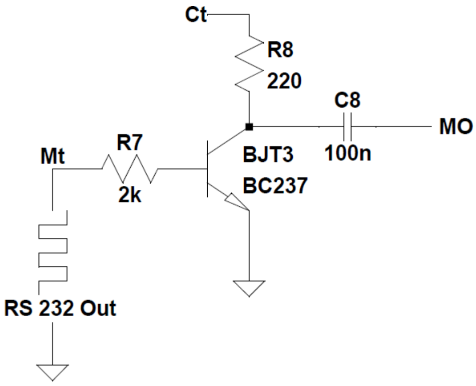

Figure 6: AM Modulator Circuit.

Inverting AM Modulator Design Parameters			
Description of circuit parameter	**Min.**	**Max.**	**Unit**
Input voltage (Mt)	**1.1**	**5**	**V**
Input voltage (Ct) (no saturation)	**0.1**	**6**	**V (Vp-p)**
Input frequency (Ct)	**$2*f_{Mt}$**	**-**	**Hz**
Input Current	**-**	**50**	**µA**
Gain	**2.38**	**2.41**	**dB**

Table 2. AM Modulator Design Parameters.

2.15 Transmitter Tuned Amplifier Design

Exclusively the signal which has carrier frequency adjusted with the tank circuit of the tuned amplifier, is amplified by transmitter tuned amplifier circuit. The unwanted frequency components generated in the modulation process required to be eliminated by the filter of the tuned amplifier. [3] [4] [5] [7]

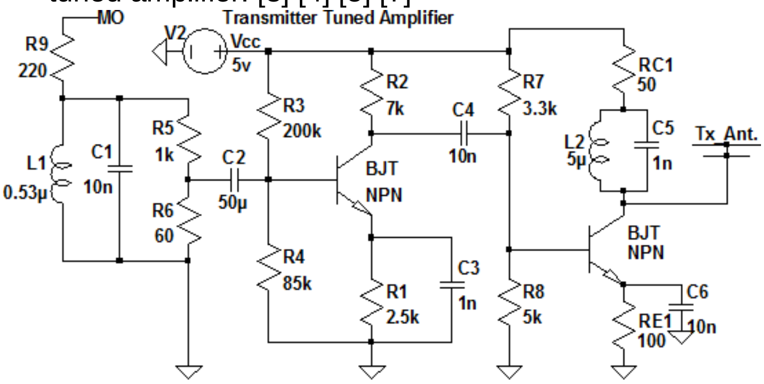

Figure 7 Transmitter Tuned Amplifier.

Transmitter Tuned Amplifier Design Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage (no saturation)	**82**	**mV (Vpp)**
Gain	**22.74**	**dB**
Output Bandwidth (-3dB)	**114**	**kHz**
Output Impedance	**50**	**Ω**
Output offset Voltage	**8.6**	**V**

Table 3. Transmitter Tuned Amplifier Design Parameters [11]

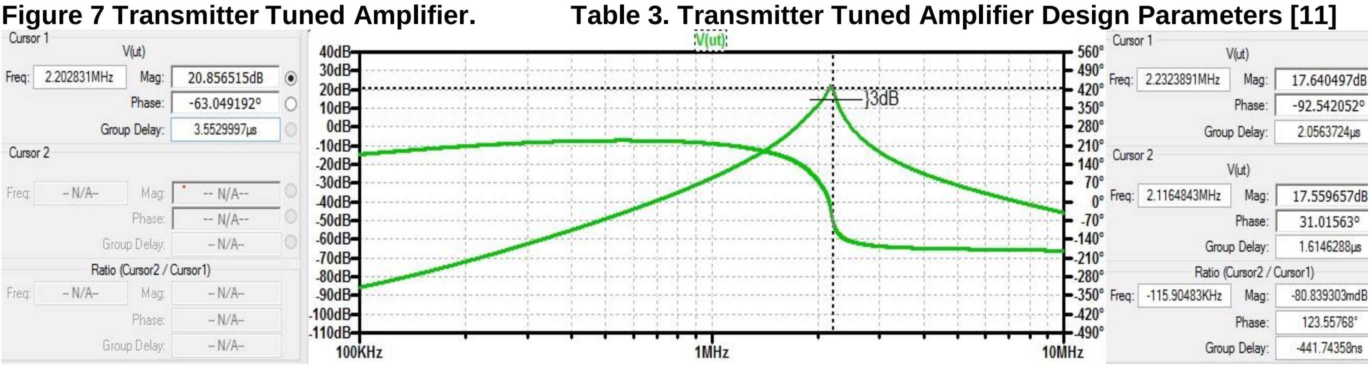

Figure 8. Gain graph of Transmitter Tuned Amplifier Circuit [11].

2.1.6 Transmitter Antenna

The amplified signal is broadcasted by the transmitter antenna to the receiver antenna. The impedance of transmitter antenna should be matched with output impedance of transmitter tuned amplifier circuit for power efficiency and preventing the mismatch reflections [5] [9]. Instead of magnetic loop antenna, Short Monopole antenna will be used as transmitter antenna shown in **Figure 13** with properties in **Table 7.**

2.2. Receiver Circuit

2.2.2. Receiver Tuned Amplifier

The tuned amplifier is essential in receiver circuit to get reliable results. Small amplitude signal includes noise received from antenna, should be amplified around 2.2MHz frequency to filter noise. [3] [4] [5] [7]

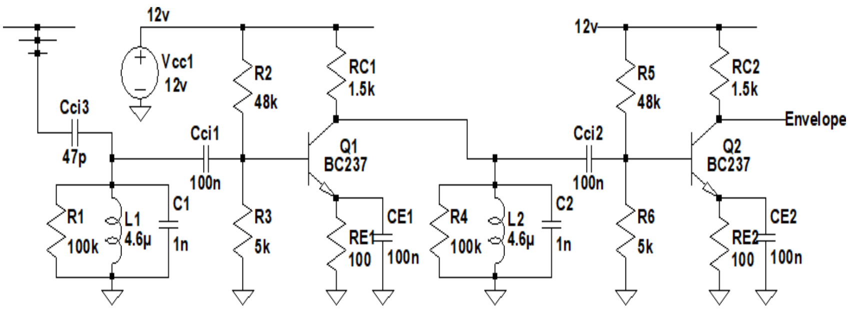

Figure 9. Receiver Tuned Amplifier.

Receiver Tuned Amplifier Design Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage (no saturation)	**130**	**mV (Vpp)**
Gain	**54**	**dB**
Output Bandwidth (3dB)	**118**	**kHz**
Output Impedance	**50**	**Ω**
Output offset Voltage	**7**	**V**

Table 4. Receiver Tuned Amplifier Design Parameters

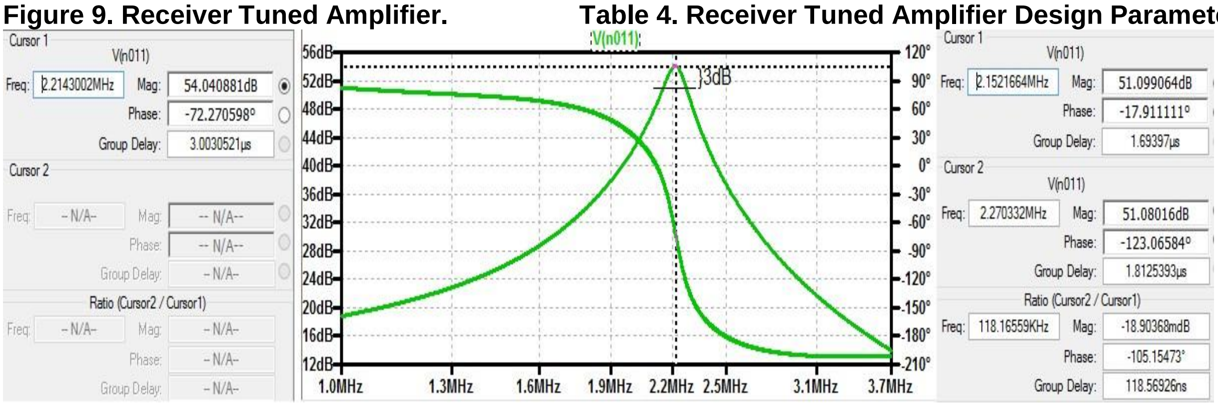

Figure 10. Gain graph of Receiver Tuned Amplifier Circuit.

2.2.3. Envelope Detector

The envelope detector circuit which is shown in Figure 11, is one of the common circuits. The principle of work for the envelope detector is that the capacitor charges on the rising edges of modulated signal and discharges gradually through the resistor. Diode acts as a rectifier and allows the current to flow only at positive cycles. [1]

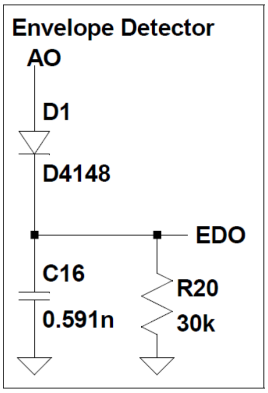

Figure 11. Envelope Detector Circuit**.**

Envelope Detector Design Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage	**0.7**	**V**
Input current	**0.55**	**mA**
Input frequency	**2.2**	**MHz**
Min. RC product	**45**	**µs**
Max. RC product	**10.4**	**ms**
Output Impedance	**30**	**kΩ**

Table 5. Envelope Detector Design Parameters.

2.2.4. Schmitt-Trigger Comparator

Schmitt trigger circuit generates a square wave by simply detecting the level of input signal with respect to a certain high and low-level voltage reference. The demodulated data signal is in the form of a digital signal with distortion. [4] [6] Since the inverting modulation used in the transmitter circuit it also been used inverting comparator.

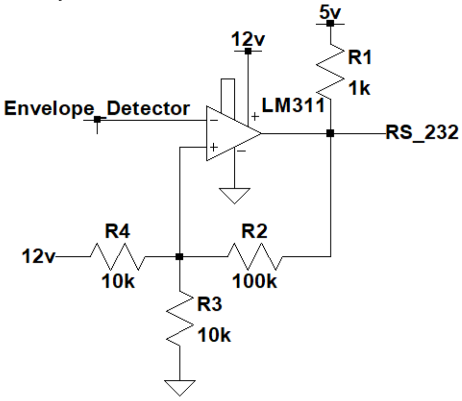

Figure 12. Schmitt-Trigger Comparator Circuit.

Schmitt Trigger Design Parameters		
Description of design parameter	**Value**	**Unit**
Low level threshold voltage	**0.608**	**V**
High level threshold voltage	**0.802**	**V**
Output slew rate	**0.052**	**V/ms**
Output frequency	**9.6**	**kHz**

Table 6. Design parameters for the Schmitt Trigger Circuit.

$$v_{treshold} = \frac{(10k//10k//100k)}{10k} x12V \mp \frac{(10k//10k//100k)}{100k} x5V \text{ [3]}$$

2.2.5. Reconstructing the Received Signal: RS-232, USB to TTL Converter and Computer

The message signal will be recovered from the output of the Schmitt trigger circuit and ready to be transferred to the Computer platform using the TTL to USB converter module in RS-232 Standards with 9600 baud rate. “Advanced Serial Port Terminal” software is used to read received signal. The reconstructed signal will be taken from Data Receiver port in **Figure 5.** “Advanced Serial Port Terminal” software will be used for reading the received signal.

2.2.6 Receiver Antenna

Due to the construction difficulties, the idea of building magnetic loop antenna is abandoned. Since it is difficult to build in the laboratory conditions we decided to build Short Monopole antenna which is simple and proper antenna type. Yet the antenna length which is required (34meters) still enormous we have constructed 10meter wire antenna. Required antenna length = $\lambda/4 = 34.07m$ [9]. Constructed antenna length $10m$ which is
suitable for 7.5Mhz but also can operate at 2.2MHz in short-range. To overcome the reactive power loss in the antenna we have constructed an empirical method to decide series inductor required to be connected $32.8\mu H$ [9].

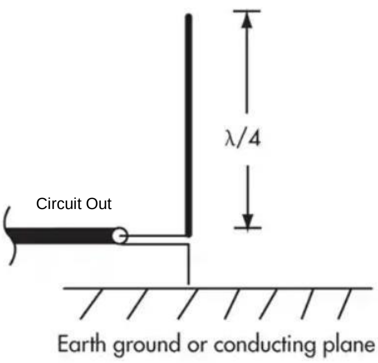

Figure 13: Monopole antenna [9].

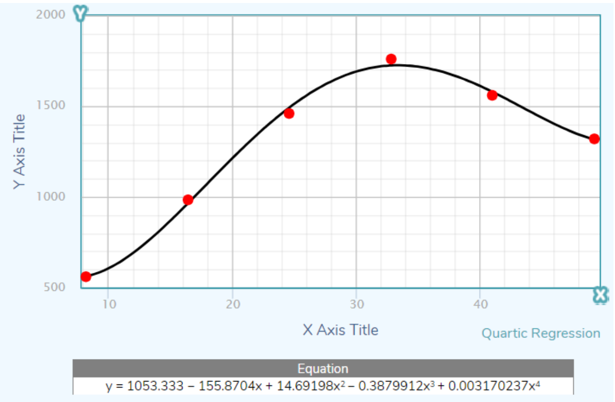

Figure 14: Monopole Antenna Empirical Reactive Power Correction.

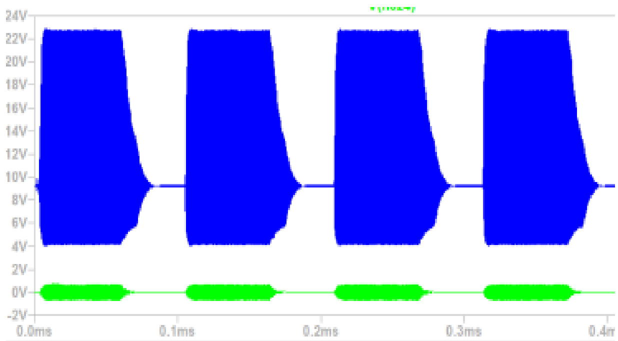

Figure 15. Transmitter Simulation, Blue: Output, Green: Modulated Signal.

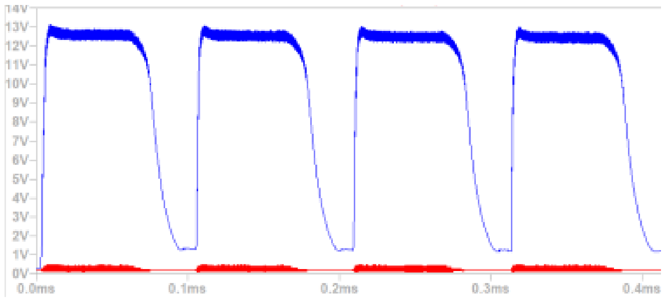

Figure 16. Receiver Simulation. Red: Input, Blue: Output.

4. Test Results

3.1. Colpitts Oscillator Test Results

The measurements corresponding to the Colpitts Oscillator circuit design targets are given in the following table 7 and Figure 17.

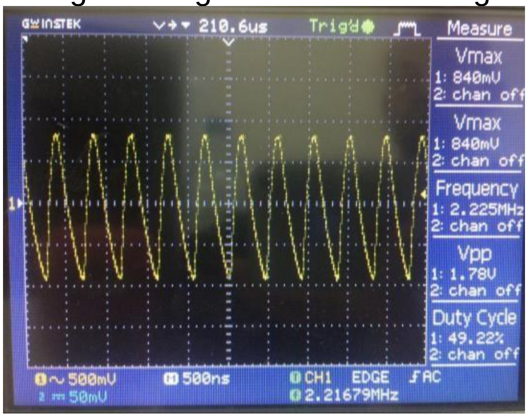

Figure 17: Colpitts Oscillator Waveform

Colpitts Oscillator Test Results		
Description of design parameter	**Value**	**Unit**
Input voltage	**5**	**Vdc**
Output voltage	**1.78**	**V(Vp-p)**
Output frequency	**2.21**	**MHz**
Output Current	**3.9**	**mA**
Oscillation Start duration	**-**	**µs**

Table 7: Test results for the Colpitts Oscillator.

The Colpitts Oscillator circuit generates a sinusoidal at 2.2MHz frequency, 2.25Vpp signal but it did not produce exactly 50% duty cycle. Positive half cycles were 24 ns shorter than the negative half cycles due to the inaccurate inductor and capacitor values charging and discharging times vary in the Colpitts oscillator’s tank circuit. Since this timing error is in nano scale, it does not affect the frequency and the performance of modulation significantly.

3.2. Inverting AM Modulator Test Results

The measurements corresponding to the Inverting AM Modulator circuit design targets are given in the following table 8 and Figure 18.

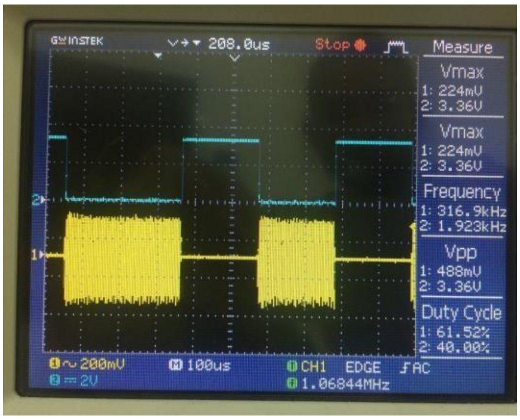

Figure 18: Message signal (up) and the Modulated signal (down).

Inverting AM Modulator Test Parameters			
Description of circuit parameter	**Min.**	**Max.**	**Unit**
Input voltage (Mt)	**0**	**5**	**V**
Input voltage (Ct) (no saturation)	**0.1**	**5.32**	**V (Vp-p)**
Input frequency (Ct)	**$2*f_{Mt}$**	**-**	**Hz**
Input Current	**-**	**43**	**µA**
Gain	**2.35**	**2.35**	**dB**

Table 8. Test Results for the AM Modulator.

The modulator is inverted in order to prevent the transmitter circuit to transmit in the idle mode. Since the RS-232 standard applies 5v DC constant output in the idle mode.

3.3. Transmitter Tuned Amplifier Test Results

The measurements corresponding to the **Transmitter Tuned Amplifier** circuit design targets are given in the following table and Figure 19.

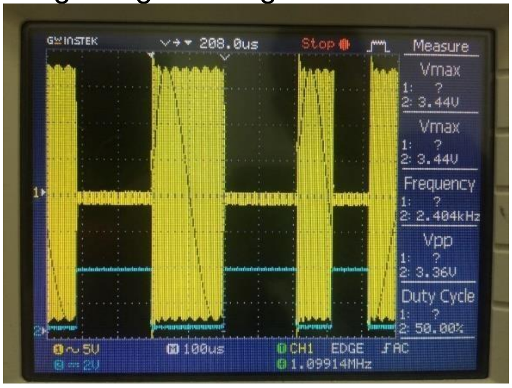

Figure 19: Transmitter tuned amplifier output

Transmitter Tuned Amplifier Test Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage (no saturation)	**82**	**mV (Vpp)**
Gain	**22.74**	**dB**
Output Bandwidth (-3dB)	**108**	**kHz**
Output Impedance	**50**	**Ω**
Output offset voltage	**8.4**	**V**

Table 8. Transmitter Tuned Amplifier Test Parameters.

The output impedance of the tuned amplifier circuit is 50 ohms and the antenna connected in series to tuned amplifier. However due to the capacitive effect of the antenna the power divided into reactive and active power therefore it has been decided to calculate a series inductor to overcome capacitive effect of the antenna. Therefore, we have used empirical mode since the antenna has very dependent measurements and dimensions so with the calculations seen in Figure 13 we have obtained the required inductor in series with the method.

3.4. Receiver Tuned Amplifier Test Results

The measurements corresponding to the receiver circuit amplifier are as follows.

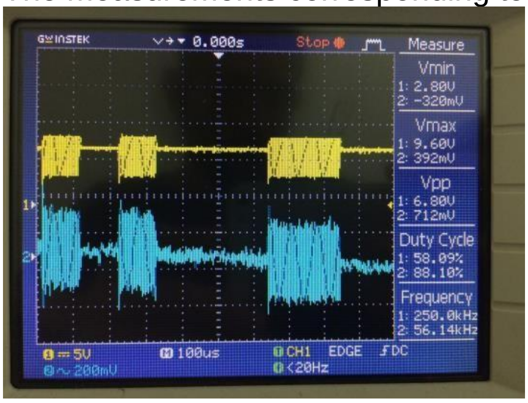

Figure 20: Receiver Tuned Amplifier

Receiver Tuned Amplifier Test Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage (no saturation, max. range)	**18**	**mV (Vpp)**
Gain	**62**	**dB**
Output Bandwidth (3dB)	**106**	**kHz**
Output Impedance	**1.480**	**kΩ**
Output Offset Voltage	**7.2**	**V**

Table 9. Receiver Tuned Amplifier Test Parameters.

Receiver tuned amplifier have a gain very close to 62dB therefore the design has efficient amplification process. Therefore, it has been enabled the further range of monitoring capability.

3.5. Envelope Detector Circuit Test Results

The measurements corresponding to the receiver envelope detector circuit are as follows.

Figure 21: Envelope Detector (yellow) and Received signal (blue)

Envelope Detector Test Parameters		
Description of circuit parameter	**Value**	**Unit**
Min. input voltage	**0.68**	**V**
Input current	**0.25**	**mA**
Input frequency	**2.218**	**MHz**
Min. RC product	**42**	**µs**
Max. RC product	**10.36**	**ms**
Output Impedance	**29.876**	**kΩ**

Table 10. Envelope Detector Test Parameters.

Using the envelope detection simplifies the demodulation step very practical. The peak voltage is quite large so the comparator works properly.

3.6. Schmitt Trigger Test Results

The measurements corresponding to the receiver Inverting Schmitt-Trigger circuit are as follows.

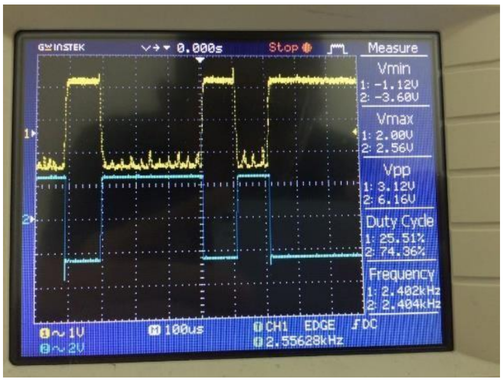

Figure 22: Envelope Detector (up) and Schmitt-Trigger Output (below)

Schmitt Trigger Test Parameters		
Description of design parameter	**Value**	**Unit**
Low level threshold voltage	**0.704**	**V**
High level threshold voltage	**0.904**	**V**
Output slew rate 2.52/440n	**0.012**	**V/ms**
Output frequency	**9.6**	**kHz**

Table 11. Schmitt Trigger Test Parameters.

The Schmitt-Trigger circuit have good stability therefore when the message signal is larger than the noise and above 1volt it starts to operate properly.

3.7. Antennas Test Results

We have tried several length antennas in the circuits. When we increase the length of the wire antenna operating quality increase dramatically however the series correction inductance requirement changes and needed to be redrived.

Antennas Test Parameters		
Description of design parameter	**Value**	**Unit**
Max. Transmission Range	**25**	**m**
Min. Transmission Range	**5**	**m**
Length	**9.8**	**m**

Table 12. Antennas Test Parameters.

3.8. RS-232 and USB to TTL Converter Test Results

Despite noisy environment and 25m distance, we transmitted and received full text message from our transceiver project.

RS-232 and USB to TTL Converter Test Parameters		
Description of design parameter	**Value**	**Unit**
Output Voltage	**4.98**	**V**
Baudrate	**9600**	**Bit/s**
Stop Bits	**2**	**-**
Parity Bit	**Odd**	**-**

Table 13. RS-232 and USB to TTL Converter Test Parameters

3.9. Power Test Results

The transmission signal seen in **Figure 19** (yellow) is the voltage applied to the antenna and the current drawn from is around 70mA. Therefore, the transmitted power is 2.38Watts. This amount of power provided us a quite long-range improvement and the transmission could be monitored from further ranges. We have been managed to monitor the transmission around 25 meters away from the transmitter.

The power measured for the receiver part is 0.12watts.

$$with\ the\ general\ formula\ P = IxV$$

5. Conclusion

In this project, we successfully designed RF data transceiver which has minimum range of 5m, with 9600 transmission rate. Our RF Data Transceiver project had two main circuit parts; transmitter and receiver. The transmitter circuit consists a Colpitts oscillator which produces 2.2MHz carrier wave, a RS232 standard TTL to USB converter to transfer message signal from computer to transmitter circuit, inverting AM modulator circuit for modulation of message and carrier signals, a tuned amplifier to only amplify 2.2MHz signal to broadcast through the air and a monopole antenna. The receiver circuit has an antenna which gathers the signal, it follows with a tuned amplifier to filter noise and amplify only 2.2MHz signal, an envelope detector for demodulation of signal, an inverting Schmitt-trigger comparator to digitalize the enveloped signal and a RS232 standard TTL to USB converter to transfer message signal from receiver circuit to computer. We used Terminal.exe to control message signal for both transmitting and receiving.

While building our project, we had to change non-inverting AM modulator circuit to inverting, because the TTL to USB converter produces 5V signal which leads to transmission and it occupies the channel in idle mode. We also had to change Schmitt-trigger comparator circuit with inverted model, to correct the inverse modulated signal. Due to limitations like cost, time and size, we changed building magnetic loop antenna idea with idea of building Short Monopole antenna which is simpler and effective. Because of changing antenna model, the impedance changed. In the receiver part the second amplifier has been changed to overcome impedance mismatch and for better amplification. The 12V to 5V regulator has been added to operate the circuit only with single power supply voltage.

The experimental parameters are not generally match with the theoretical ones, however since they are close with the expected values they do not affect the general circuit behavior in significant manner.

To sum up, we successfully designed and produced a RF transceiver project. Dealing with problems process was competitive for us, however we managed to send and receive a full text without noise in maximum range of 25m.

5. Component List

Component description	**Part Number**	**Manufacturer**	**Supplier**
Small signal fast switching diode	**1N4148**	Vishay Semiconductors	Electronics Lab.
Operational amplifier	**LM311**	Texas Inst.	Electronics Lab.
NPN Expitaxial Silicon Transistor	**BC237**	Fairchild semiconductor	Electronics Lab.
5v Positive Voltage Regulator	**L7805CV**	ST Microelectronics	Electronics Lab.
USB to TTL Converter	**CH340 Chip**	DreamCity Innovations	RoboTekno

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