Dept. of Electronics and Electrical Communication Engineering
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DIGITAL COMMUNICATION LAB (EC39001)

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Title Of Experiment: DEMODULATING BPSK SIGNAL
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Introduction

This experiment involves demodulating the BPSK signal generated in the previous experiment, in order to recover the original PN Sequence. Modulation involves **Envelope Detector** circuit along with a comparator circuit that applies a threshold and converts the Analog Singal to Digital(**HIGH** and **LOW**).

Key Objectives

For this experiment, out key objectives are:

- Demodulating the BPSK Signal.
- Threshold the demodualted signal in order to recover the original Digital Signal.

Circuit Components Used

The components used for this experiment were:

- IC 74LS95B Shift Register
- IC 7486 Quad 2 input ExOR
- IC 7427 Triple 3 input NOR
- IC 7432 Quad 2 input OR
- 4 x 330Ω Resistors
- 4 LEDs
- IC 4016 Switch
- 3 x IC 741 Op-Amp
- Zener Diode
- 7 x 1KΩ Resistors
- 1 x 100pF Capacitors
- 1 x 100KΩ Resistors
- 1 x 4.7pF Capacitors

Theory

Now that we have modulated the PN Sequence using BPSK Modulation, we need to demodulate the modulated signal at the receiver's end. The Demodulation, as mentioned in the Discussion of previous lab report, can be performed by following the following steps:

- Subtraction with Carrier Signal.
- Envelope Detector.
- Thresholding with a threshold voltage(V_t).

Subtraction(or addition) with the carrier signal, results in a signal which is looks like the product of Carrier Signal and the PN Sequence(Figure 4). Finding it's envelope will result in the PN Sequence. However, the envelope won't be capped from 0V to 5V, like a Digital Signal should be. This can be solved using a Thresholding Circuit, by using appropriate threshold.

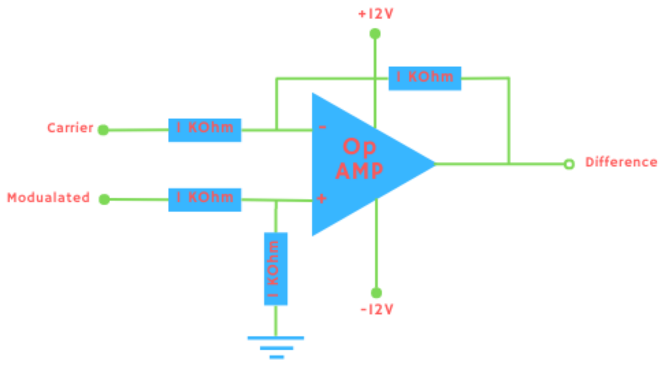


Figure 1: Subtractor Circuit

The difference is passed through an Envelope Detector circuit.

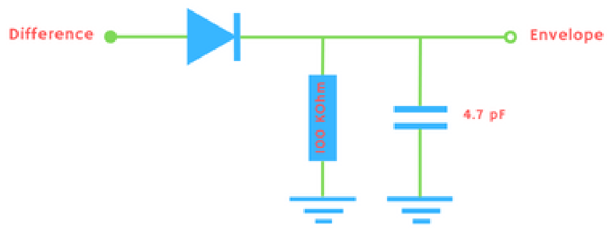
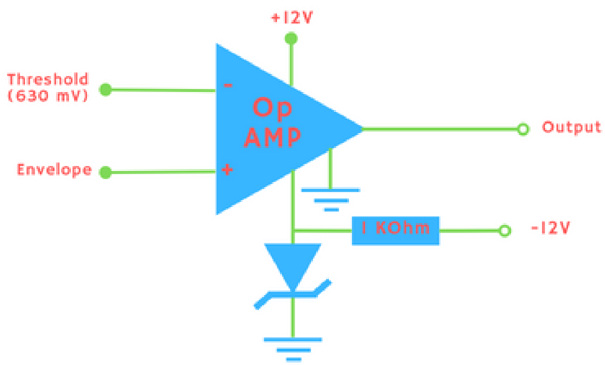


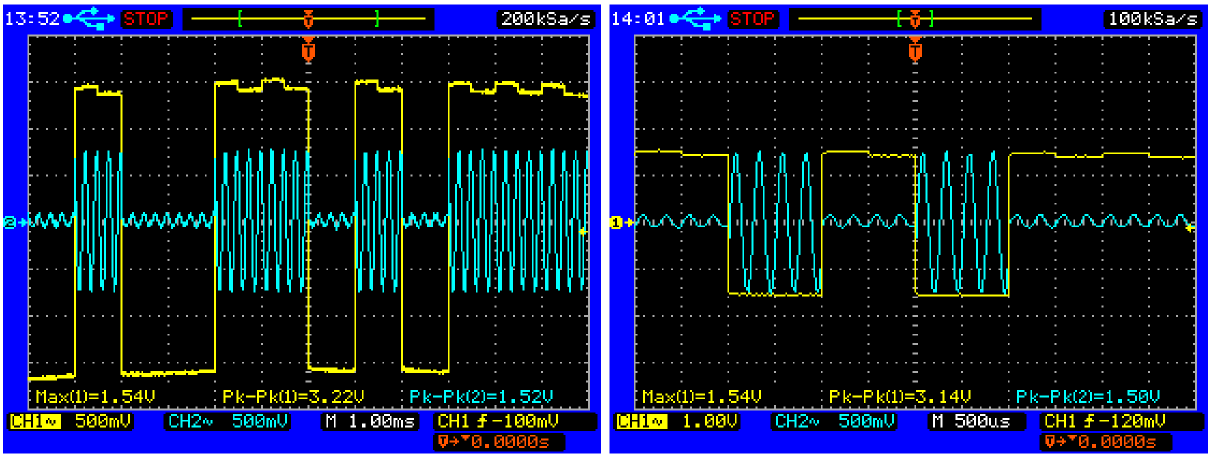
Figure 2: Envelope Detector Circuit

After Envelope detector, we pass it through a Comparator Circuit, that performs a thresholding operation on the output of Envelope Detector to give us the final Digital Signal.



Results

Green Signal represents the **PN signal** which serves as our Input Digital Signal, whereas **Blue Signal** is the **Difference** of BPSK and Carrier Signals.

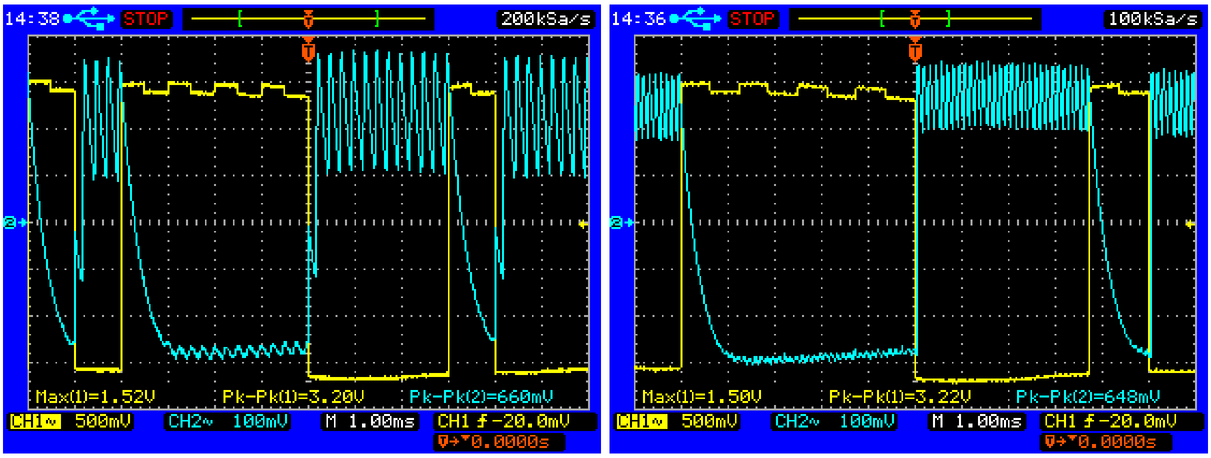


(a) Finding out the difference between BPSK and Carrier Signal

(b) After inverting it in order to match with the output shown in Manual

Figure 4: Difference Output

Green Signal represents the **PN signal** which serves as our Input Digital Signal, whereas **Blue Signal** is the **Envelope** of the Difference of BPSK and Carrier Signal.



(a) Envelope Detector (1st Iteration)

(b) Envelope Detector (Final Iteration)
R = 100KΩ & C = 4.7pF

Figure 5: Envelope of the Difference between BPSK and Carrier Signal

Green Signal represents the **PN signal** which serves as our Input Digital Signal, whereas **Blue Signal** is the **Demodulated Signal**.

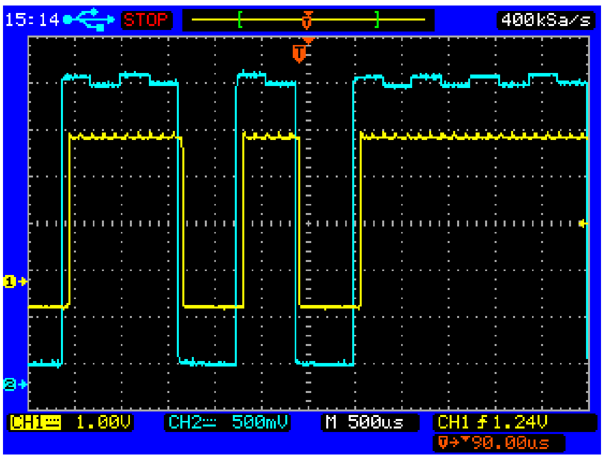


Figure 6: Final Output of Demodulation

Discussion

From this experiment, our key takeaways were:

- **Comparator Circuit**

  It can be noticed that **unequal voltages** are being provided at the 2 Power Supply inputs of the Op-Amp. This has been done in order to **clamp the output values** of the Comaprator Circuit **between +5 V and 0 V**. The Zener Diode provides a volatage of -6.2 V to the Negative Supply of the Op Amp. Also note that the Op-Amp used for this purpose is IC 710. It is not the regular Op-Amp(IC 741) that we use.

- **Tuning Threshold**

  Comparator Circuit performs a **Thresholding Operation** on the Envelope of the Difference between BPSK and Carrier Signal. As we can see in the Envelope (Figure 5), there are oscillations at both **HIGH** and **LOW** states of the PN Sequence. A threshold must be carefully chosen that maintains **maximum separation** with both Minima of Upper Oscillations and Peaks of Lower Oscillations. Threshold Voltage can be pre-calculated or manually adjusted using a Potentiometer. It may happen that the gap isn't enough for one to be able to manually find the threshold. In those cases, the gap can be increased by changing the following:

  - **Increasing Carrier Frequency**
  - **Decreasing Message Frequency**
  - **Increasing Carrier Amplitude**

  We performed all of these changes and finally found a better output(Figure 5 Final Iteration).

- **Delay in Demodulation**

  We can notice a bit of Delay in the Final Output(Figure 6). Delay is inevitable for this Demodulation Scheme. It originates from the fact that, there is **Time Constant** involved in Envelope Detector and therefore the **Decay** from **HIGH** to **LOW** happens gradually(**cannot be infinitely sharp**). Therefore, it **crosses the Threshold after a finite Delay**. This **Delay can be reduced by keeping the RC** value as **close to** $1/F_c$ **(Carrier Time Period)** as possible. However, it comes with a **Tradeoff**. The **amplitude of Upper Oscillation**s in the Envelope(Figure 5) **increases**, therefore creating issues with finding the Threshold Voltage.

Conclusion

In this experiment, we learnt about Binary Phase Shift Keying, circuit required to generate it, its properties and importance.

References

- Digital Communication Theory Class Notes
- Wikipedia
- ChatGPT
- Lab Manual