FUNDAMENTALS OF TELECOMMUNICATION

Lab. 3. FM - PM

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Introduction

This laboratory assignment aims to provide a comprehensive understanding of the principles of frequency and phase modulation and demodulation. Through this experiment, we will gain hands-on experience with the equipment, allowing us to observe and adjust the modulator and demodulator manually. This process will enhance our comprehension of how these mechanisms function, as we observe the resulting changes on the oscilloscope screen.

Exercises FM

6.1&6.2

V+[V]	V-[V]
4.9933	-5.0282

6.3

$Freq_{min}$	$Freq_{max}$	A_{min}	A_{max}
462.7 Hz	10.24 kHz	304 mV	2.18 V

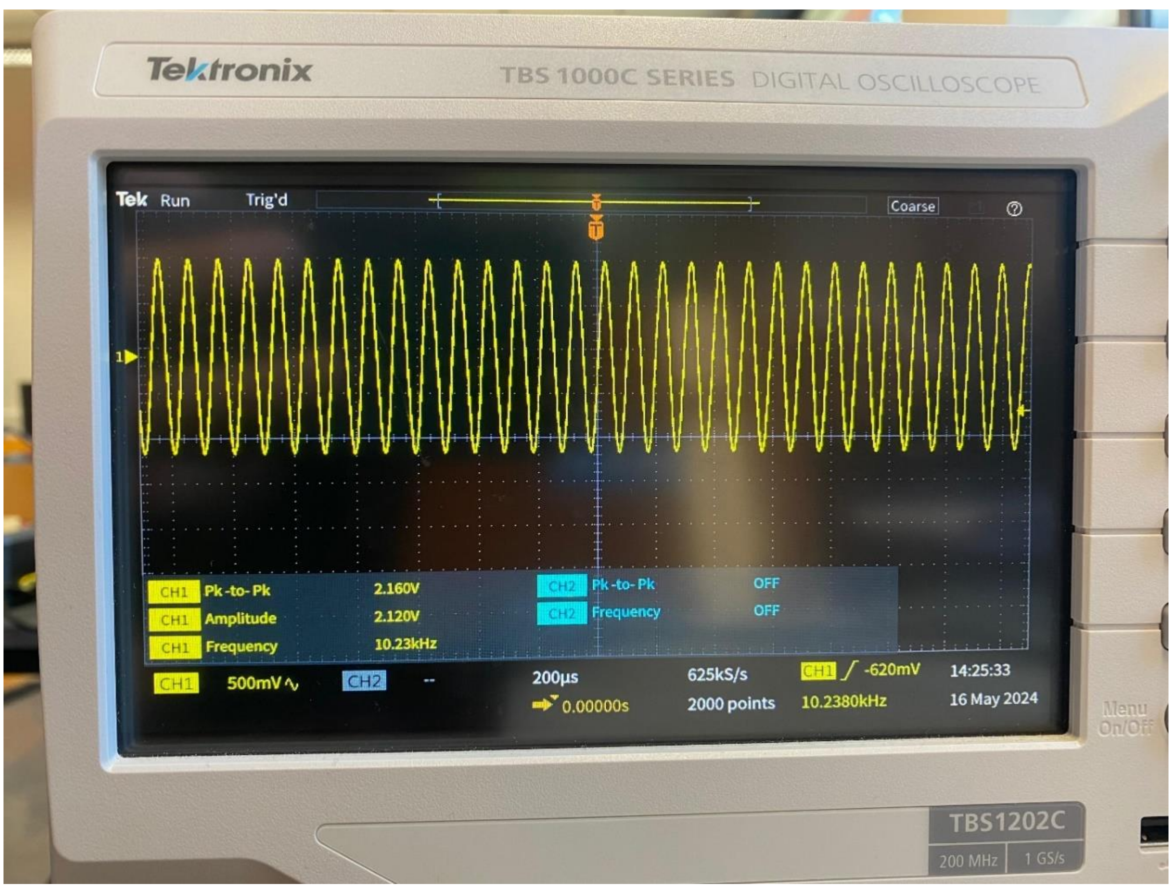


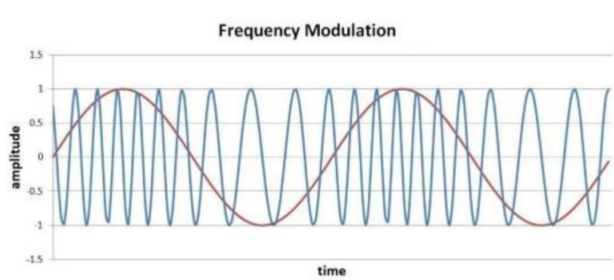
Fig. 6.3.1

Here we observe a simple sine wave signal, this signal can be modified using knobs to change the frequency and amplitude of the sine wave generator.

6.4

Fig. 6.4.1

For this question, we should have observed the two channels of the oscilloscope at the same time to be able to correctly observe the carrier wave in the MODULATOR section. We should have observed a signal like this. However, we can still see that the modulated signal observed seems to change.



6.5

We set the frequency f to 3.4 kHz and the amplitude to 2V and observed the following signals:

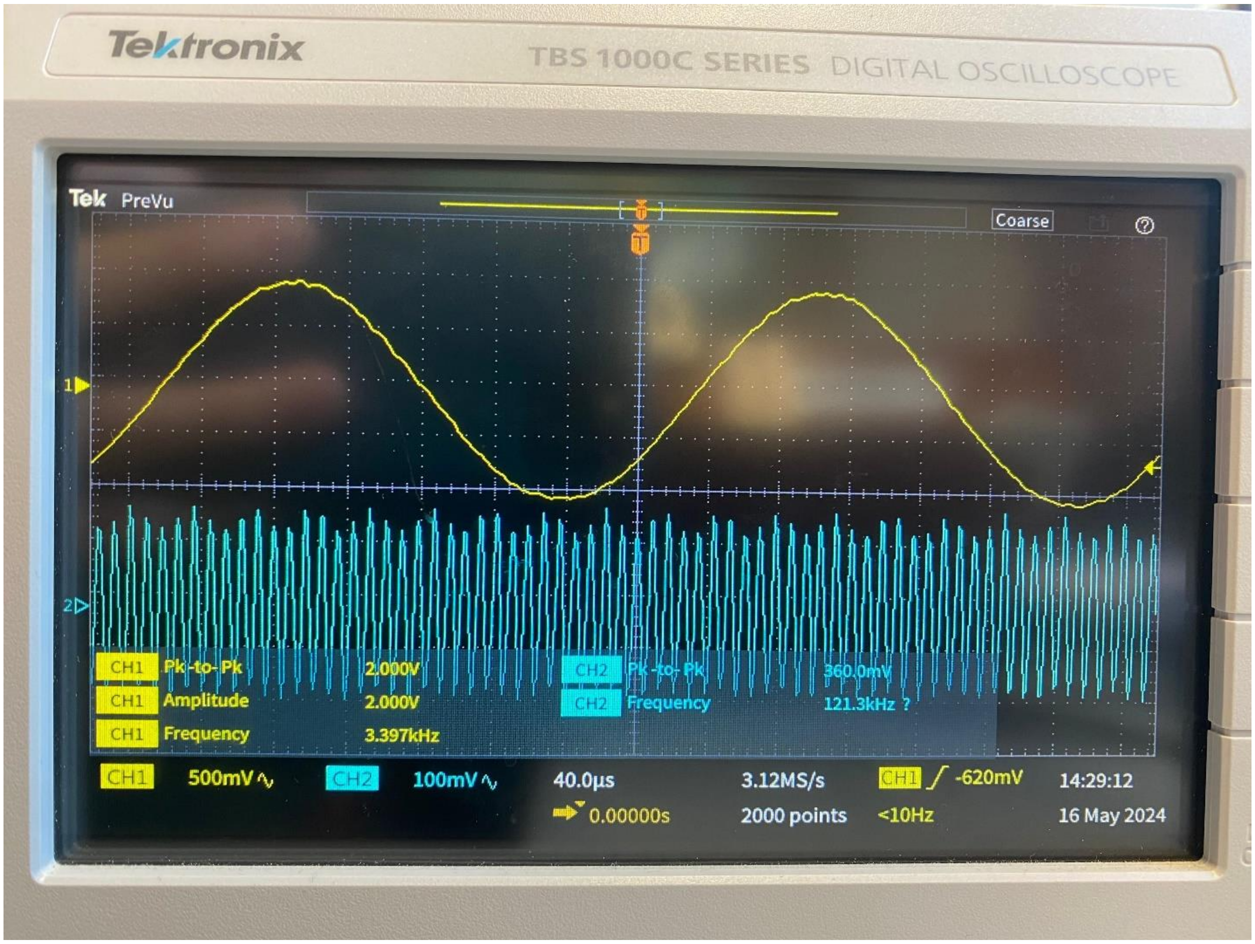


Fig. 6.5.1

6.6

Switching the oscilloscope's second channel to the modulator output and observe the modulated signal.

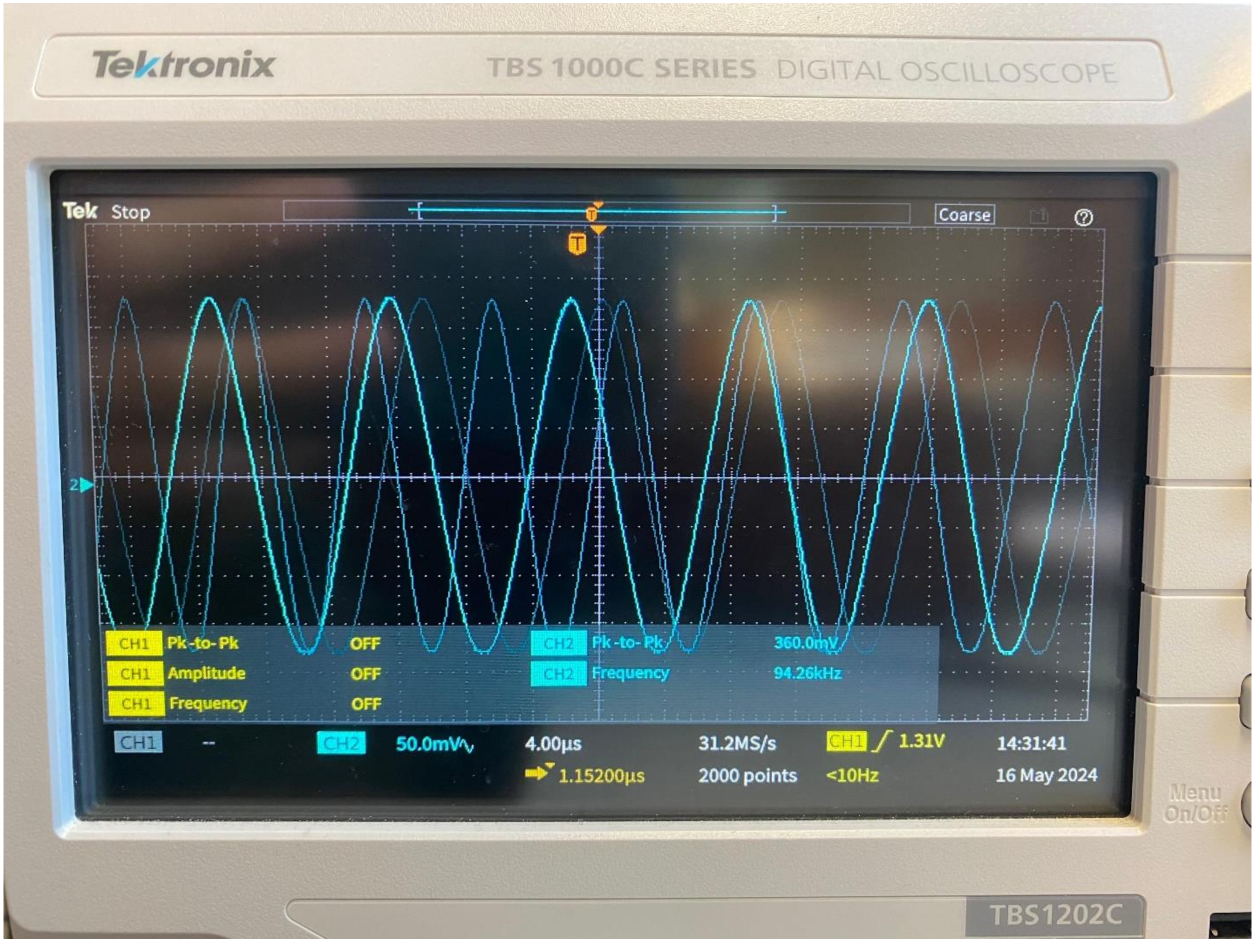


Fig. 6.6.1

The picture is somewhat noisy, but it's clear that certain sections have a lower frequency than others. This indicates that the modulation process has been correctly applied to the main signal.

6.7

Now, let's connect the modulator output to the demodulator PLL output and observe the signal:

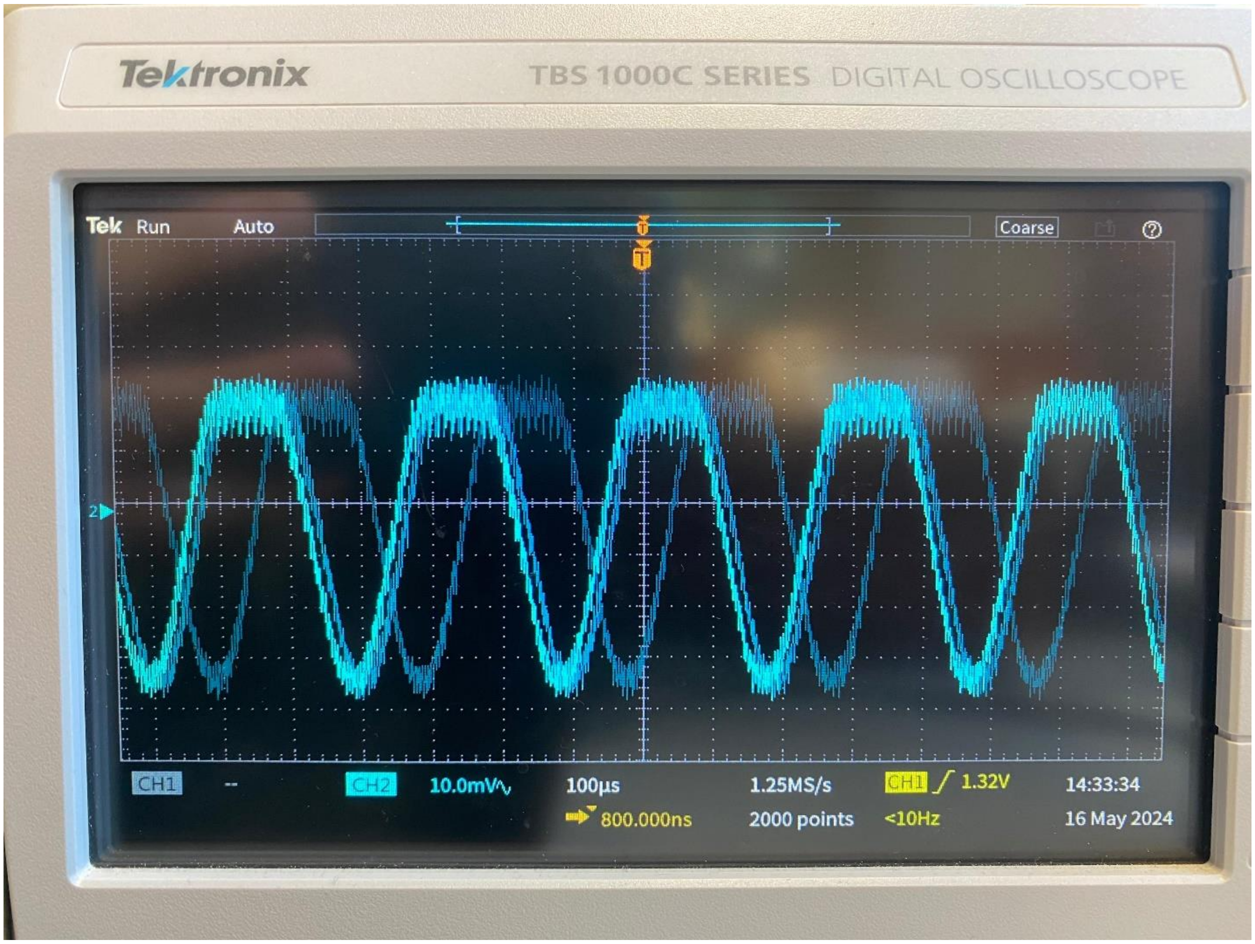


Fig. 6.7.1

6.8

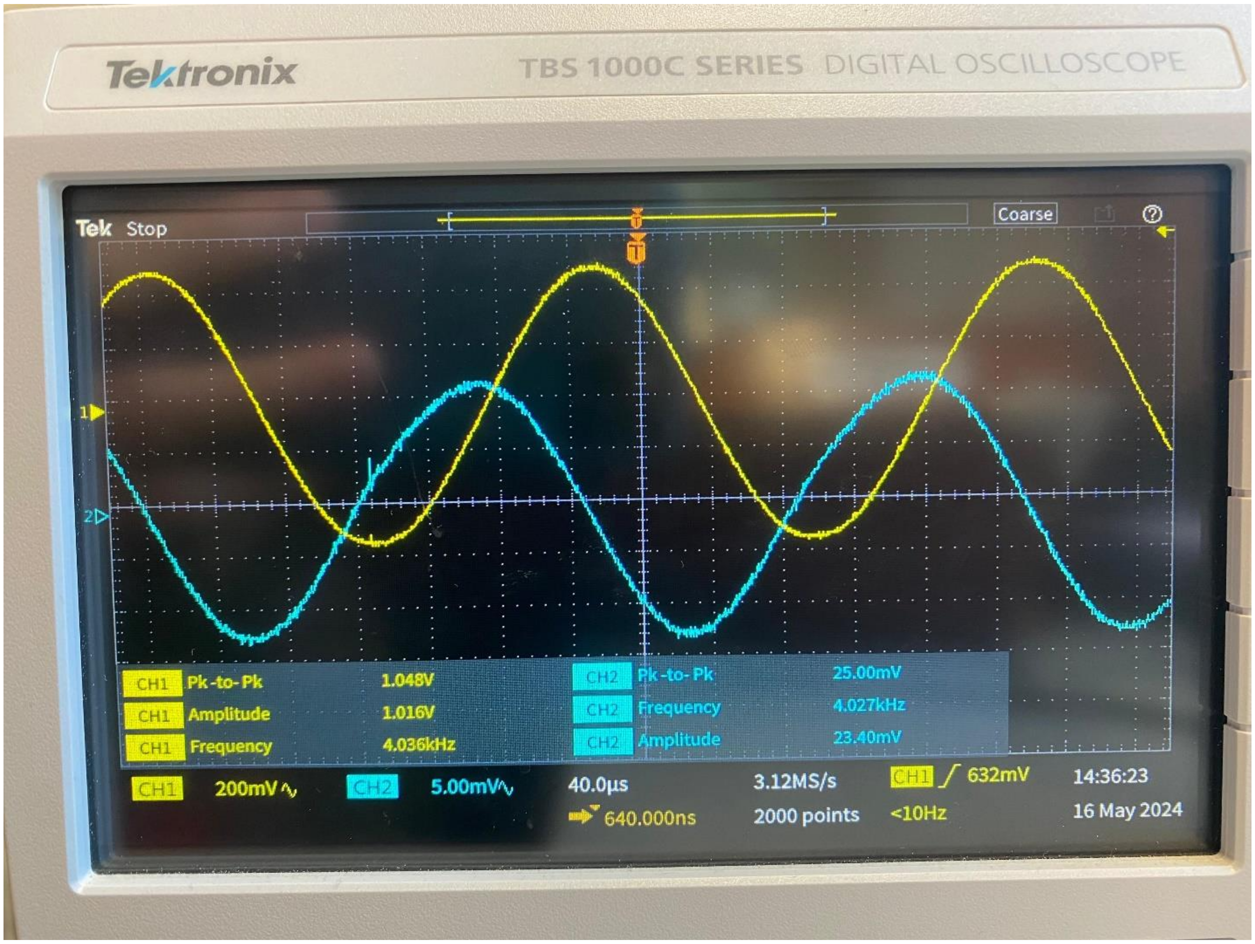


Fig. 6.8.1

We observed two sine signals with the same frequency, but the amplitude and the phase are different.

6.9

After reproducing the above circuit and plugging in the microphone, here is the signal observed:

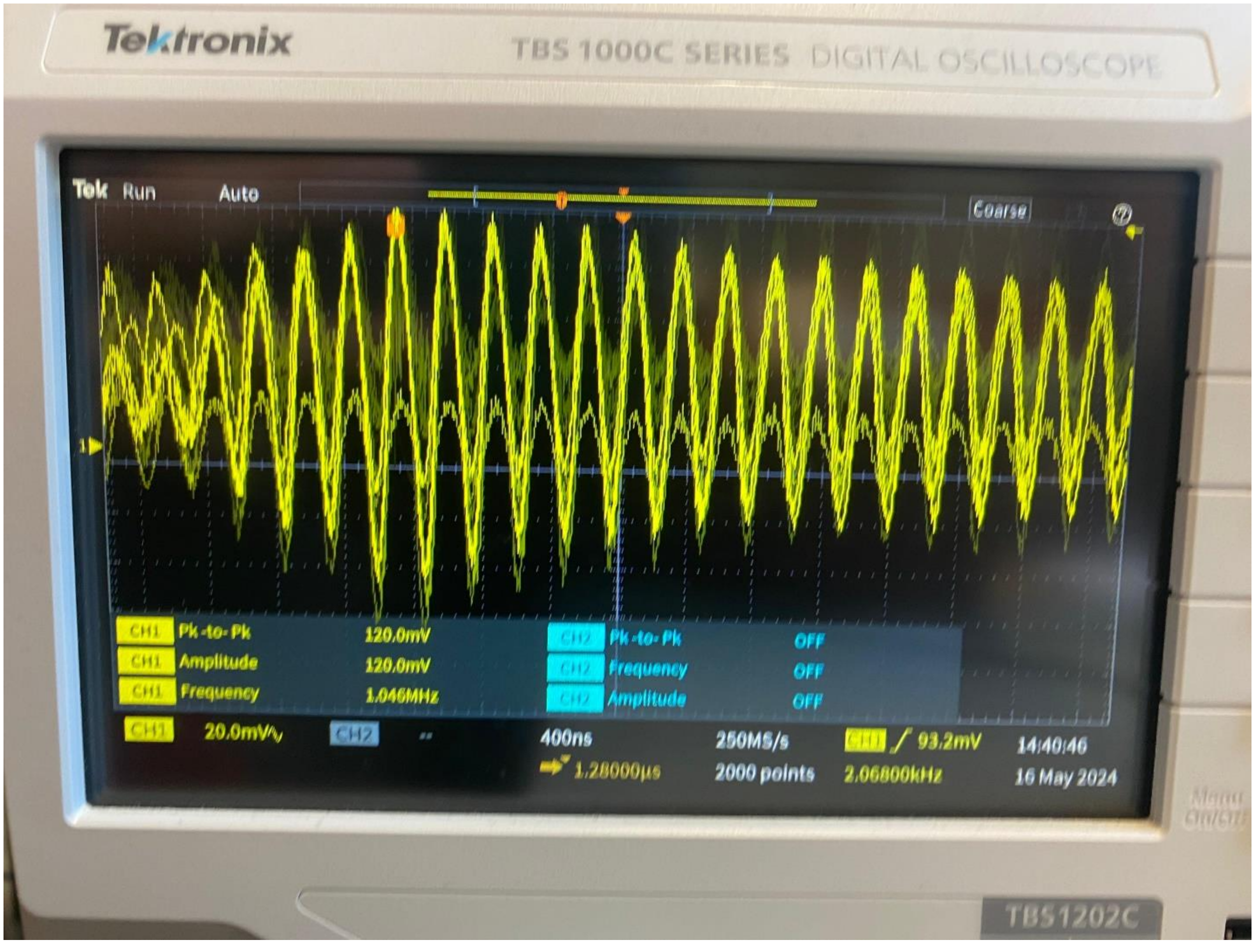


Fig. 6.9.1

The amplitude of the signal varies as we speak in the microphone. So, we can observe the waveforms of our sounds.

Exercises – PM

7.2

We monitored the output of the sine wave generator and recorded how much we could alter the signal's frequency and amplitude.

$Freq_{min}$	$Freq_{max}$	A_{min}	A_{max}
362.3 Hz	2.26 kHz	328 mV	2.8 V

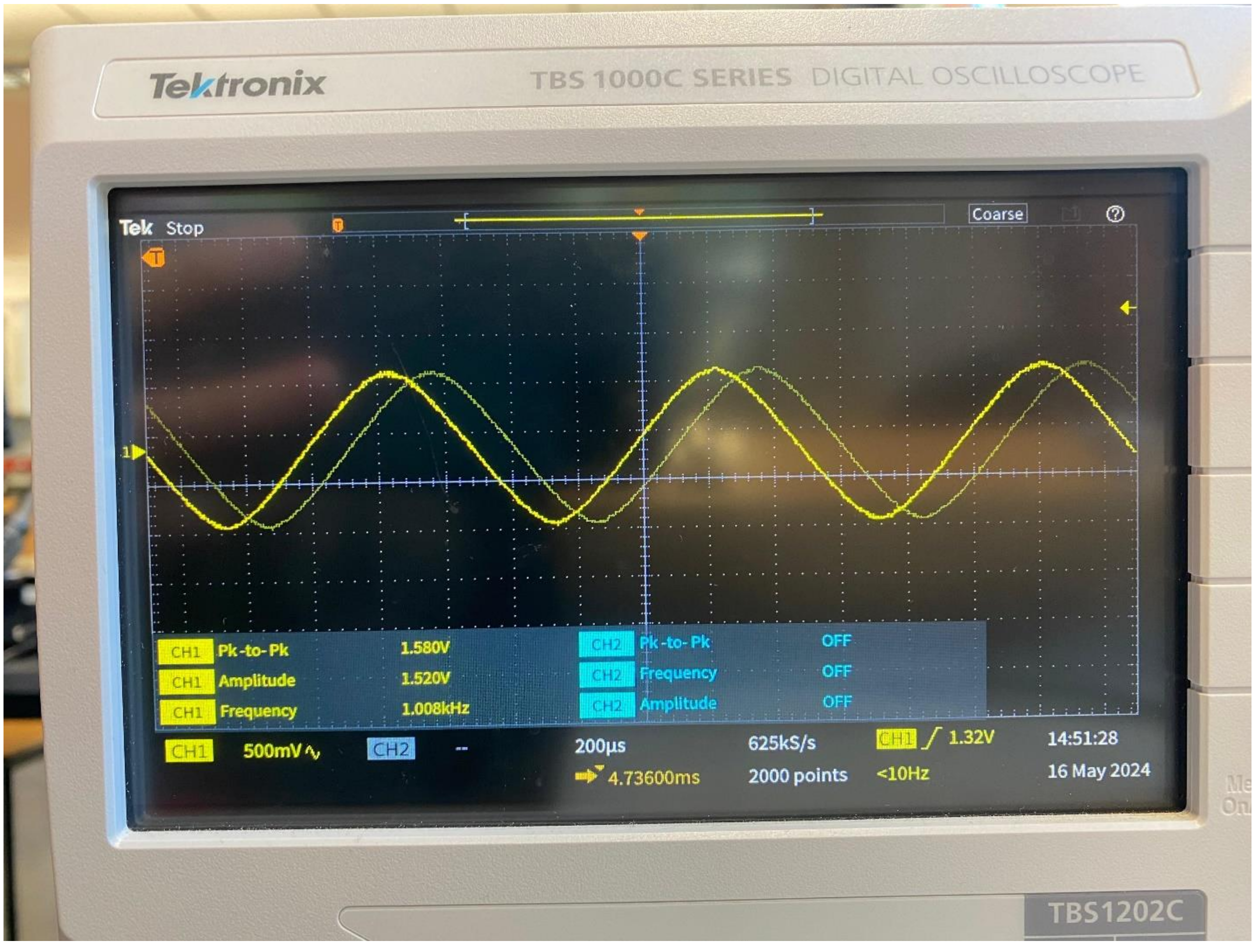

Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Tek Stop
Coarse
CH1 Pk-to-Pk 1.580V
CH1 Amplitude 1.520V
CH1 Frequency 1.008kHz
CH2 Pk-to-Pk OFF
CH2 Frequency OFF
CH2 Amplitude OFF
CH1 500mV
CH2 --
200µs
4.73600ms
625kS/s
2000 points
CH1 1.32V
<10Hz
14:51:28
16 May 2024
TBS1202C

Fig. 7.2.1

7.3

We examined the sawtooth generator output and confirmed that the carrier signal has the expected shape.

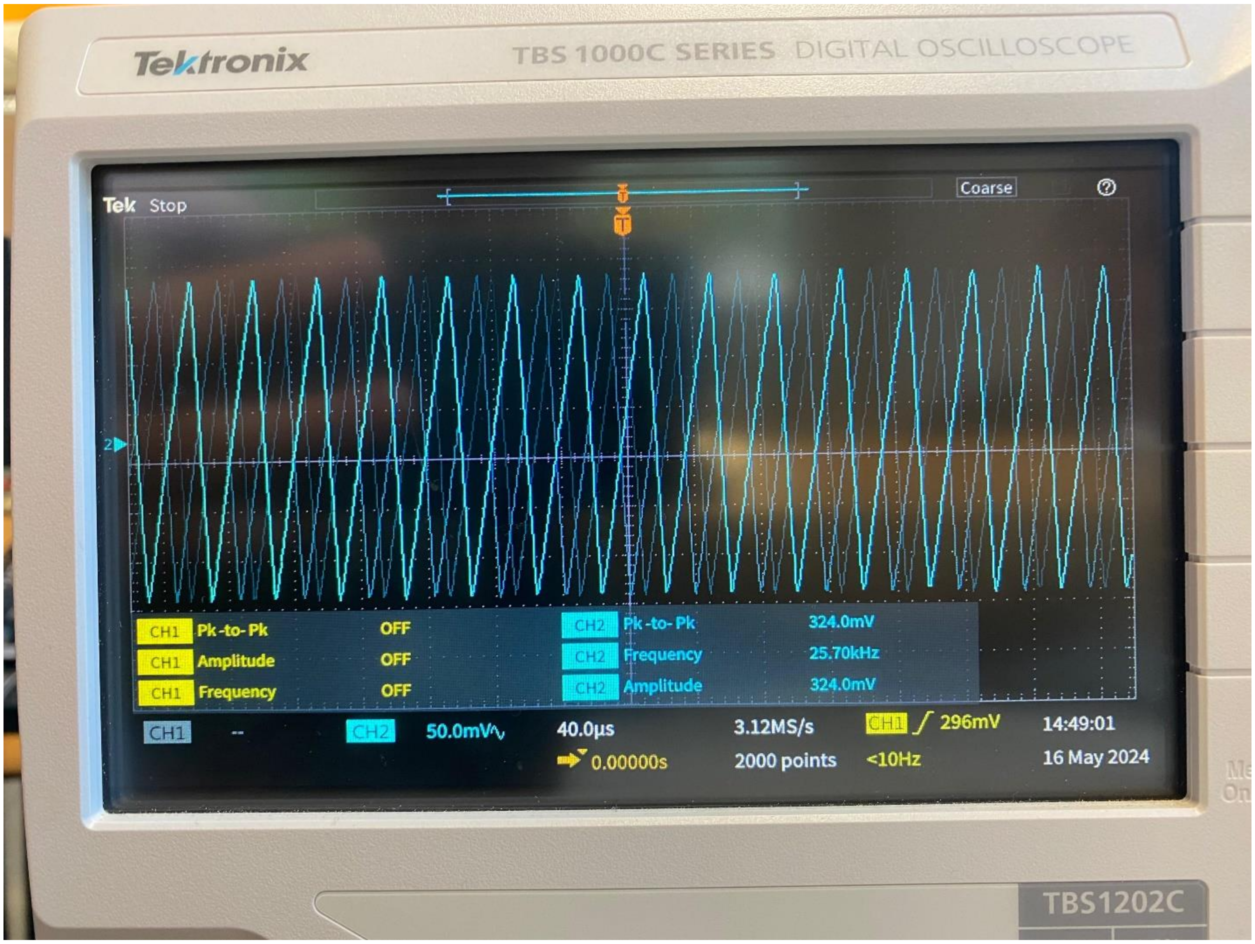


Fig. 7.3.1

7.4

This is our observations after setting the indicated values:

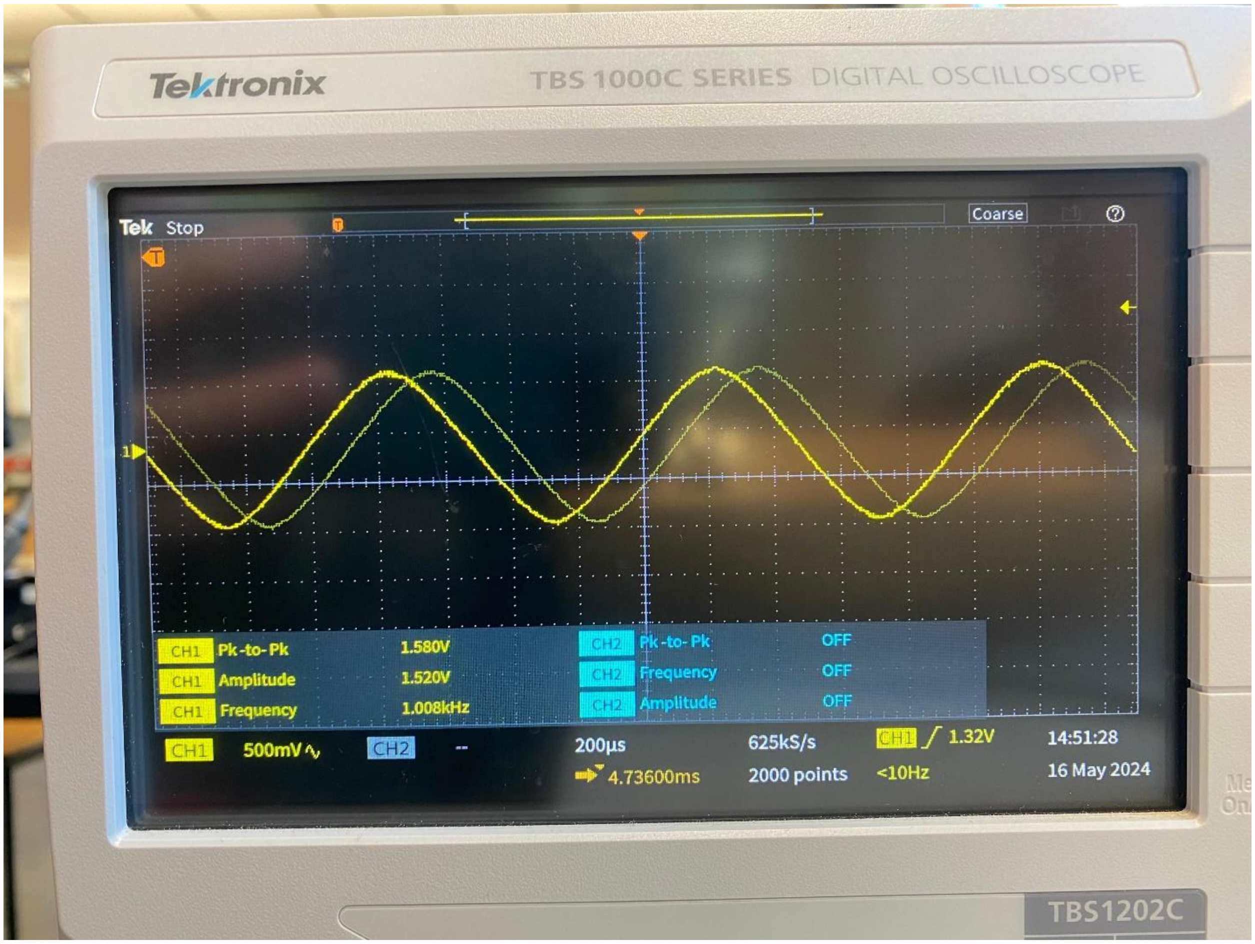


Fig. 7.4.1

7.5

We connected the sine wave generator and the sawtooth generator to the comparator and observed the resulting pulse width modulation signal.

Fig. 7.5.1

7.6

We connected the comparator to the modulator and obtained the phase-modulated (PM) signal.

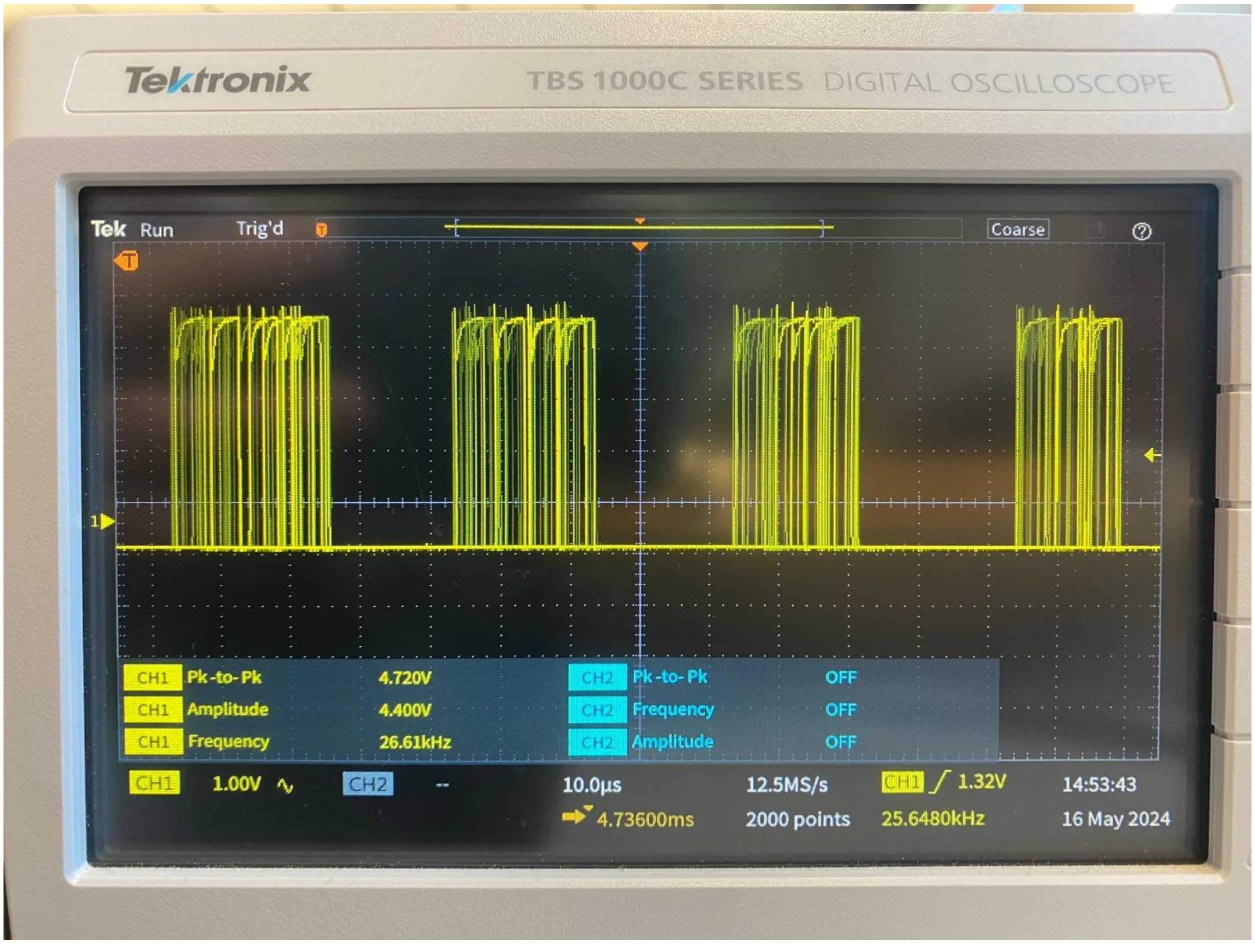


Fig. 7.6.1

7.7

We connected the modulator to the demodulator and retrieved the original PWM signal.

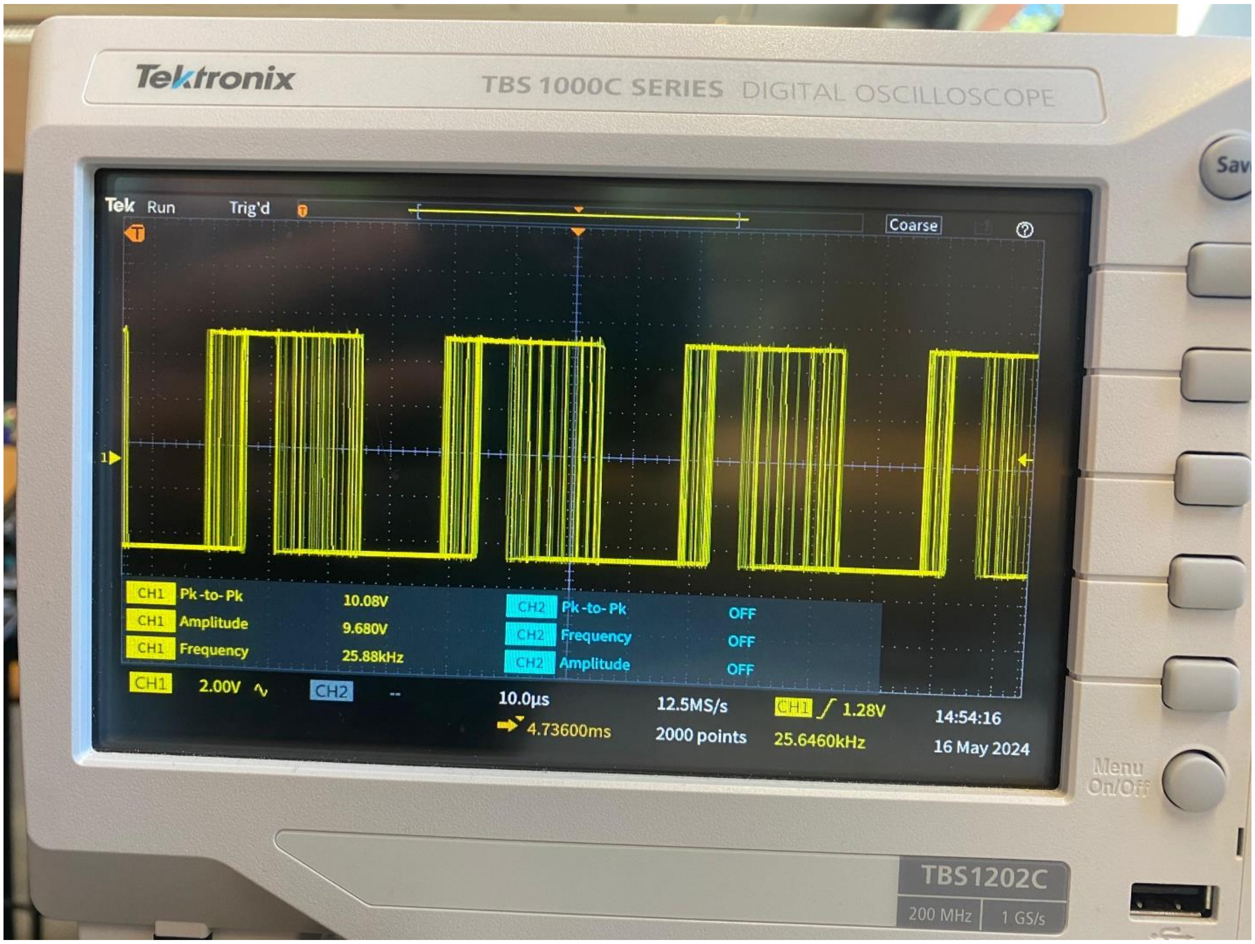


Fig. 7.7.1

7.8

We connected the demodulator to the low-pass filter (LPF) and the amplifier. The output produced the original sine wave, confirming that the process is functioning correctly.

Fig. 7.8.1

Conclusion

In conclusion, the FM and PM experiments produced expected results, demonstrating the effectiveness of these modulation techniques in reliably encoding and decoding information. FM modulation is widely used in radio communication, telemetry, radars, seismic surveys, EEG monitoring, bidirectional radio systems, music synthesis, magnetic tape recording, and some video transmission systems. FM offers higher signal-to-noise ratio and better interference rejection than AM. PM modulation is used in telecommunications, satellite communication, and radar systems, though less common in analog systems due to the simpler and cheaper FM modulators and demodulators. PM is prevalent in digital transmission as phase keying (PSK), offering noise immunity, interference suppression, increased resistance to signal loss, and reduced susceptibility to non-linearity.