Submitted in partial fulfillment of the requirements

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Bachelor of Technology

by

SHREYAS ABHIJIT TALOKAR,612207092

SURAJ RAVINDRA SHEWALE,612207077

TANMAY MANOHAR RAUT, 612207070

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FSK MODULATOR

By

SHREYAS ABHIJIT TALOKAR,612207092
SURAJ RAVINDRA SHEWALE,612207077
TANMAY MANOHAR RAUT,612207070

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Examiners	Name	Signature
1. External Examiner	____________________	
2. Internal Examiner	____________________	
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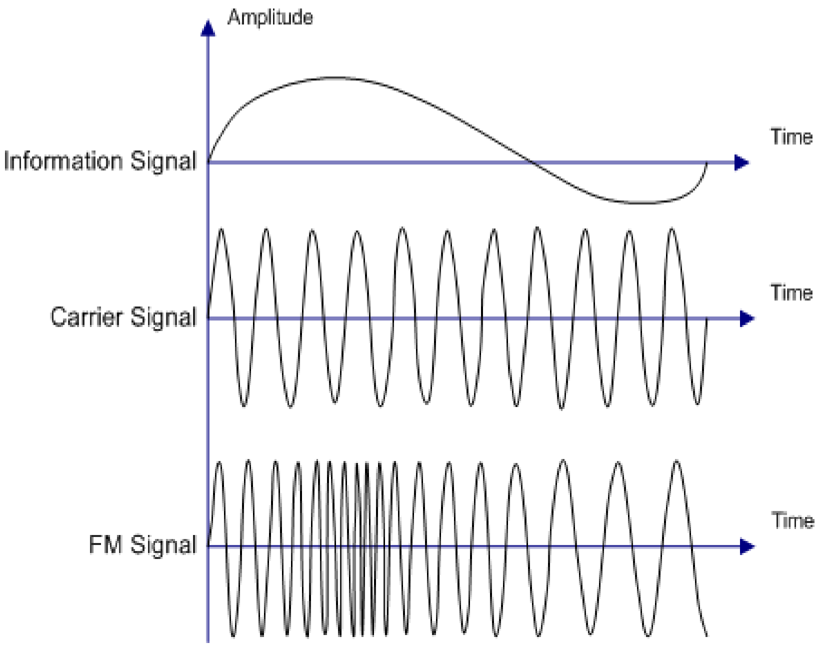
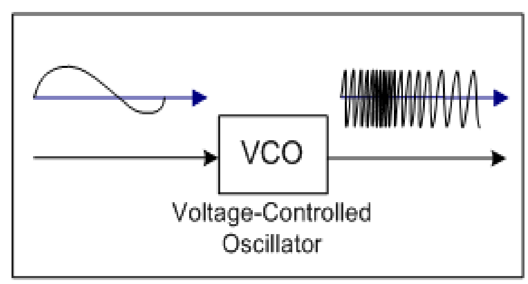
1)INTRODUCTION

1.1 WHAT IS MODULATION ?

If you use a radio, you must have heard the terms FM and AM. Ever wondered how two radio stations have a different address on the FM scale? The radio waves travel from the radio station to our position in a different form than they actually are.

We all know that most signals generated in everyday life are sinusoidal waveforms. Modern signals include the basic sinusoidal form signal containing important information. Modulation is the branch of science in electronics and communication systems including varying the fundamental properties of the basic signal by superimposing it with a carrier signal to carry the signal from one location to the other. This process is ‘Modulation’.





1.2 NEED FOR MODULATION

The need for modulation arises because of various factors. We live in an electric age where the world is connected for every person, without the need of being actually connected with the help of wires. Messages, information, and signals are sent from one part of the world to the other within minutes and seconds. All of this is possible only with the help of signals from one device to the other from one location to another one, miles away and the quantity and dependence on these signals and their inter-conversions are humongous.

i)Modulation helps to increase strength of the signal.The baseband signals transmitted by the sender are not capable of direct transmission.
ii)Modulation helps signal travel long distances.
iii)Modulation has removed the necessity of using wires in communication.
iv)Modulation helps prevent mixing of message signal with other signals.
v) When the transmission occurs over free space, the antennae radiate the signal, and the receiver receives it. To operate efficiently, antennae need to be in the order of the magnitude of the wavelength of the transmitted signal.

Length of antenna=lambda=speed of light/frequency

Speech frequencies range from 20 Hz to 20 kHz. So supposing this is a frequency of 20 kHz and radiated out to a receiver through a channel of free space.

1.3 TYPES OF MODULATION

Amplitude Modulation:
In amplitude modulation (AM), auditory or visual information is impressed on a carrier wave by varying the amplitude of the carrier to match the fluctuations in the audio or video signal being transmitted.

Frequency Modulation:
In frequency modulation (FM), unlike AM, the amplitude of the carrier is kept constant, but its frequency is altered in accordance with variations in the audio signal being sent.

Phase Modulation:
The phase of a carrier wave varies in response to the vibrations of the sound

source in phase modulation (PM). This form of modulation is often considered a variation of FM.

1.4 WHY FSK OVER ASK AND PSK?

Frequency Shift Keying (FSK) offers several advantages over Amplitude Shift Keying (ASK) and Phase Shift Keying (PSK) in certain scenarios:

Compared to ASK:

- **Noise Immunity:** FSK is less susceptible to amplitude variations in the channel caused by noise or interference.expand_more This is because the data is encoded in the frequency shift, not the amplitude of the signal. Fluctuations in amplitude won't affect the ability to decode the data as long as the frequency remains distinct.
- **Simpler Implementation:** FSK demodulation is generally simpler than ASK demodulation. Exclamation FSK only requires a frequency detector to recover the digital data, whereas ASK may require circuitry to determine the specific amplitude level representing a 1 or 0, which can be more sensitive to noise.

Compared to PSK:

- **Less Sensitive to Phase Noise:** FSK is not affected by phase shifts in the channel caused by noise or imperfections. Exclamation As long as the frequencies remain distinct, the data can be recovered. Exclamation PSK relies on precise phase differences to encode information, and phase noise can introduce errors.
- **Easier Synchronization:** FSK receivers can achieve synchronization with the carrier signal faster and easier than PSK receivers. Exclamation This is because FSK only needs to detect the frequency changes, while PSK needs to determine the absolute phase of the signal.

However, FSK also has some drawbacks:

- **Larger Bandwidth:** FSK signals generally occupy a wider bandwidth compared to ASK or PSK for the same data rate.expand_more This is because the signal needs to shift frequencies to represent the data.
- **Lower Data Efficiency:** For the same bandwidth, FSK can transmit less data compared to some PSK schemes that use multiple phase shifts to represent more than one bit per symbol.

In conclusion, FSK is a good choice when noise immunity, ease of implementation, and synchronization are critical. However, if bandwidth efficiency or data rate is a top priority, ASK or PSK might be better options. The best choice depends on the specific requirements of the communication system.

(Henceforth we will be focusing only on Frequency Modulation)

Frequency Shift Keying Modulation:

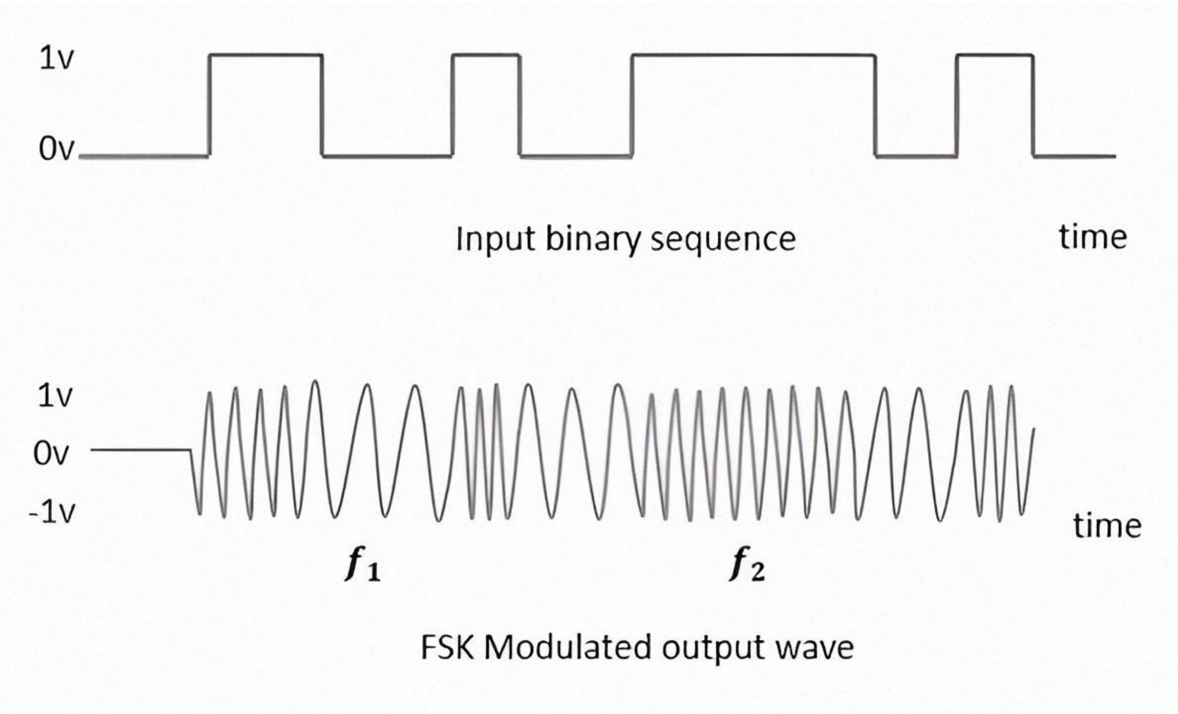
Frequency-shift keying is a frequency modulation scheme in which digital information is encoded on a carrier signal by periodically shifting the frequency of the carrier between several discrete frequencies.

1.5 HOW IS FSK EXECUTED?

- **Digital Data Input :** The digital data to be transmitted is represented by binary symbols (0s and 1s).
- **Carrier Signals :** FSK uses two or more carrier signals with different frequencies. Each carrier frequency represents a different digital symbol (e.g., 0 or 1).
- **Frequency Selection :** Depending on the input binary data, the system selects the appropriate carrier frequency to transmit. For example, one frequency may represent a '0' while another frequency represents a '1'.
- **Modulation :** The selected carrier signal is modulated by the binary data. When transmitting a '0', the carrier frequency is one value, and when transmitting a '1', it switches to another frequency.
- **Transmission :** The modulated carrier signal is transmitted through the

communication channel.

- **Reception :** At the receiver end, the incoming signal is demodulated to extract the original binary data. By analysing the frequency changes, the receiver determines the transmitted binary symbols.



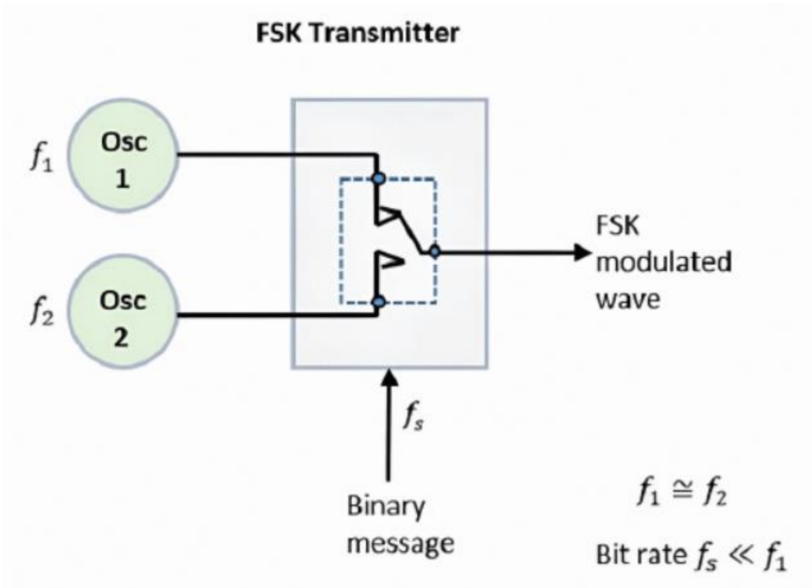
2)METHODOLOGY

2.1) COMPONENTS

- IC 555
- PNP Transistors
- Resistors
- Capacitors
- POTs
- Power Supply

2.2) BLOCK DIAGRAM

The FSK modulator block diagram comprises of two oscillators with a clock and the input binary sequence. Following is its block diagram.



The two oscillators producing a higher and a lower frequency signals are connected to a switch along with an internal clock.To avoid the abrupt phase discontinuities of the output waveform during the transmission of the message,a clock is applied to both the oscillators,internally.The binary input sequence is applied to the transmitter so as to choose the frequencies according to binary input.

2.3)CIRCUIT DIAGRAM AND WORKING PRINCIPLE

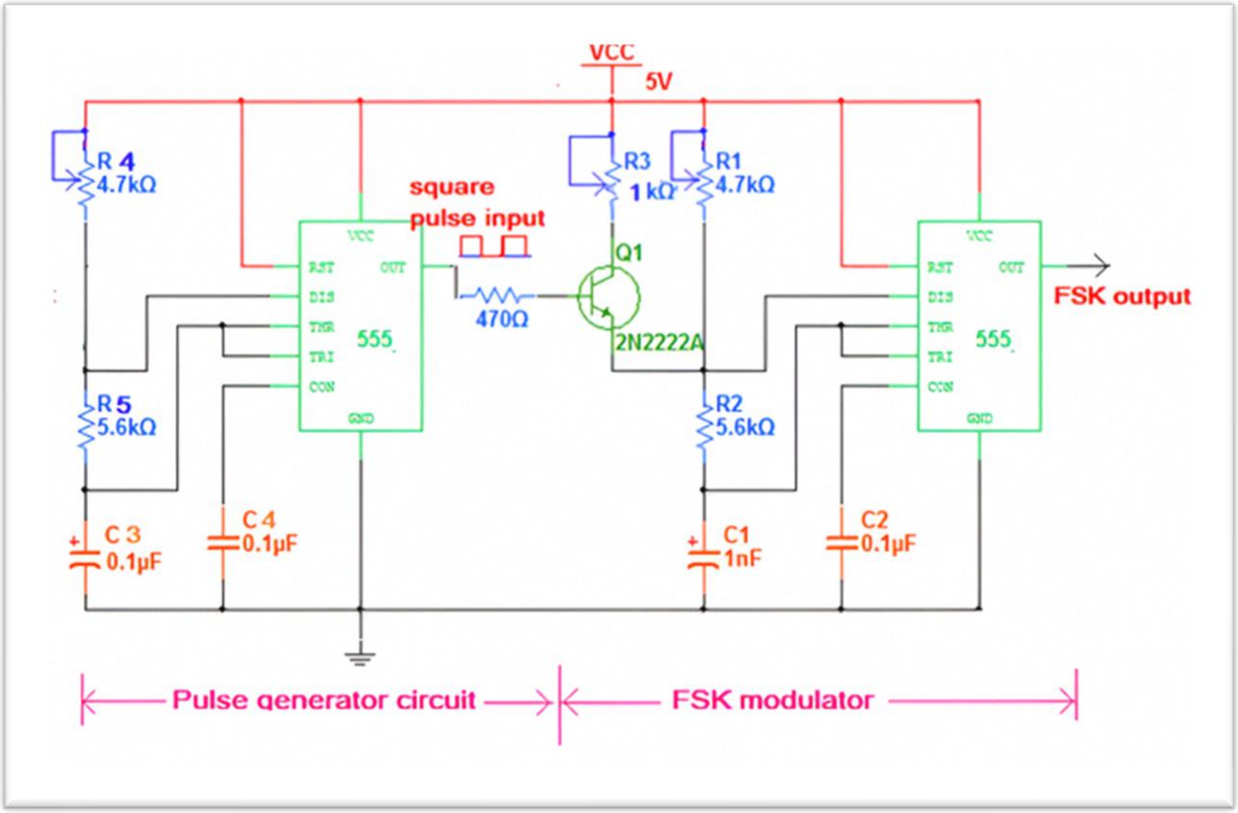


Figure 1REFERENCE DIAGRAM

PULSE GENERATOR CIRCUIT

In this part of the circuit one more IC555 is connected in astable mode generating continuous pulses at a frequency of 1khz. As 5V supply is given to the circuit pulse generator will generate square pulse of 1khz.These pulses are given to the base input of transistor. Since the transistor is connected in switch mode it will switch on and off. Instead of giving square pulses as input we can give bit stream of 1's and 0's.

FSK MODUKATOR

All IC555 is configured as astable multivibrator.It generates 2 different frequencies.F1 frequency is obtained when transistor Q1 is off and F2 when transistor Q1 is on.When Q1 is off R3 is not connected in circuit.When Q1 is on,R3 is not connected in circuit.When Q1 is on R3 gets connected in parallel with R1.The square pulses are applied at the base input of Q1 for bit 1 input to Q1 is high,so it is in on state,frequency obtained by IC555 is F2.Similarly for 0 bit that is low input to Q2 is off so IC555 generates F1.

2.4) CALCULATION

As shown in figure IC 555 is configured as Astable Multi-vibrator. It generates two different frequencies. It generates one frequency F1 when transistor Q1 is OFF and another frequency F2 when transistor Q1 is ON.

· When Q1 is OFF R3 is not connected in the circuit. The frequency is given by

F1 = 1.44 / (R1 + 2×R2) × C1

· When Q1 is ON, R3 get connected in parallel with R1. So frequency is given by

F2 = 1.44 / (R’ + 2×R2) × C1

Where R’ = R1×R3 / (R1+R3)

The Square Pulses (bit stream) are applied at the base input of Q1. So for bit 1 input to Q1 is high, so it is ON, so IC555 generates frequency F2 in the output. Similarly for bit 0 – input to Q2 is low, so it is OFF, so IC555 generates frequency F1. So we get one frequency F1 for bit 1 and other frequency F2 for bit 0 as per requirement.

Please refer Circuit Diagram in the Circuit Diagram Tab above

Pulse Generator Circuit

Here also IC555 is connected in Astable mode. It will generate continuous pulses. It generates pulses at 1 KHz frequency. The frequency is determined by RC components R4, R5 and C3 as

$$F = 1.44 / (R4 + 2\times R5) \times C3$$

Circuit Designing

Let us see how values of R1, R2, R3 and C1 can be found out or calculated. I have selected F2 as 120 KHz for bit 1 and F1 as 90 KHz for bit 0.

Assume $C1 = 1\ nF = 1 \times 10^{-9}\ F$

Substituting this value in to above equation

$F1 = 1.44 / (R1 + 2\times R2) \times 10^{-9}$

Because F1 is 90 KHz

$90 \times 10^{3} = 1.44 / (R1 + 2\times R2) \times 10^{-9}$

$R1 + 2\times R2 = 1.44 /(9 \times 10^{4} \times 10^{-9})$

$R1 + 2\times R2 = 16000$

Now to get around 50% duty cycle R2 > R1 so let us take R1 = 4.5 K. So

$2\times R2 = 16000-4500 = 11500$

So R2 = 5750 = 5.75 K

The nearest practical value can be 5.6 K.

Thus finally R1 = 4.5 K, R2 = 5.6 K and C1 = 1 nF. Instead of selecting fixed value of R1, a Potentiometer is used to tune the frequency and get exact value of 90 KHz.

Now let us find out value of R3 for frequency F2 = 120 KHz

$F2 = 1.44 / (R' + 2\times5600) \times 10^{-9}$

Because F1 is 90 KHz

$120 \times 10^{3} = 1.44 / (R' + 11200) \times 10^{-9}$

$R' + 11200 = 1.44 /(12 \times10^{4} \times 10^{-9})$

$R' + 11200 = 12000$

$R' = 800$

But $R' = R1 \times R3 / (R1+R3)$. So

$(R1 \times R3) / (R1+R3) = 800$

$4500 \times R3 / (4500+R3) = 800$

$3700 \times R3 = 4500 \times 800$

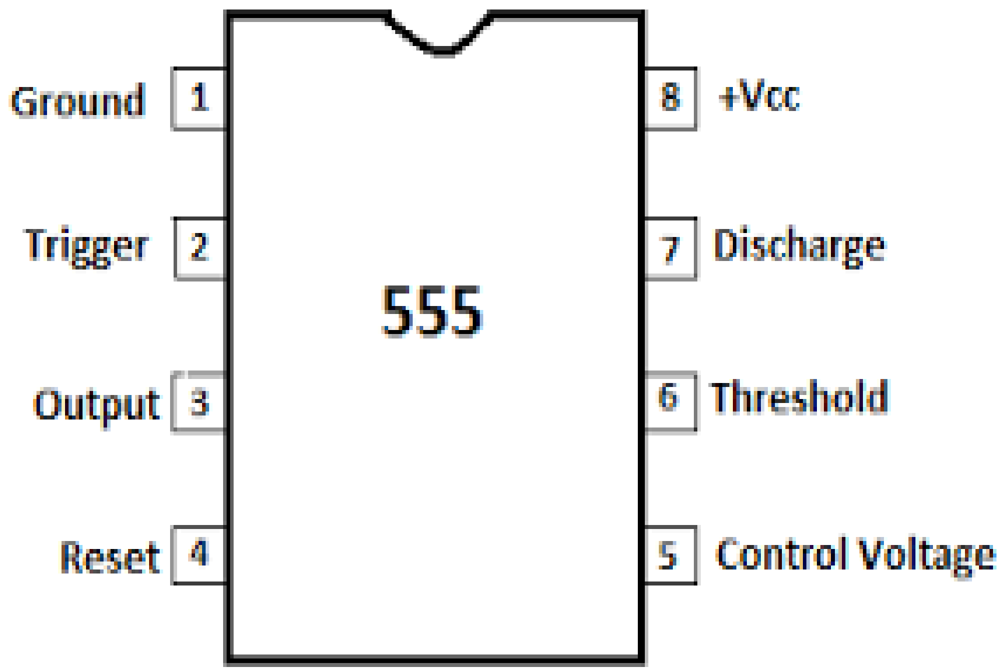
Finally

$R3 = 973$

We can select nearest practical value as 1K. But instead of using fixed value 1 K Resistor, a Potentiometer of 1 K is used so that the frequency can be adjusted to exactly 120 KHz.

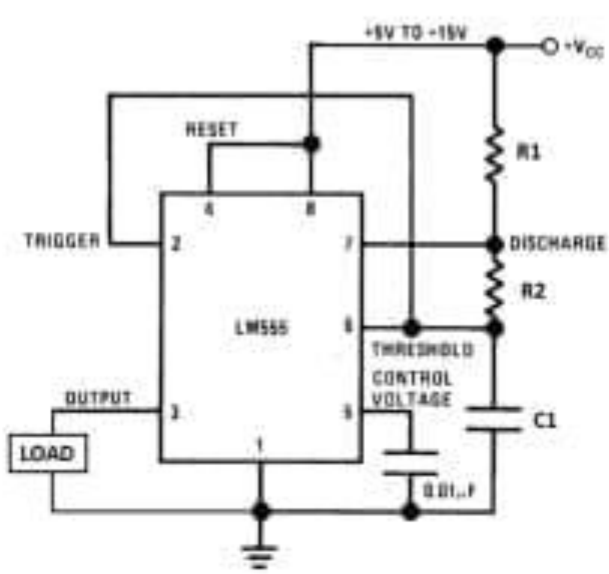
Similarly we can calculate values of R4, R5 and C3 in pulse generator circuit to generate pulses at 1 KHz. The values are calculated as R4 = 3.3 K, R5 = 5.6 K and C3 = 0.1 μF.

2.5) PIN DESCRIPTION OF IC555



Pin		I/O	DESCRIPTION
NO.	NAME		
1	GND	O	Ground Reference Voltage
2	Trigger	I	Responsible for transition of SR flip-flop
3	Output	O	Output driven waveform
4	Reset	I	A negative pulse on reset will disable or reset the timer
5	Control Voltage	I	Controls the width of the output pulse by controlling the threshold and trigger levels
6	Threshold	I	Compares the voltage applied at the terminal with a reference voltage of 2/3
7	Discharge	I	Connected to open collector of a transistor which discharges a capacitor between intervals.
8	V_{CC} Supply	I	Supply voltage

2.6) HOW ASTABLE MODE WORKS?



- *Pin 2 – Trigger*: Turns on the output when the voltage supplied to it drops below 1/3 of Vcc
- *Pin 6 – Threshold*: Turns off the output when the voltage supplied to it reaches above 2/3 Vcc.
- *Pin 7 – Discharge*: When the output voltage is low, it discharges C1 to ground.

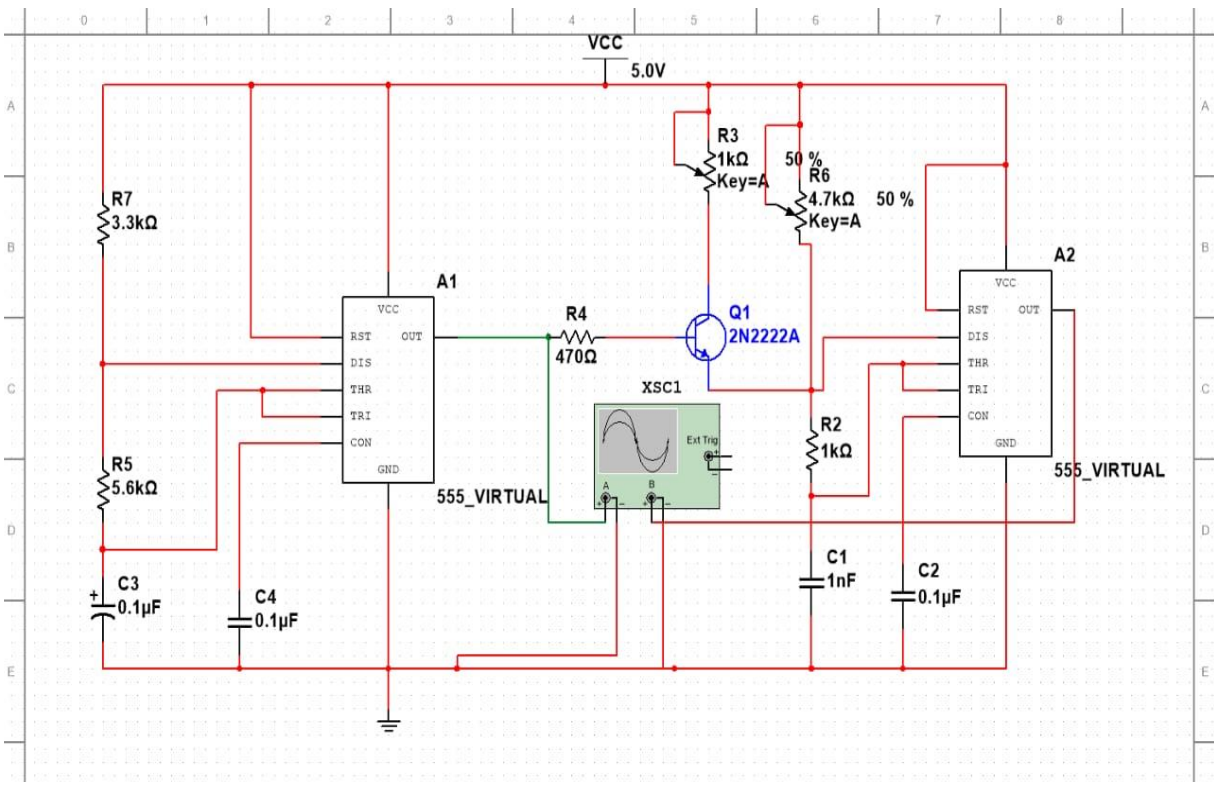
In astable mode, the output cycles on and off continuously. In the schematic above, notice that the threshold pin and the trigger pin are connected to C1. This makes the voltage the same at the trigger pin, threshold pin, and C1.

At the beginning of an on/off cycle, the voltage is low at C1, the trigger pin, and the threshold pin. Whenever the trigger pin voltage is low, the output is on, and the discharge pin is off. Since the discharge pin is off, current can flow through resistors R1 and R2, charging capacitor C1. Once C1 charges to 2/3 Vcc, the output is switched off by the threshold pin. When the output goes off, the discharge pin switches on. This allows the charge accumulated on capacitor C1 to drain to ground.

Once the voltage across C1 drops to 1/3 Vcc, the trigger pin turns off the discharge pin, so C1 can start charging again.

3)SIMULATION AND OUTPUT

3.1) SIMULATION



Circuit Operation

- As 5 V supply is given to circuit, Pulse Generator will generate square pulses of 1 KHz

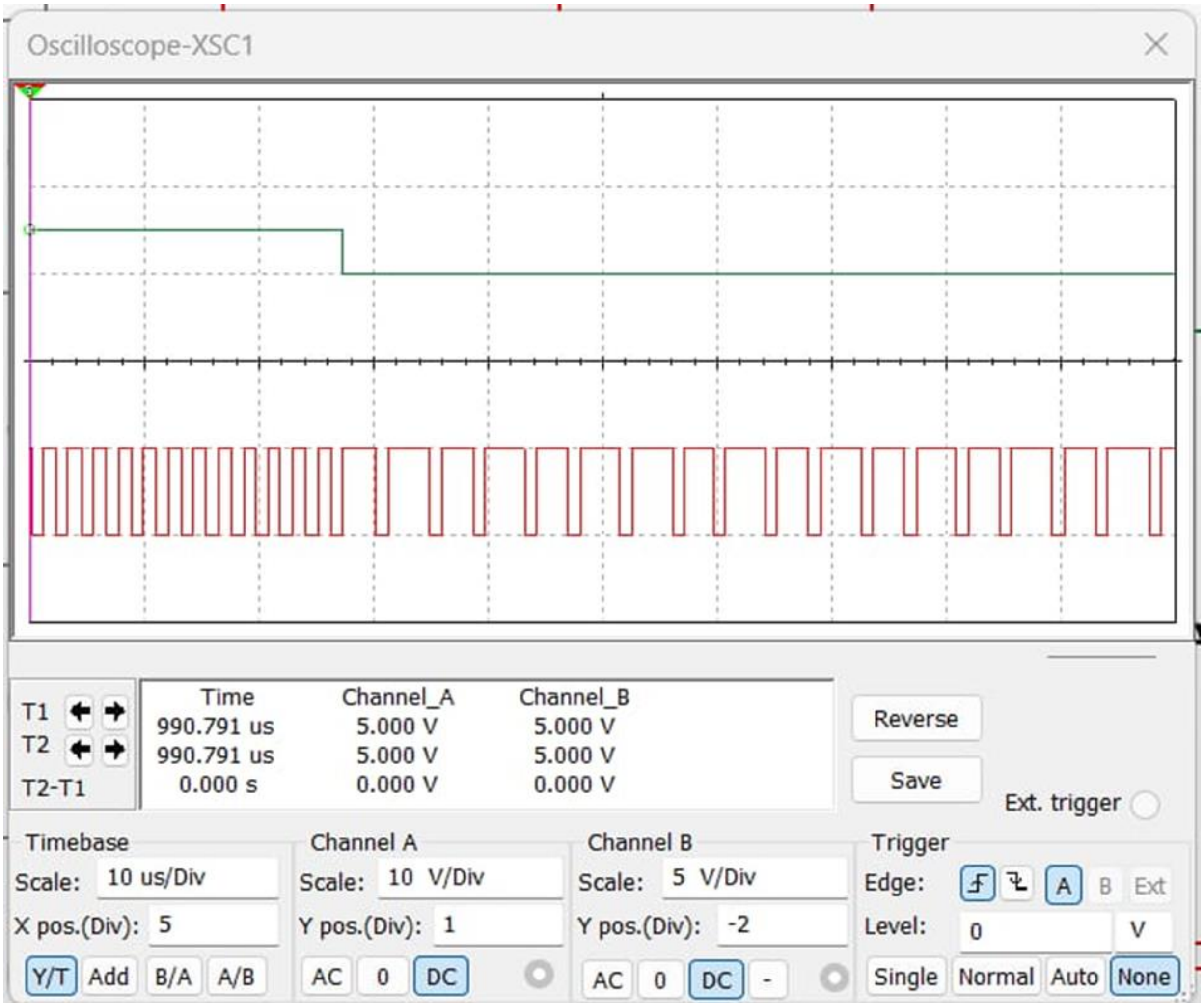
- These pulses are given to base input of Transistor. Because Transistor is connected in switch mode, it will switch ON and OFF

- When pulse input to Transistor is high – Transistor is ON – R3 connects in parallel with R1 – IC555 generates 120 KHz frequency in the output

- When pulse input Transistor is low – it is OFF – only R1 is connected in IC555 circuit – it generates 90 KHz frequency in the output

- In place of giving Square Pulses as input we can give bit stream of 1’s and 0’s also

3.2) OUTPUT

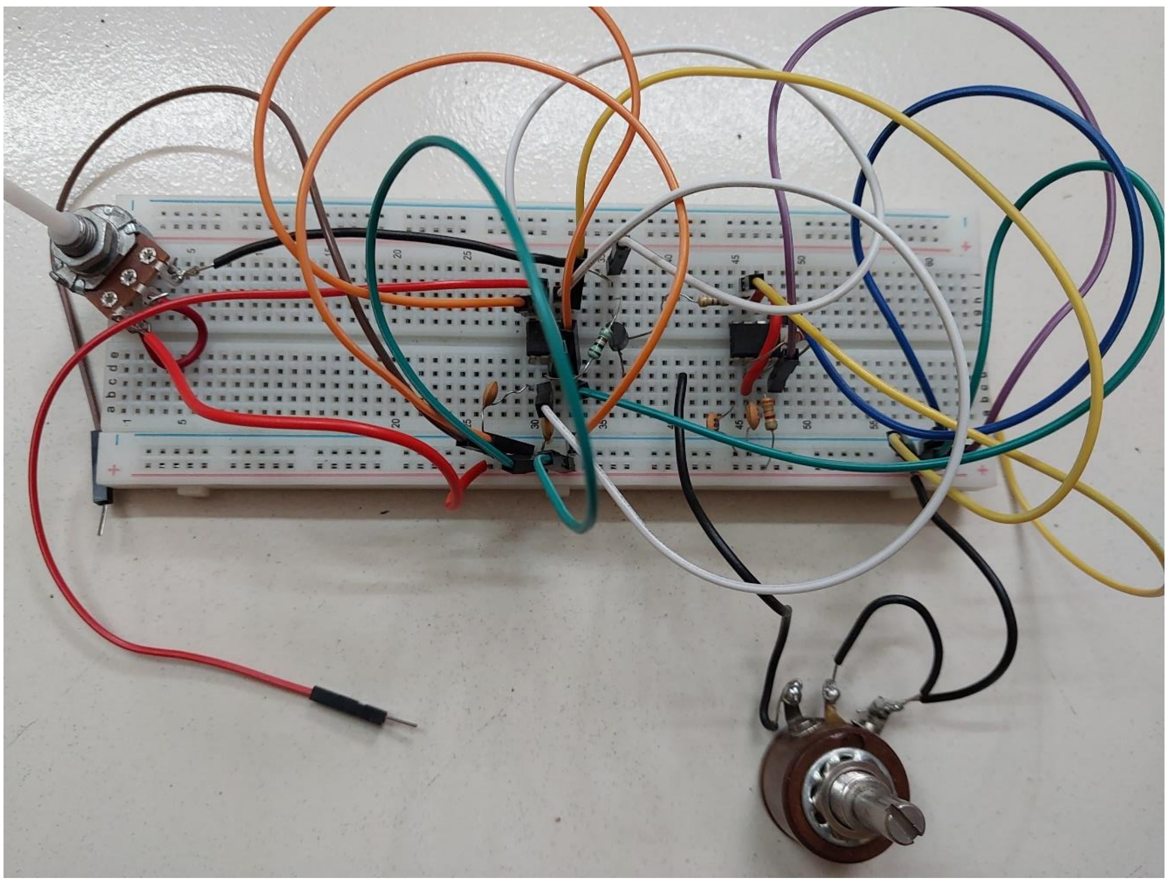


Channel A is our Pulse Generated output from the first IC 555.

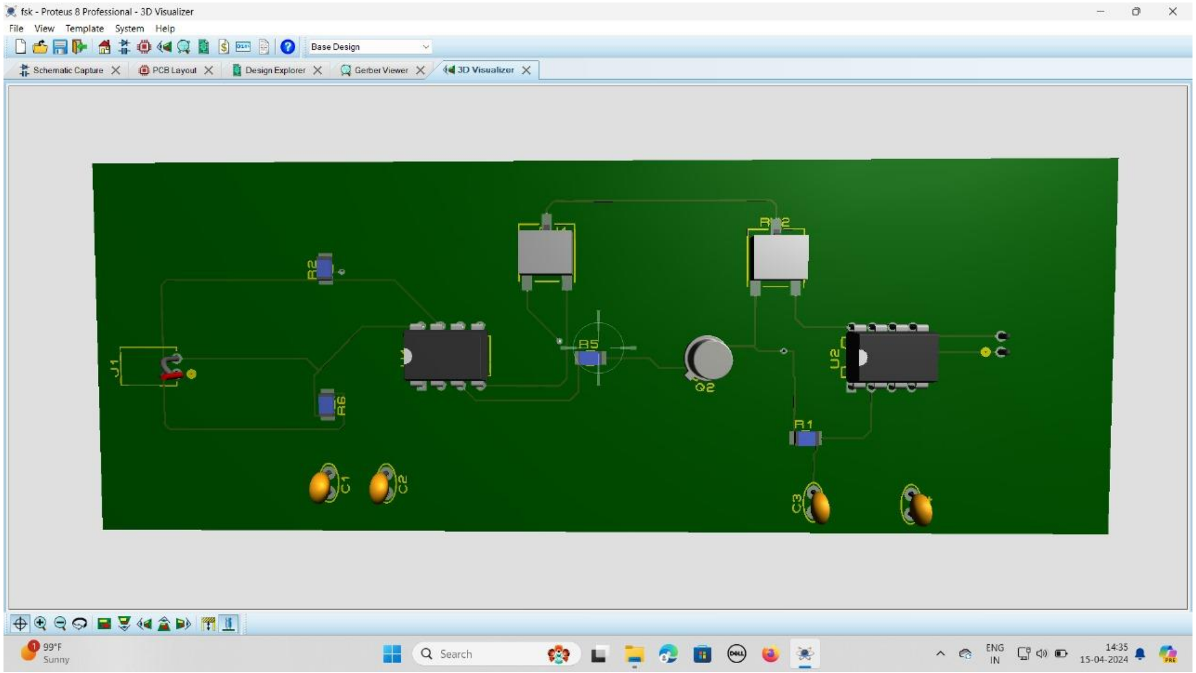
Channel B is the modulated waveform obtained from the second IC 555.

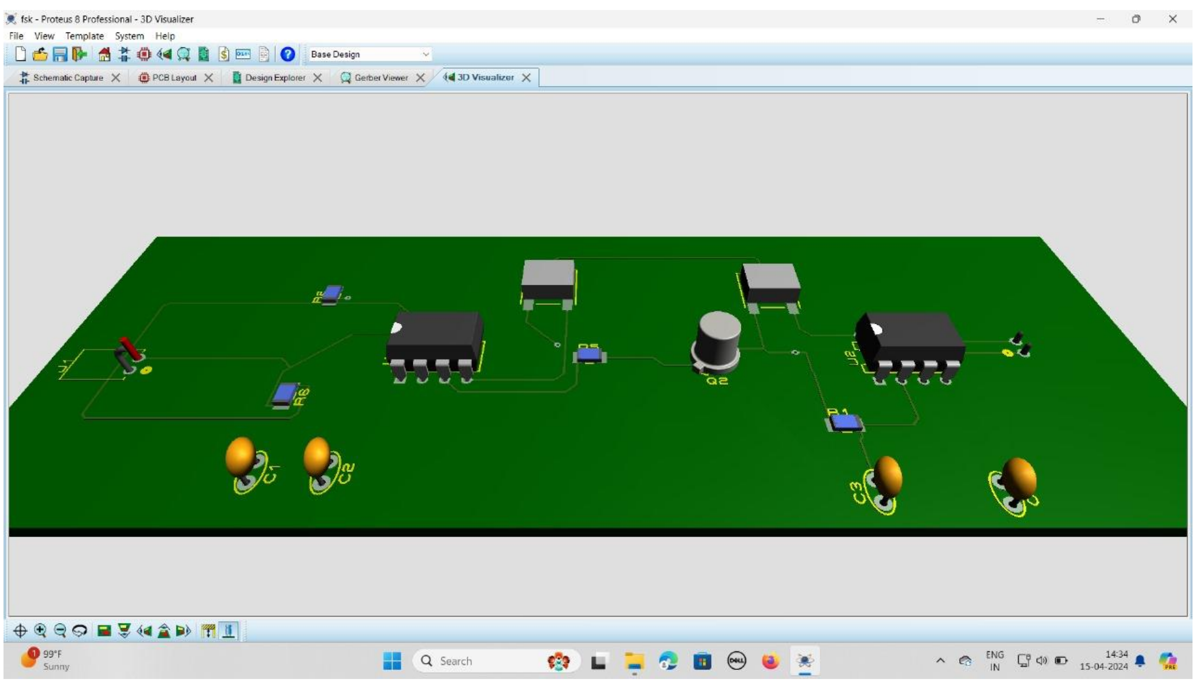
4) HARDWARE IMPLEMENTATION AND PCB LAYOUT

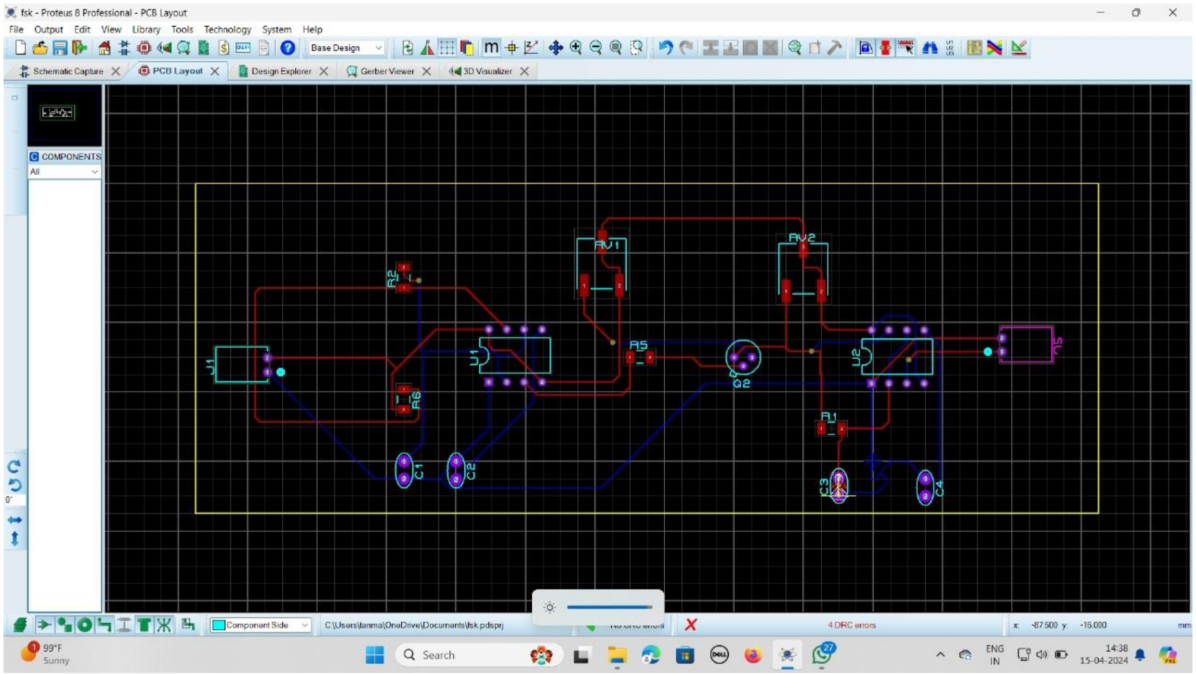
4.1) HARDWARE IMPLEMENTATION



4.2) PCB LAYOUT AND DESIGN







5)PROBLEMS FACED & CONCLUSION

5.1) PROBLEMS FACED

- While implementing the hardware design we were getting distorted output waveform which was certainly due to improper or loose grounding.

- We also faced challenges while doing proteus software design,we didn't get the desired libraries which we needed.

5.2) CONCLUSION

Hence by overcoming the challenges and proceeding further we successfully tested and implemented the modulator circuit.Long distance data transfers cannot be imagined without a modulator in today's world hence a modulator and modulation process has a very great significance.

6)REFERENCES & DATASHEETS

6.1) REFERENCES

- https://www.engineersgarage.com/fsk-modulators-using-ic-555/
- https://www.electronicsforu.com/technology-trends/learn-electronics/555-timer-working-specifications

6.2) DATASHEETS

- https://www.onsemi.com/pdf/datasheet/p2n2222a-d.pdf
- https://www.ti.com/lit/ds/symlink/lm555.pdf?ts=1713438297908

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