Date:
Experiment No : 6
Experiment Name: Study of pulse width modulation and demodulation.

Theory:

i) Modulation :

Pulse width modulation is a modulation technique where the width of the pulses of the pulsed carrier wave is changed according to the modulating signal is known as Pulse Width Modulation (PWM). It is also known as Pulse duration modulation (PDM).
In pulse duration modulation (PDM), the amplitude of the pulse is kept constant and only the variation in width is noticed. As the information component is present in width of the pulses. Thus, during signal transmission, the signal undergoes pulse width modulation. Due to constant amplitude property, it gets less affected by noise. However, during transmission channel noise introduces some variation in amplitude as it is additive in nature. But that is totally easy removable at the receiver by making use of limiter circuit.

As the width of the pulses contains information. Thus the noise factor does not cause much signal distortion. Hence the immunity to the noise of a PWM system is better than the PAM system.

Generation of PWM signal waveform :

The figure below shows the process of pulse width modulation. It is commonly known as an indirect method of PWM generation.

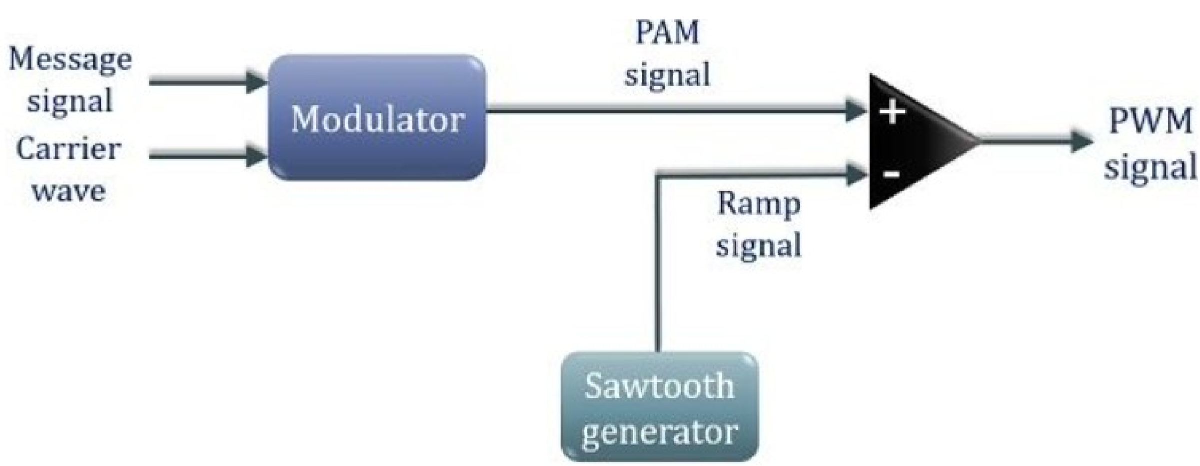

Figure 6.1 : Generation of PWM Signal

The message signal and the carrier waveform is fed to a modulator which generates PAM signal. This pulse amplitude modulated signal is fed to the non-inverting terminal of the comparator.A ramp signal generated by the sawtooth generator is fed to the inverting terminal of the comparator.These two signals are added and compared with the reference voltage of the comparator circuit. The level of the comparator is so adjusted to have the intersection of the reference with the slope of the waveform.The PWM pulse begins with the leading edge of the ramp signal and the width of the pulse is determined by the comparator circuit.

The width of the PWM signal is proportional to the omitted portion of the ramp signal by the comparator level.

The figure below will help us to understand in a better way how PWM signal is generated by the comparator:

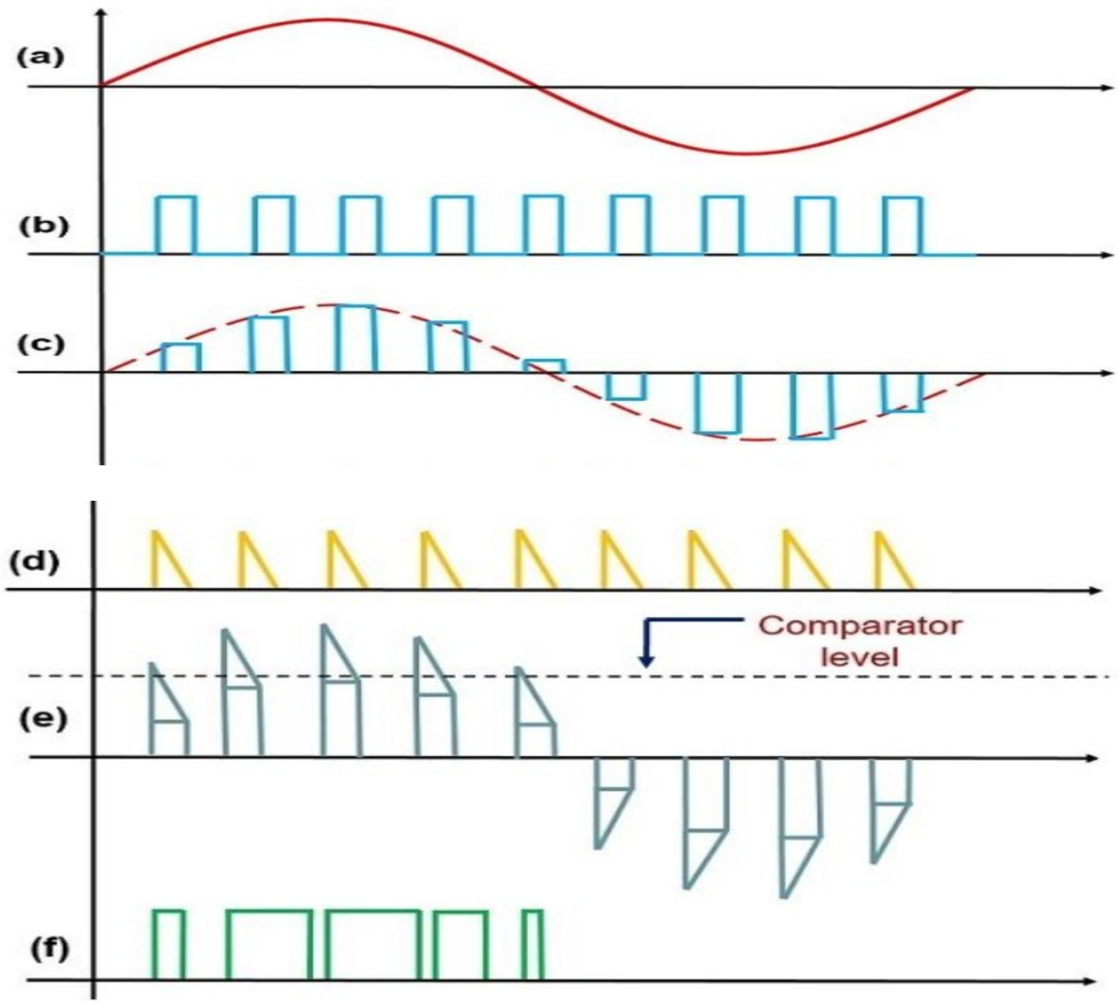

Figure 6.2 : Waveform representation of PWM signal generator.

Here, the first image i.e., (a) shows the waveform of the sinusoidal modulating signal and the second one (b) shows the pulsed carrier. After modulation, a PAM signal is generated that is shown in (c). This PAM signal, when added with ramp signal shown in (d), is compared with the reference voltage of the comparator shown in figure (e).

Lastly, figure (f) shows the PWM signal.

We have already mentioned that the width of the pulse is directly dependent on the portion of the waveform that lies above the comparator level.This is how a pulse width modulated signal is generated.

ii) Demodulation :

To recover the original audio signal from a PWM signal, a decoder or demodulator is need in the receiver circuit.

There are two common techniques used for pulse-width demodulation. One method is that the PWM signal must first be converted to a pulse-amplitude modulation (PAM) signal and then passed through a low-pass filter. The PWM signal is applied to an integrator and hold circuit. When the positive edge of pulse appears, the integrator generates ramp output whose magnitude is proportional to the pulse width. After the negative edge, the hold circuit maintains the peak ramp voltage for a given period and then forces the output voltage to zero. The waveform is the sum of a sequence of constant-amplitude and constant-width pulse generated by demodulator. This signal is then applied to the input of clipping circuit, which cuts off the portion of signal below the threshold voltage and outputs the reminder. Therefore the output of clipping circuit is a PAM signal whose amplitude is proportional to the width of PWM signal. Finally, the PAM signal passes through a simple low-pass filter and the original audio signal is obtained.

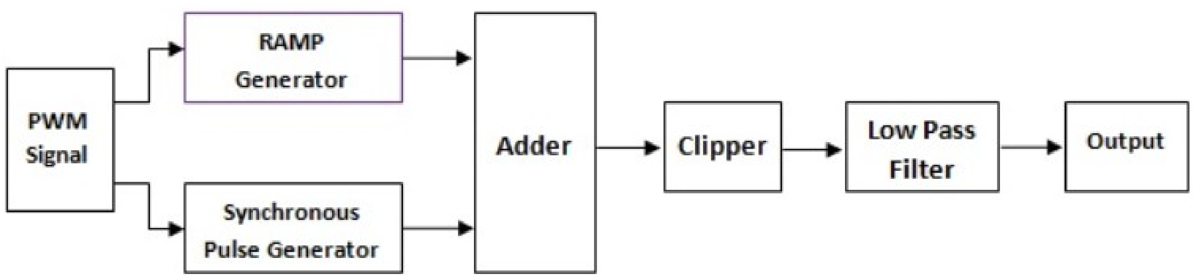

Figure 6.3 : Block diagram of PWM demodulation.

The other technique for demodulating a PWM signal is consist of a product detector and a low-pass filter. The PWM and the carrier signals are connected to the inputs of a product detector, and then a sequence of pulses having the width inversely proportional to the width of PWM pulse presents at output. When the Va signal passes through the low-pass filter, a demodulated signal is obtained.

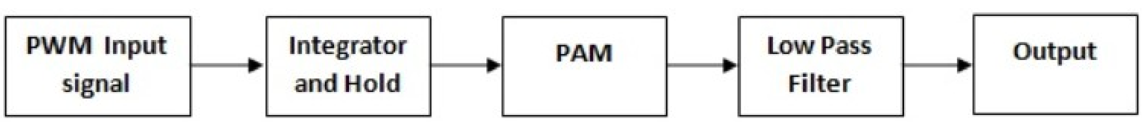

Figure 6.4 : Another diagram of PWM demodulation.

For any pulse wave modulation, before modulating, the original continuous type signal must be sampled and the sampling rate of the sampling signal cannot be low, or else the recovered signal will cause distortion. The sampling rate depends on the sampling theorem which the sampling theorem is defined as: for any pulse wave modulation system, if the sampling rate excesses double or more times of the maximum frequency of the signal, then the distortion level of the data recovery at the receiver will be the minimum. For example, the frequency range of the audio signal is 40 Hz ~ 4 kHz, then the sampling signal frequency of the pulse wave modulation must be at least 8 kHz, therefore, the sampling error can be reduced to minimum.

Required Apparatus :

i) For Modulation :

1. Function generator
2. DCS3 PWM Modulator (µA741)
3. Power supply
4. Oscilloscope
5. Connecting wire.

6.3. DCS4-1 PWM Demodulator Circuit

Circuit Diagram :

i) Modulation :

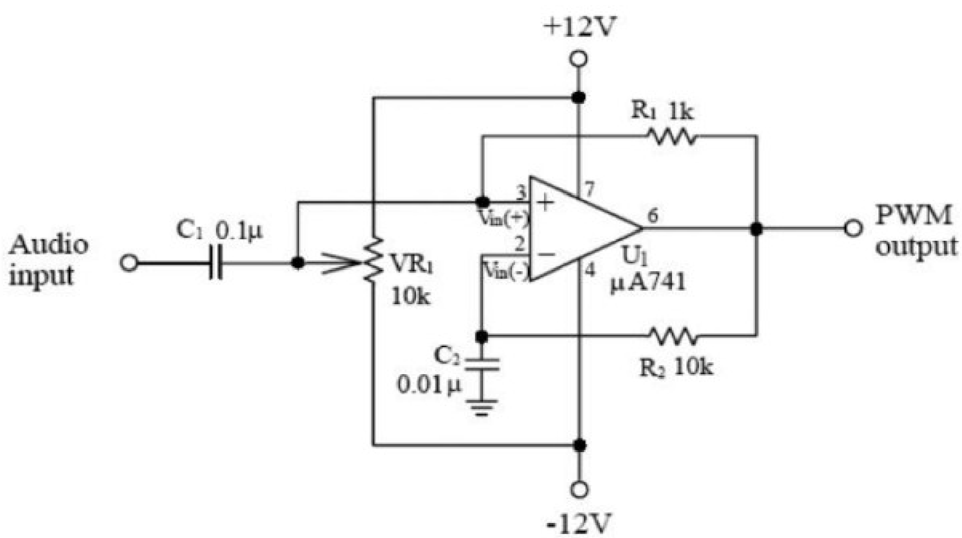

Figure 6.5 : Circuit diagram of PWM by using µA741

i) Demodulation:

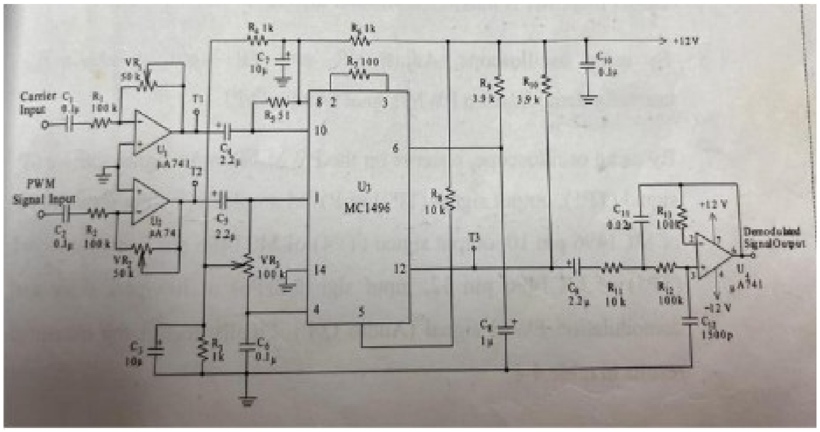

Figure 6.7 : Demodulation Circuit

iii) Function Generator :

Figure 6.8 : Function Generator

iv)

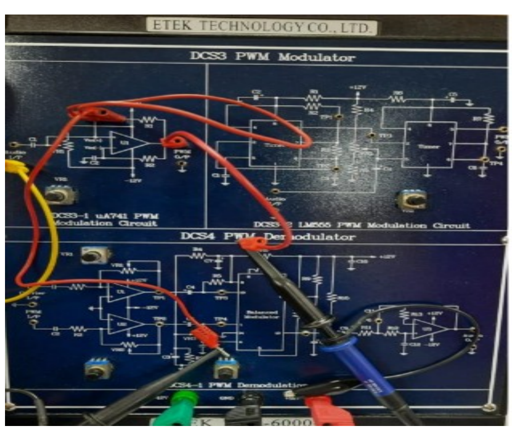

Figure 6.9 : Figure PWM Modulator

Wave Shape :

1.

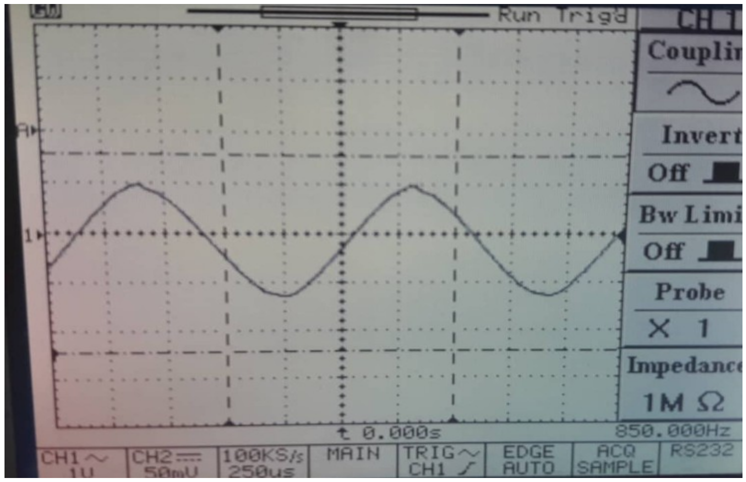

Figure 6.10 : Audio Signal /Message Signal

2.

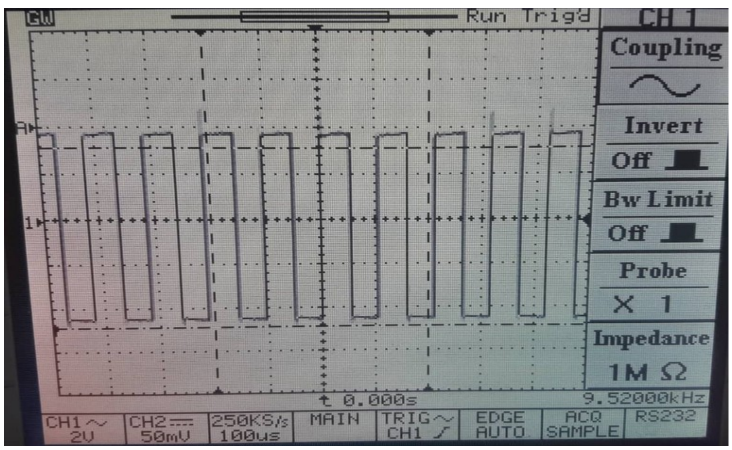

Figure 6.11 : Carrier Signal

3.

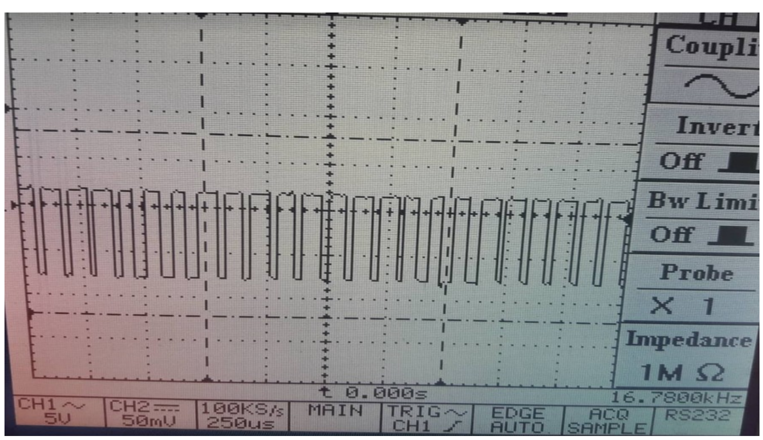

Figure 6.12 : PWM signal

4.

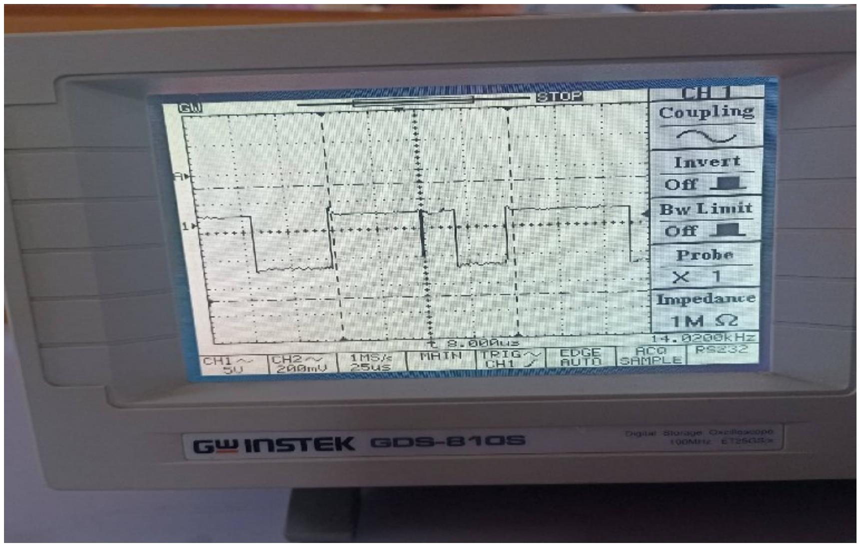

Figure 6.13 : Modulated signal for PWM 555 timer circuit.

5.

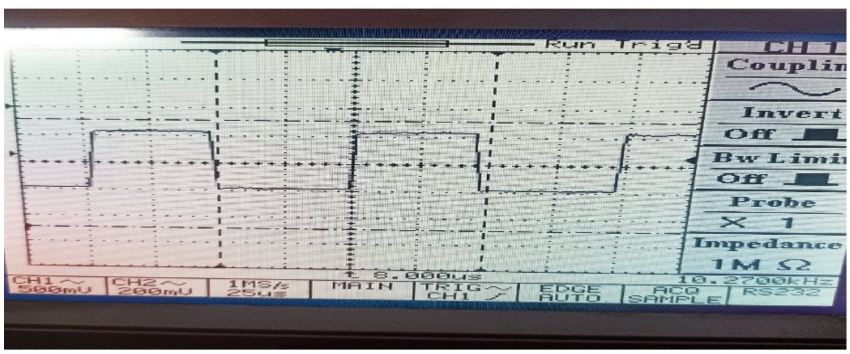

Figure 6.14 : Input for demodulation circuit.

6.

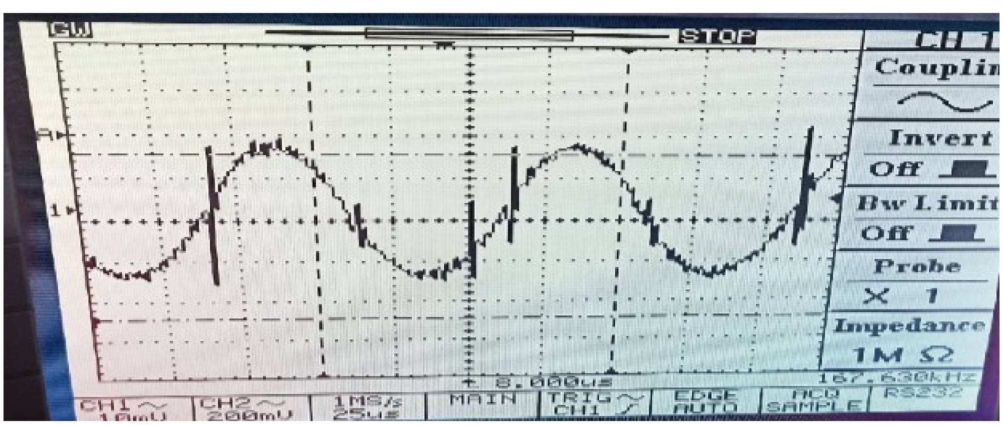

Figure 6.15 : Demodulated Signal

7.

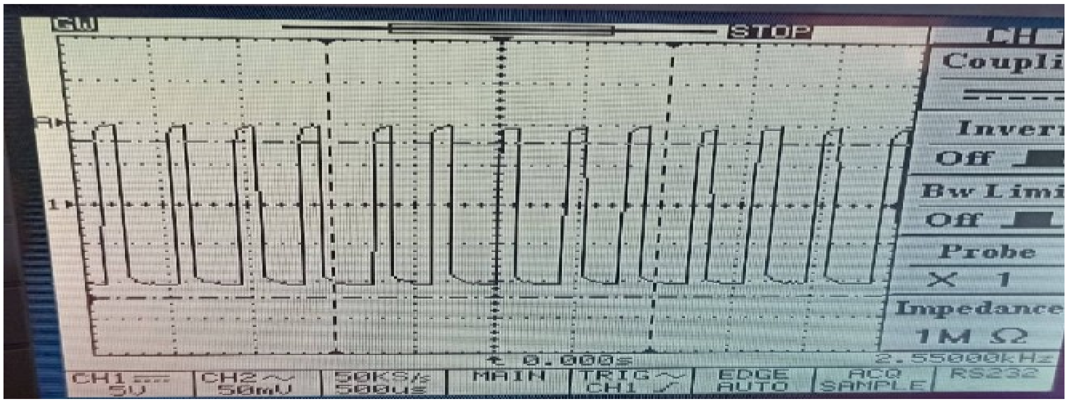

Figure 6.16 : Pulse signal at VR1 negative.

8.

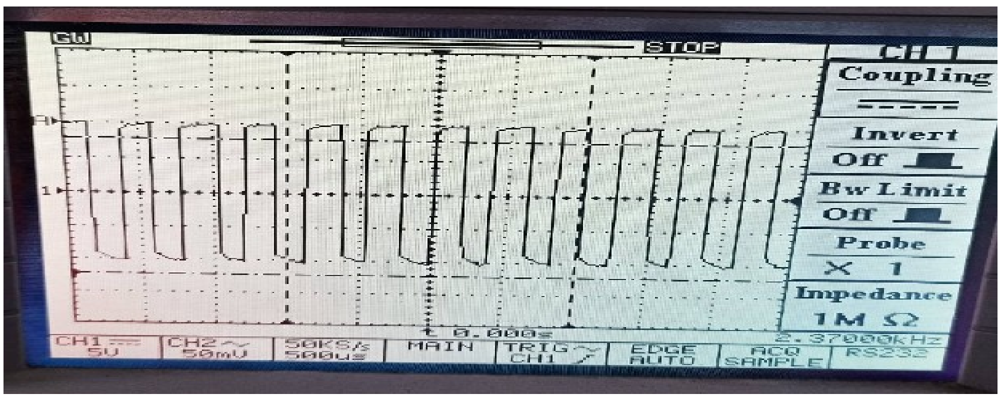

Figure 6.17 : Pulse signal at VR1 zero

Discussion :

In this experiment , we can see that the amplitude of the pulse width modulator is fixed. The pulse width can be varied and controlled by the message signal. When the amplitude of the message signal is larger, then the pulse width becomes wider. When the amplitude of the message signal is getting smaller, then the pulse width becomes narrow.A sine wave was fed as an audio signal. Carrier wave and audio signal combination results in PWM through astable multivibrator. Carrier pulse was taken from the terminal Tp3 of astable multivibrator. There are 3 resistors Vr1, Vr2 and Vr3 in receiver circuit. By varying Vr1 we tried to get maximum amplitude and distortion free square wave at Tp1. Vr2 and Vr3 were used to get a noise free message signal from the whole demodulation process.

Conclusion:

The overall signal was very similar to the theoritical concept. But still there were some distortion in the signal because of some problem in the signal generator or in the circuit.

Department of Electrical and Computer Engineering

Course No : ECE 3208
Course Title : Communication Engineering Sessional
Submission Date :

Submission To:
Milton Kumar Kundu
Assistant Professor,
Dept of ECE
RUET

Submission From:
Tamim Hasan
Roll : 1810044
Session : 2018-19