ECE 4705 Lab
Experiment 9 – FSK Modulation and Demodulation
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ECE4705L_03

ECE 4705L **EXPERIMENT 9**

FSK MODULATION AND DEMODULATION[1]

OBJECTIVE

The objective of this experiment is to understand FSK modulation and demodulation.

EQUIPMENT

HP 3312A Function Generator, Krohn-Hite Filter, Oscilloscope.

PRE-LAB

1. Suppose that the rectangular pulse train shown in Fig. 1 is applied to the VCO input of the HP 3312A Function Generator. The HP 3312A is set in sinusoidal mode at frequency 500 kHz. Using the frequency deviation constant, f_d, calculated in experiment 7, complete the following:

(a) Find the maximum frequency deviation.
(b) Plot the frequency deviation as a function of time.
(c) Plot the instantaneous frequency as a function of time.
(d) Plot the phase deviation as a function of time.
(e) Plot the FSK wave as a function of time.
(f) Plot the two-sided amplitude spectrum of the rectangular pulse train.
(g) Sketch the amplitude spectrum of the FSK wave.

2. Design a simple FSK detector utilizing only the ECE 4705 laboratory equipment and simple components of your own.

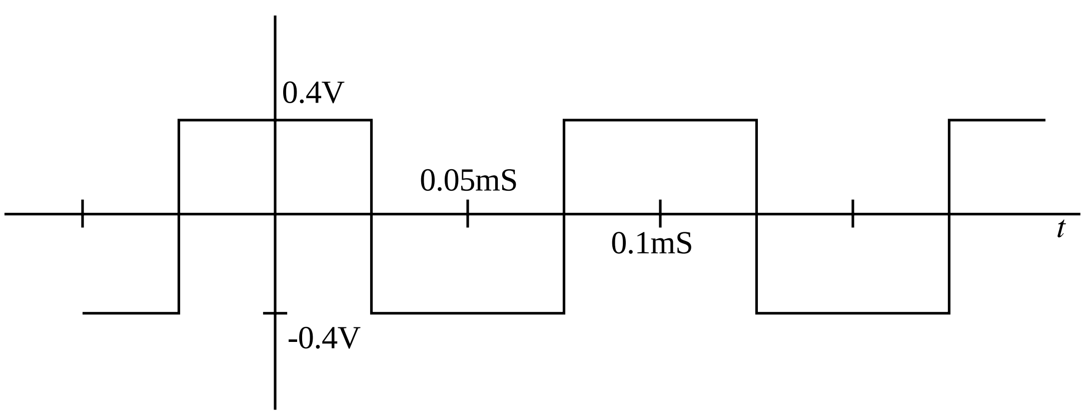


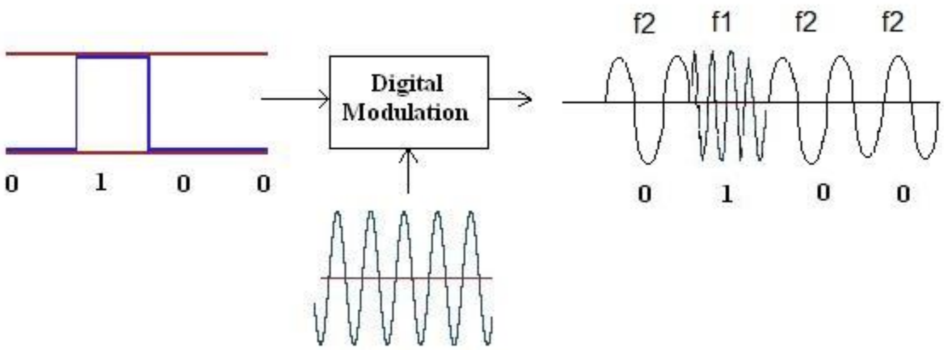
Fig. 1

[1] Based on a lab from Dr. James Kang

PRE-LAB & DISCUSSION

Introduction

To begin, let us obtain some background knowledge on the topif of Frequency Shift Keying, FSK for short. FSK modulation is a technique used to transmit digital data, consisting of binary ones and zeros, over a carrier signal. The carrier frequency varies according to binary one or binary zero for a given digital signal. In FSK, two different carrier signals will correspond to a logic high or logic low binary state. FSK can be achieved by implementing a digital modulator that outputs the frequency shifted signal, as pictured below.



(a) Find the maximum frequency deviation.

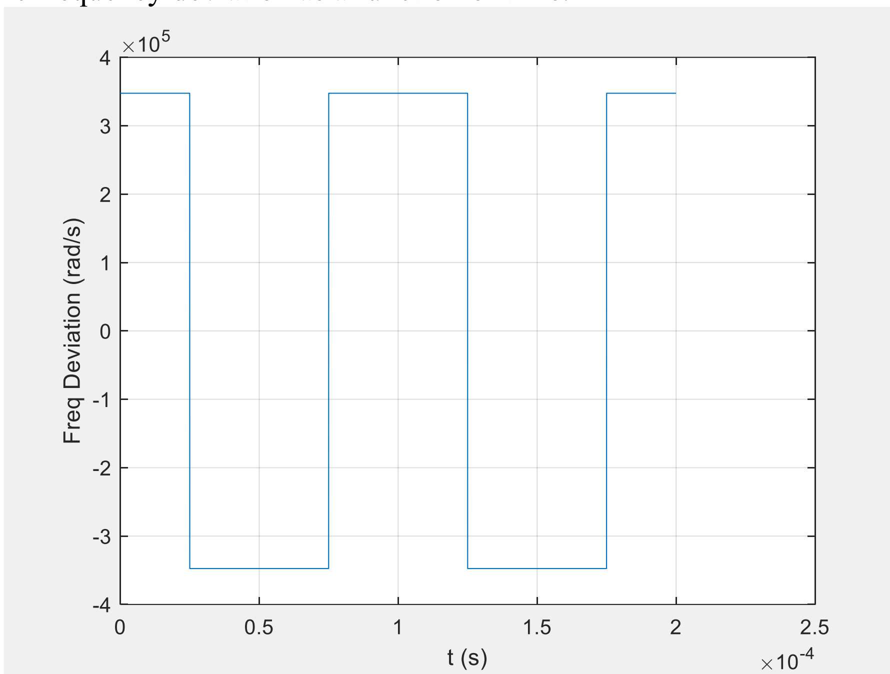
1. $\Delta f_{max} = 2\pi f_d \cdot max|m(t)|$

$max|m(t)| = 0.4 \quad f_d = 138260\ Hz$

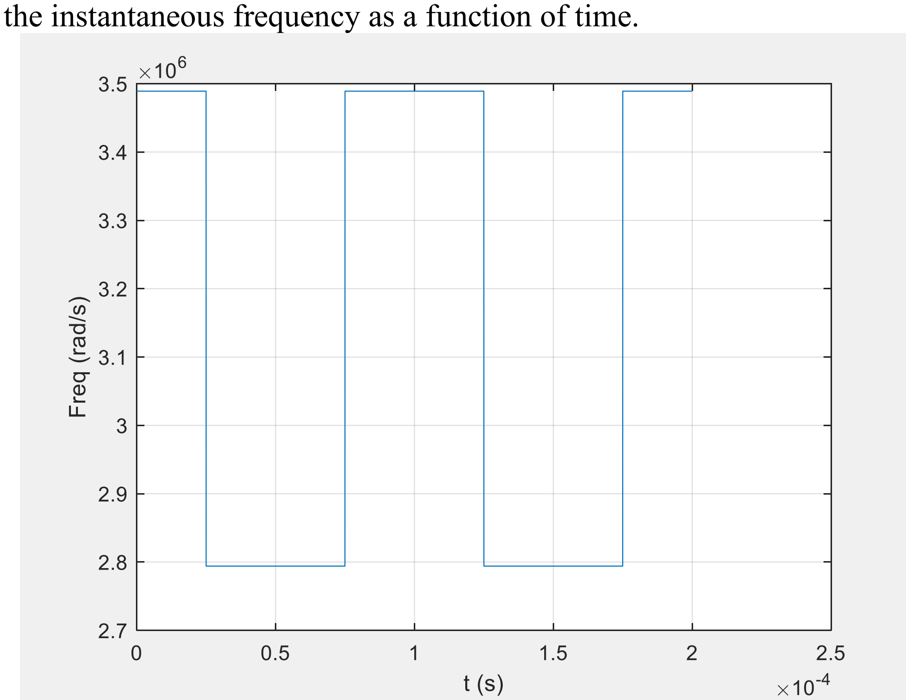
$\Delta f_{max} = 2\pi \cdot 138260 \cdot 0.4$

$\Delta f_{max} = 347.5\ KHz$

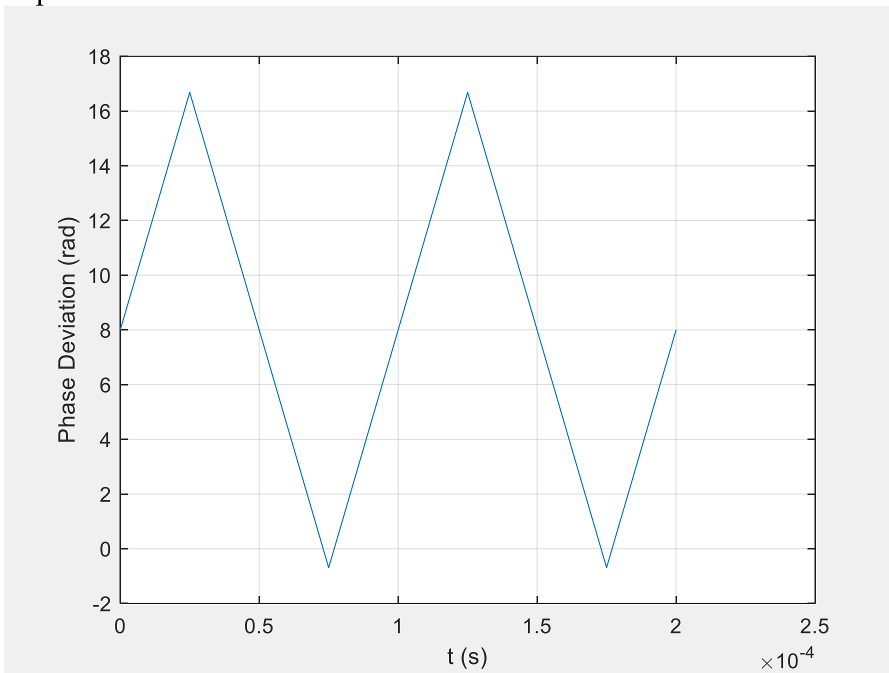
(b) Plot the frequency deviation as a function of time.



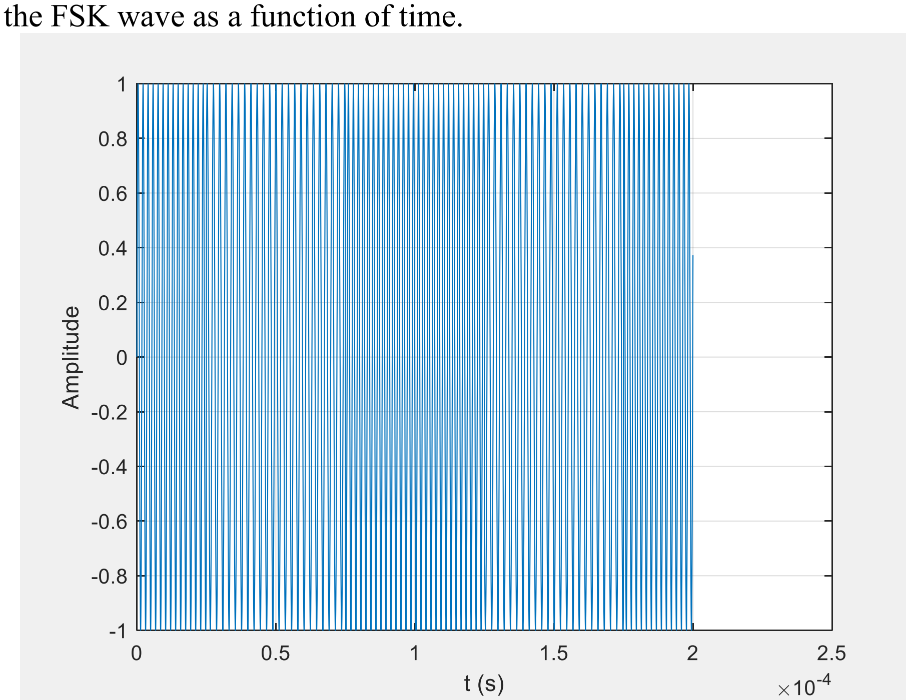
(c) Plot the instantaneous frequency as a function of time.



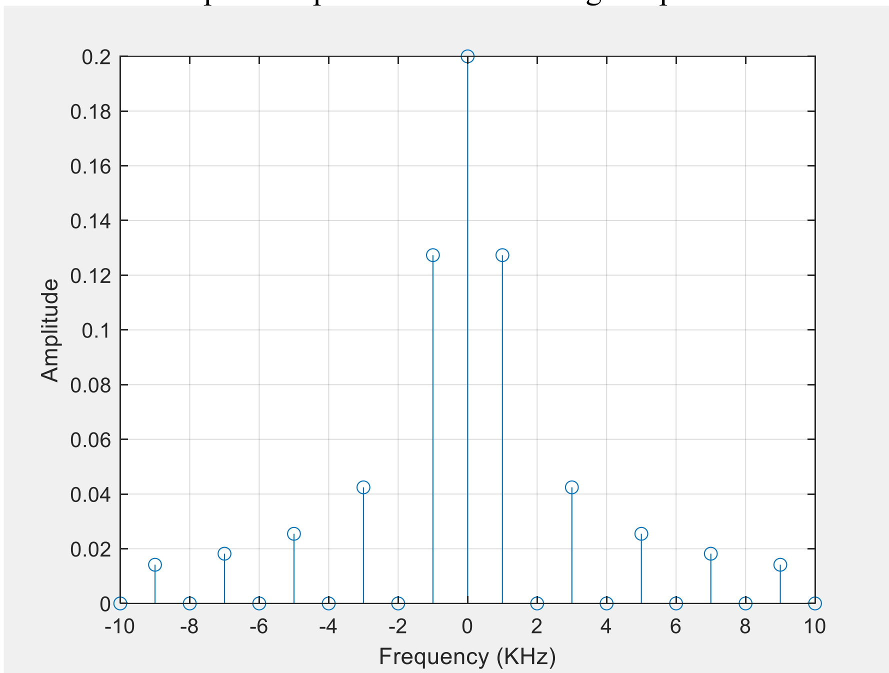
(d) Plot the phase deviation as a function of time.



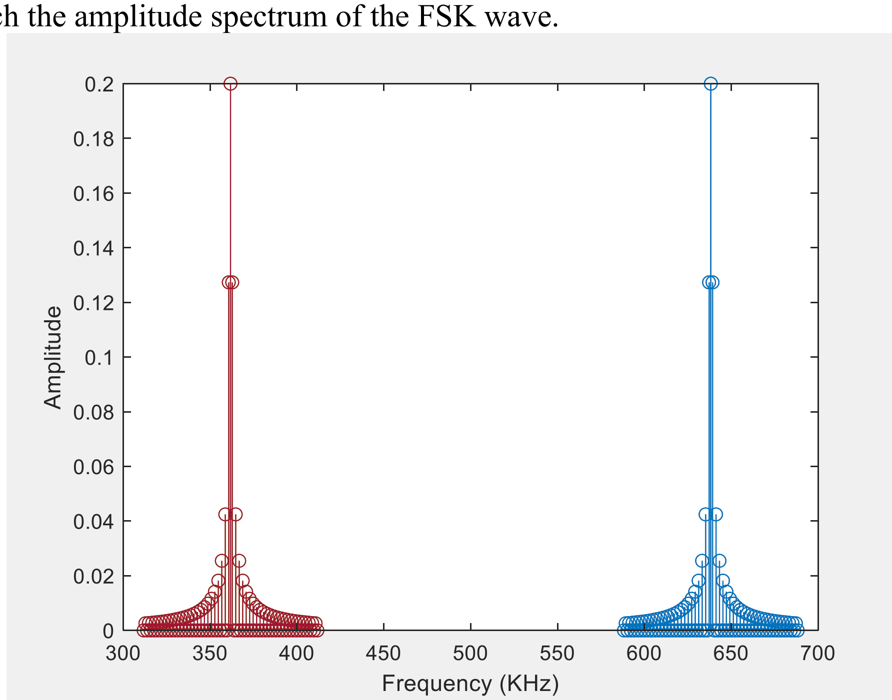
(e) Plot the FSK wave as a function of time.



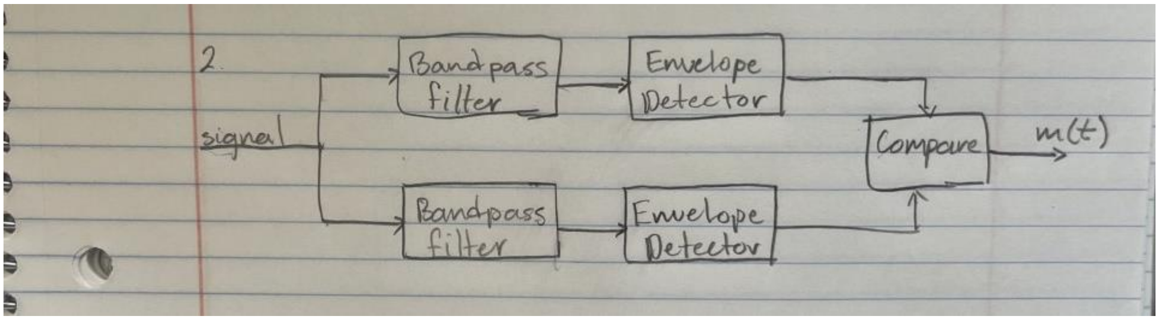
(f) Plot the two-sided amplitude spectrum of the rectangular pulse train.



(g) Sketch the amplitude spectrum of the FSK wave.



2. Design a simple FSK detector utilizing only the ECE 4705 laboratory equipment and simple components of your own.



LAB

1. Input the rectangular wave from Fig. 1 into the back of the HP 3312A's VCO input as the message signal (like you did in Experiment 7, except that the carrier frequency is 500 kHz instead of 250 kHz.) Print the amplitude spectrum of the FSK wave from the spectrum analyzer (use a 2MHz span centered around dc.) What happens to the spectrum when the message amplitude changes? Discuss how this result could aid in the decoding performance vs. bandwidth tradeoff.

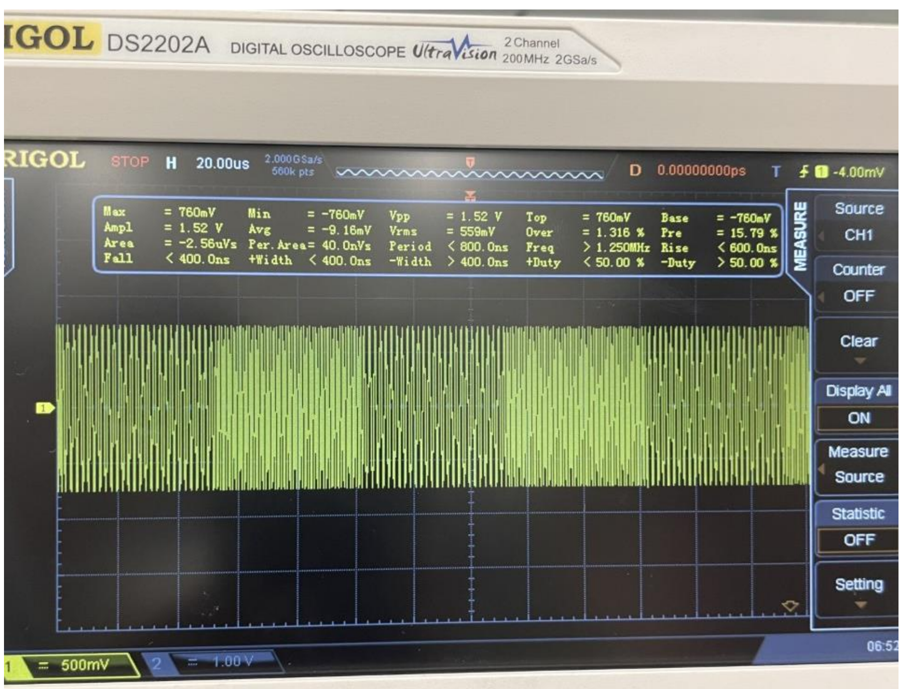


Fig. 2 – FSK Modulated Signal in Time Domain

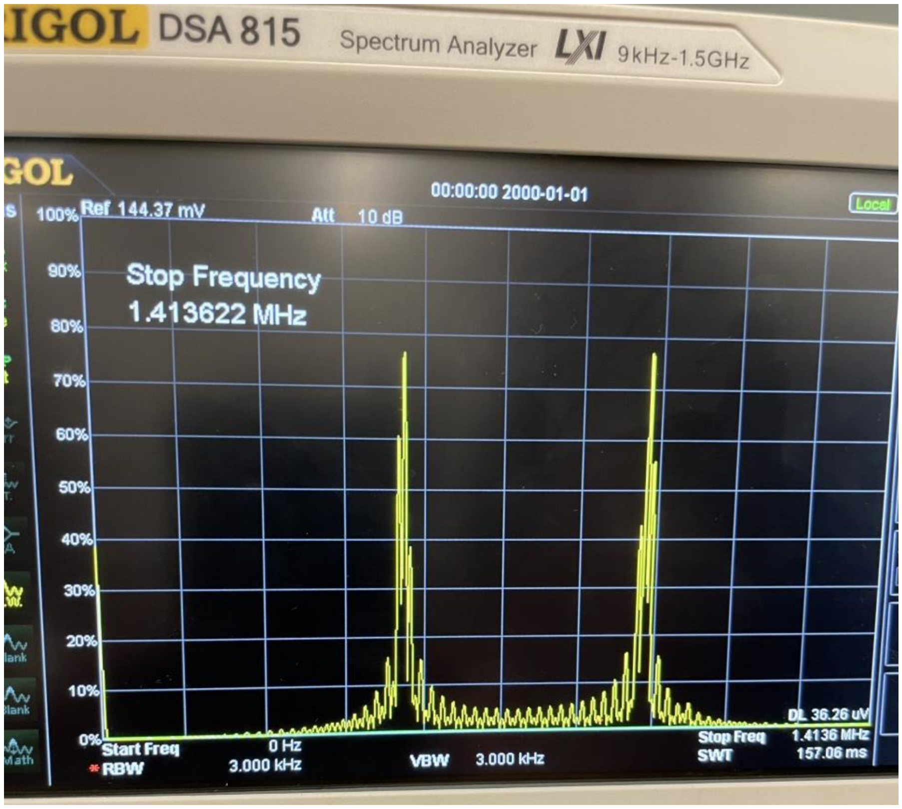


Fig. 3 – Amplitude Spectrum of FSK Modulated Signal

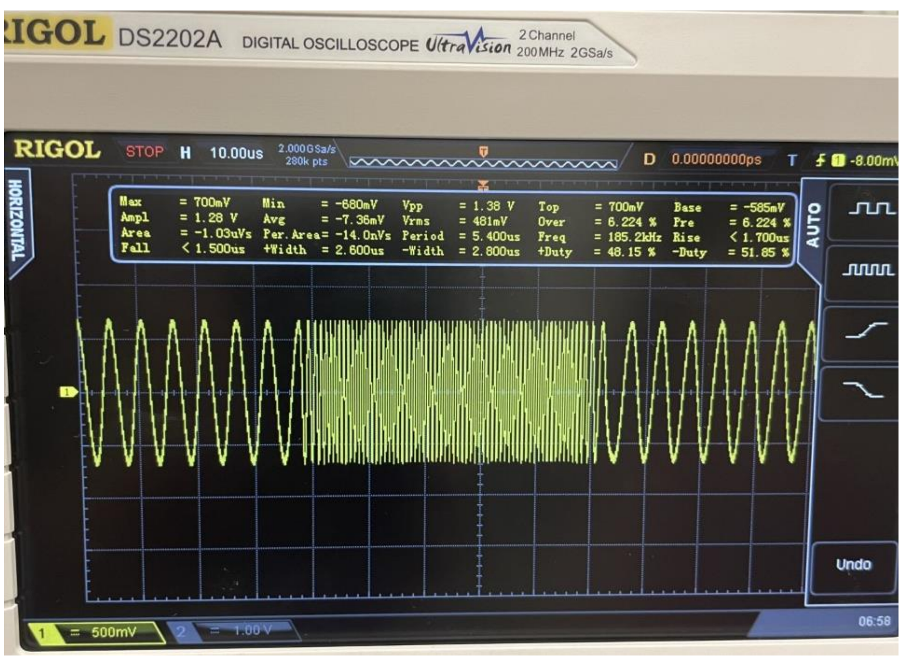


Fig. 4 – FSK Modulated Signal with Wider Bandwidth

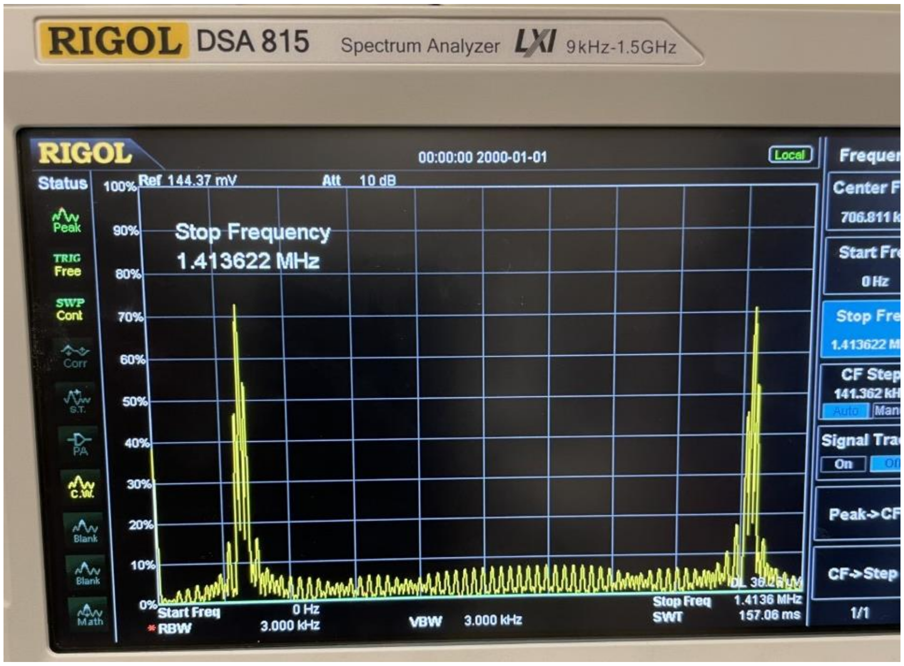


Fig. 5 – Amplitude Spectrum of FSK Modulated Signal with Wider Bandwidth

Using a higher amplitude does not produce a difference in the resulting modulated waveform because the resulting modulated data represents either a zero or a one. By increasing the frequency bandwidth there is a larger frequency deviation allowing for a more distinct lower frequency to represent a binary zero and a higher frequency to represent binary one.

2. Print the waveform in the time domain at the output of the FSK detector (you only need to get the recovered envelope) and compare it to the original message.

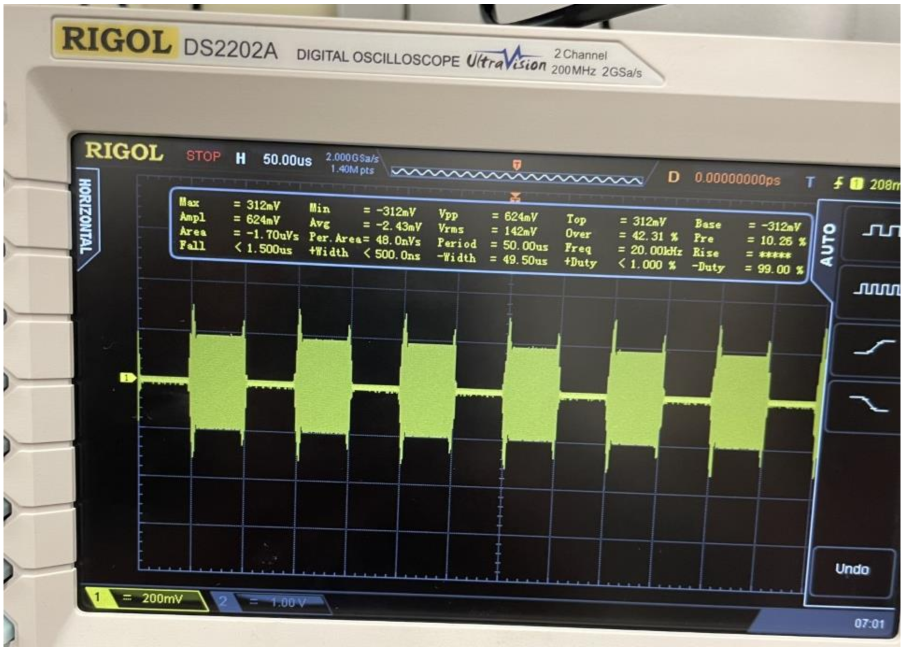


Fig. 6 – Output of the FSK Detector

Conclusion

By implementing an FSK detector, we were able to combine a carrier signal with a digital signal to produce a FSK modulated waveform representinig the two binary states of logic high, a one, and logic low, a zero. As you can see, the resulting modulated wave uses the ones and zeros of the digital data and converts them to frequencies according to the binary state.

APPENDIX

I. MATLAB Code:

```
clear all;

Fd = 138260;
Fc = 500e3;
Fm = 10e3;
t=0:1e-2/Fc:100/Fc;

freqdev = square(2*pi*Fm*t + pi/2)*0.4*2*pi*Fd;

figure(1)
plot(t,freqdev);
grid;
xlabel('t (s)');
ylabel('Freq Deviation (rad/s)');

figure(2)
plot(t,(2*pi*Fc+freqdev));
grid;
xlabel('t (s)');
ylabel('Freq (rad/s)');

figure(3)
plot(t,(8+cumtrapz(t,freqdev)));
grid;
xlabel('t (s)');
ylabel('Phase Deviation (rad)');

figure(4)
plot(t,sin((2*pi*Fc+freqdev).*t));
grid;
xlabel('t (s)');
ylabel('Amplitude');

figure(5)
n=[-10:10];
duty = 0.5;
amp = 0.4;
stem(n,abs(amp*duty*sinc(n*duty)));
grid;
xlabel('Frequency (KHz)');
ylabel('Amplitude');

figure(6)
n=[-50:50];
duty = 0.5
amp = 0.4
stem((Fc-Fd)/1000+n,abs(amp*duty*sinc(n*duty)));
grid; hold on;
stem((Fc+Fd)/1000+n,abs(amp*duty*sinc(n*duty)));
```

```
xlabel('Frequency (KHz)');
ylabel('Amplitude');
```