EXPERIMENT: 5.1
EXAMINATION OF PWM (PULSE WIDTH MODULATOR) (741)

PREPARATION INFORMATION

Change of pulse width of the carrier signal with data signal is called "**Pulse Width Modulation**" (**PWM**). As the pulse width modulation is done, if the carrier signal (Fc), data signal (Fm) and modulated signal (PWM) is examined in oscilloscope, the signals shown in Figure 5.1.1. are observed.

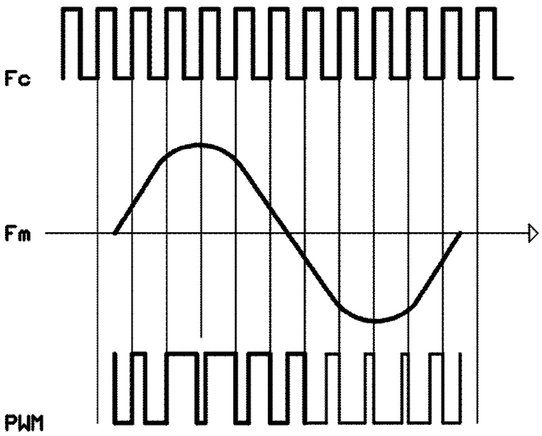


Figure 5.1.1

When a modulated signal is examined, amplitude is constant always. Although positive and negative times are equal in the period of carrier signal, at the positive alternations of data signal at the period of modulated signal the time passing in positive grows and the time passing in negative becomes shorter. In negative alternations of data signal, it is just the opposite, negative time of modulated signal period grows, positive time gets shorter. When the data signal is "0" or does not exist, positive and negative times are equal at the period of the modulated signal. In a one period square wave signal, adjustment characteristic of positive and negative time durations to be equal or different is called "**Duty Cycle**".

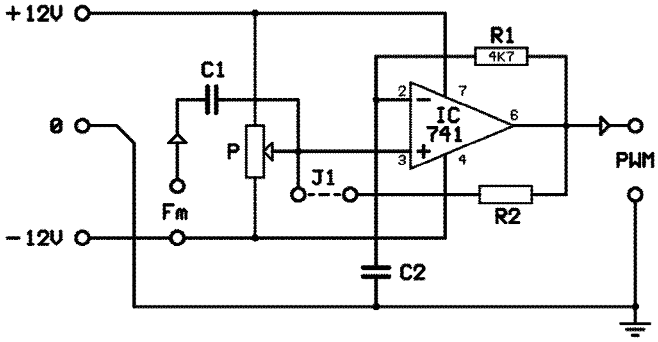


Figure 5.1.2

In Figure 5.1.2, a square wave oscillator made with operational amplifier is shown. The values of R2 resistor and C2 capacitor determine the oscillation frequency. Polarization of positive input pin (pin no. 3) changes the duty cycle ratio of the output signal. When J1 points are open circuit, there is no output signal. At this moment, positive input pin of operational amplifier is made "0" volt according to the ground by P potentiometer and if J1 points are made short circuit, positive and negative times of the output signal are equal. If the polarization of the operational amplifier's positive input pin is made positive, in the period of the modulated output signal, time duration in the positive gets longer, time duration in the negative gets shorter. If polarization of operational amplifier's positive input pin is made negative, in the period of the modulated output signal, time that passes in the negative gets longer, time that passes in the positive gets shorter.

If data signal (Fm) is applied to the positive input pin of operational amplifier, the process that is made by P potentiometer turns out to be made by the data signal. At the output, a sign with pulse width modulation (PWM) is obtained. The ratio of the data signal's amplitude to the duty cycle of the modulated signal changes as directly proportional.

EXPERIMENTAL PROCEDURE

Mount Y-0024/005 module to its place. Do the circuit connections as shown in Figure 5.1.3. Apply energy to the circuit.

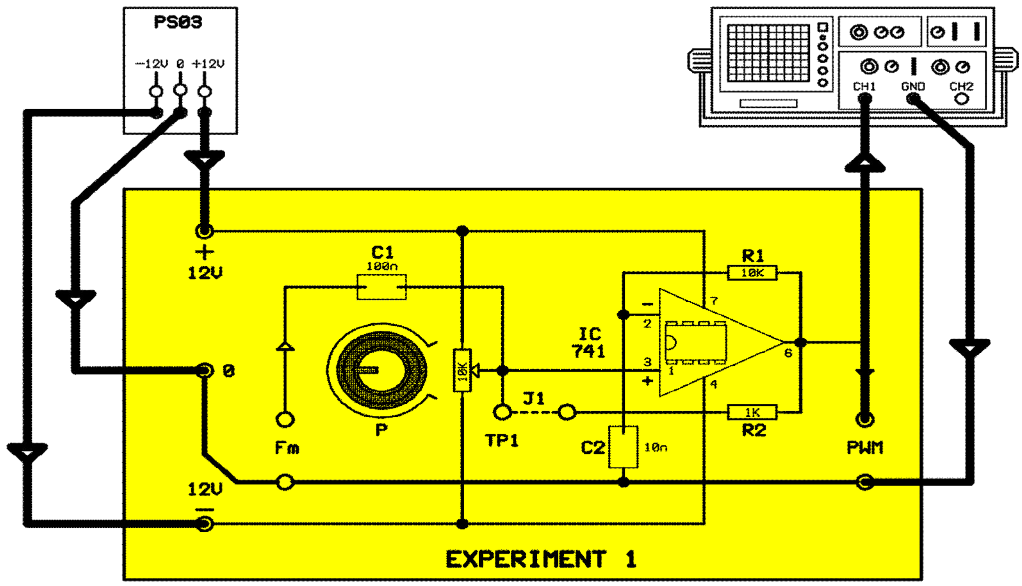
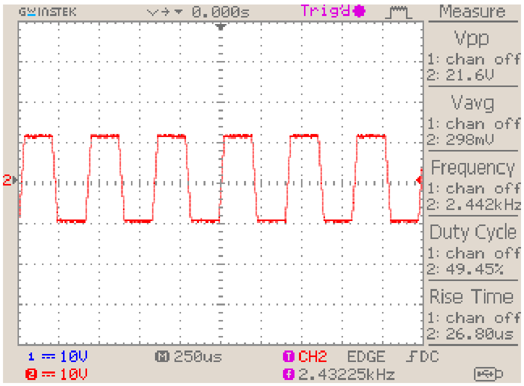


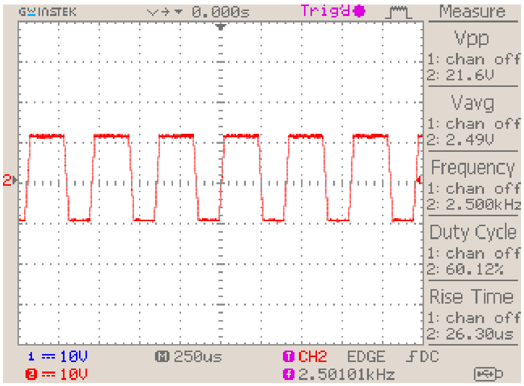
Figure 5.1.3

1- Open up J1 points. Connect a digital voltmeter between TP 1 point and the ground. Adjust P potentiometer so that it will be "0" volt at TP1 point. Do J1 points short circuit. Define the output signal.



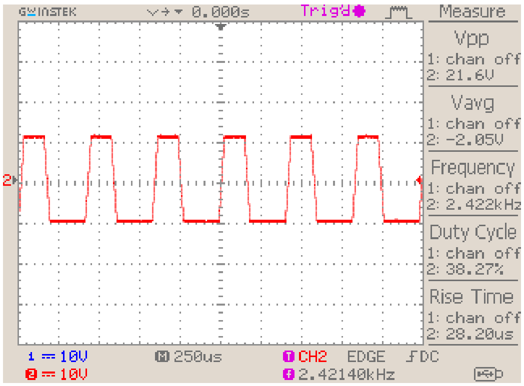
The sign at the output en is a square wave signal. Positive and negative times are equal at the period. In other words, Duty-Cycle is 50%.

2- Open up J1 points. Adjust P potentiometer until +5V is obtained at TP1 point. Do J1 points short circuit. Define the output signal.



The output signal is again a square wave signal. However, in its period, positive time is long, and negative time is short.

3- Open up J1 points again. This time adjust P potentiometer until obtaining -5V at TP1 point. Do J1 points short circuit. Define the output signal.



The output signal is again is a square wave signal. This time positive time is short in its period and negative time is long.

4- Open up J1 points again. Adjust P potentiometer until obtaining "0" Volt at TP1 point.

5- Do the circuit connections as shown in Figure 5.1.4.

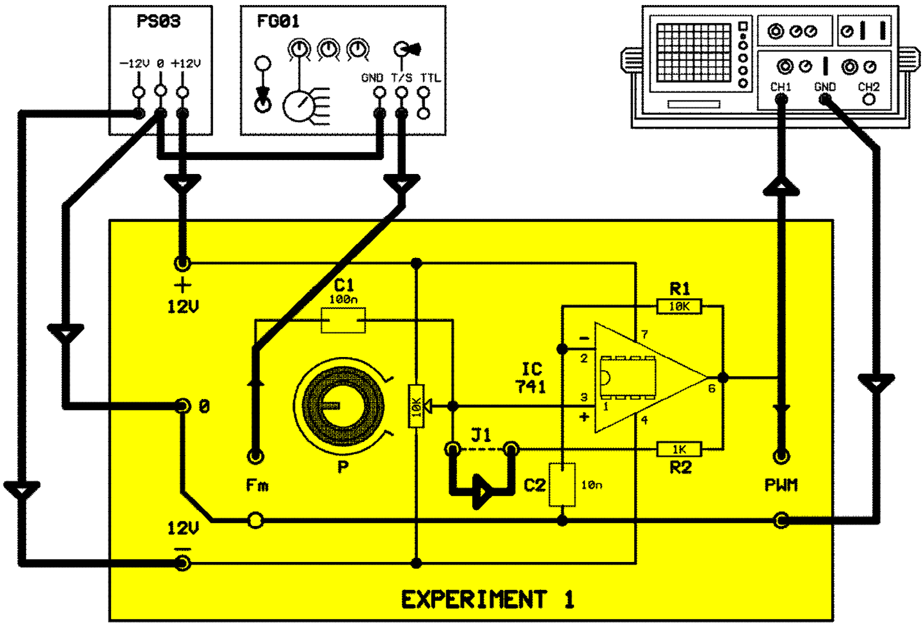
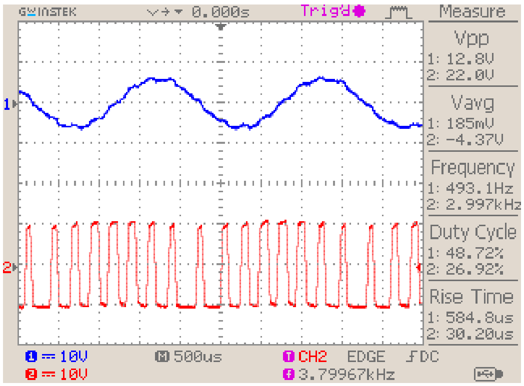


Figure 5.1.4

6- From one of the function generators, apply sine with a frequency of F=500Hz and amplitude VPP=10V sign to the modulator input. See this sign in the second channel of the oscilloscope. Define the output signal.



The output signal is a sign with pulse width modulation (PWM). The ratio of the output signals to duty cycle changes directly proportional to the amplitude of the input signal.

7- Adjust the data signal’s frequency as 1KHz-2KHz-3KHz. Define the signal at the output.

The output signal is again PWM signal at each frequency of the data signal.

EXPERIMENT: 5.2
EXAMINATION OF PWM (PULSE WIDTH MODULATOR) (555)

PREPARATION INFORMATION

LM 555 integration is used widely and it generates a square wave, could be used as a timer and can do pulse width modulation. If LM 555 integration is to be used as a square wave generator, it can work as an unstable multi-vibrator or mono-stable multi-vibrator. As we already know, an unstable multi-vibrator can generate square wave signal without any input signal. Mono-stable multi-vibrator preserves its position when there is no trigger signal from outside and when the trigger signal is applied, it produces a pulse at the output and after a while it goes back to its start position. When pulse width modulation is made, mono decisive multi-vibrator characteristic of LM 555 integration is used. LM 555 integration operates at 5-15V voltage interval and its maximum output current is 200mA. This current value is quite high. In Figure 5.2.1, pin connection of LM 555 integration is shown.

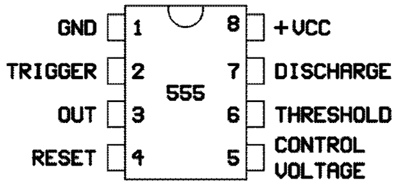


Figure 5.2.1

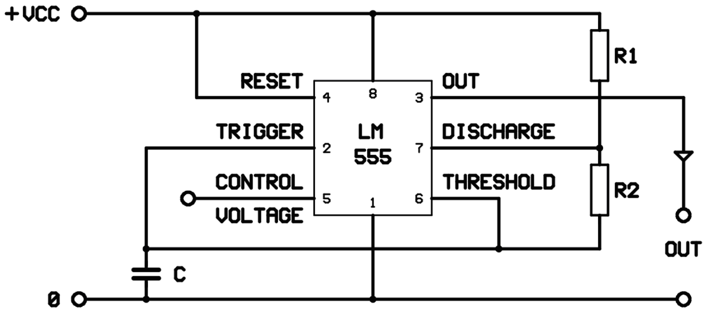


Figure 5.2.2

Figure 5.2.2 shows a circuit where LM 555 integration is used as an unstable multi-vibrator. The output signal of the circuit is a square wave. The oscillation frequency depends on the value of R1-R2 resistors and C capacitor.

Capacitor charge time (**t1**);
t1=0.693.(R1+R2)

Capacitor discharge time (**t2**);
t2=0.693.R2.C

The signal at the capacitor pins is saw tooth signal. When the control voltage pin (pin no. 5) is connected to the ground by a 10nF capacitor, the possible noise signals are prevented.

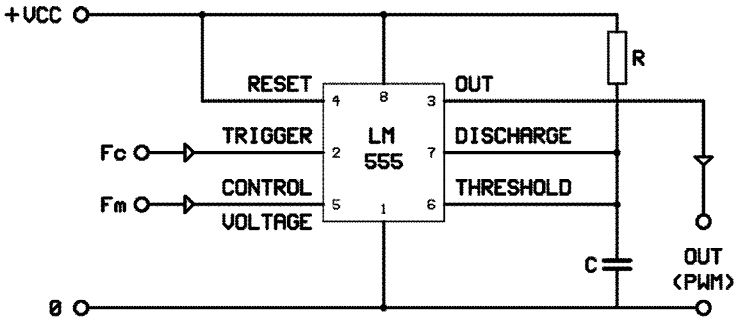


Figure 5.2.3

Figure 5.2.3 shows a circuit where LM 555 integration is used as a mono-stable multi-vibrator. When the trigger pin goes from “1” to “0” digitally, a pulse is obtained at the out pin. The pulse width (T) obtained at the out pin;

T=1,1.R.C

As an example, if R=10K and C=10nF

$T=1,1.10.10^{3}.10.10^{-6}$

T=110μS (**micro seconds**)

According to this, the frequency of the output signal (**F**);

$$F=\frac{1}{T}=\frac{1}{100\mu S}=\frac{1}{110.10^{-6}}=9{,}09KHz$$

If there is a signal with a frequency smaller than 9,09KHz at the trigger pin, a signal is formed with a duty cycle of 50% at the output. If the data signal (Fm) is applied from the control voltage pin (pin no. 5), a signal with pulse width modulation (PWM) is obtained at the output.

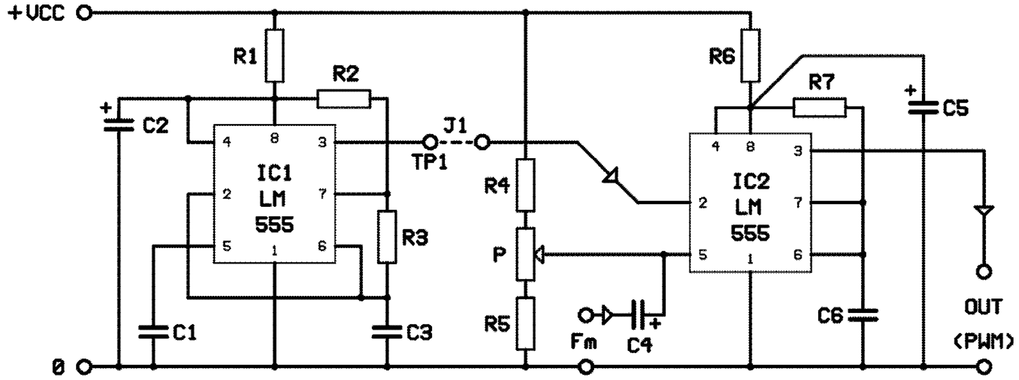


Figure 5.2.4

Figure 5.2.4 shows a pulse width modulator that is made by using two LM 555 integrations. IC1 is an unstable multi-vibrator and IC2 is a mono-stable multi-vibrator. A square wave which is the output signal of IC1 (pin no. 3(is applied to the trigger pin (pin no. 2) of IC2. By applying an data signal to IC2 at the control voltage pin simultaneously, a pulse is formed at IC2 output for each pulse of the input signal. Duty cycle ratio of this pulse is adjusted to the desired ratio by P potentiometer. If an data signal (Fm) is applied to IC2 control voltage pin (pin no. 5), duty cycle ratio of the pulse at IC2 output changes depending on the data signal and a signal with pulse width modulation (PWM) is obtained.

There are two LM 555 integrations within LM 556 integration. By using LM 556 integration, PWM signal can be obtained physically by a very small circuit. In our experiment set, two LM 555 integrations are used for better understanding of pulse width modulation.

EXPERIMENTAL PROCEDURE

Mount Y-0024/005 module to its place. Make the circuit connections as shown in Figure 5.2.5. Apply energy to the circuit.

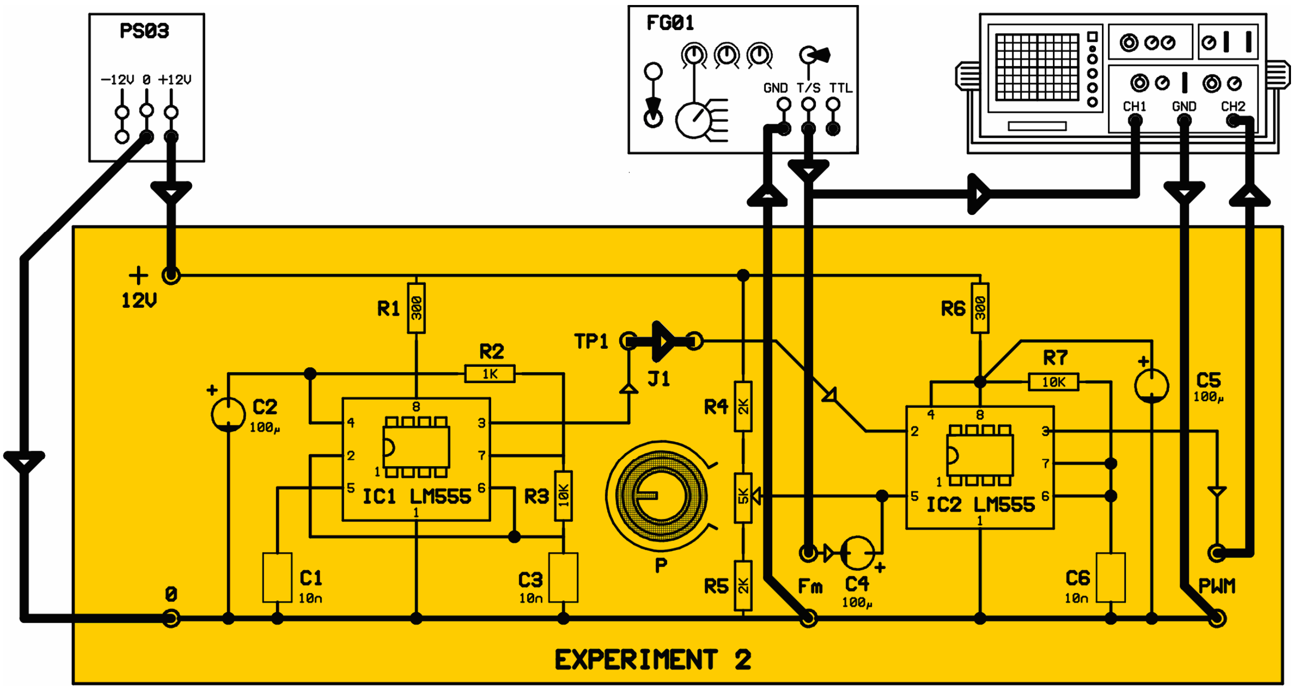
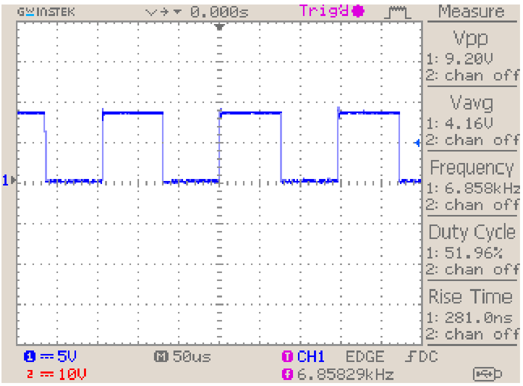


Figure 5.2.5

1- Open up J1 points. Adjust CH2 input of the oscilloscope to TP1 point. Since TP1 point is an output of IC1 integration, how does IC1 work? Define the signal of IC1 integration at the output signal.

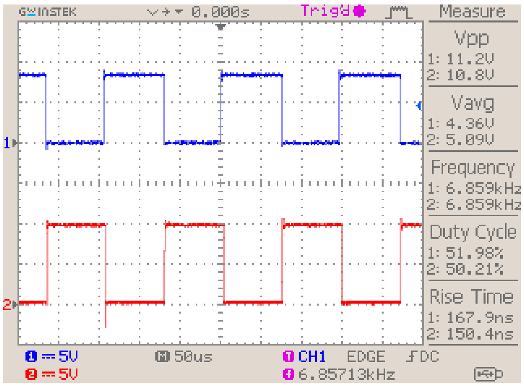


IC1 integration works as an unstable multi-vibrator. The output signal is a square wave. Duty cycle ratio is 50%.

2- What type of signal is there at the output of IC2 integration? Define it.

There are no signals at the output of IC2 integration.

3- Do short circuit to J1 pins. Define the signal at the output of IC2 integration. Adjust P potentiometer. Write down the change of the signal at the output.



A square wave signal is formed at IC2 output pin. In the Figure, when the middle pin of P potentiometer is at the bottom, the input signal is above and output signal is at the bottom.

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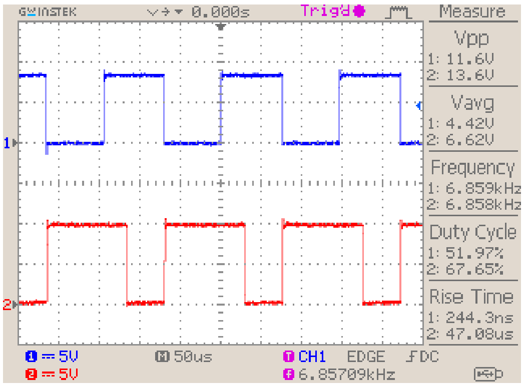
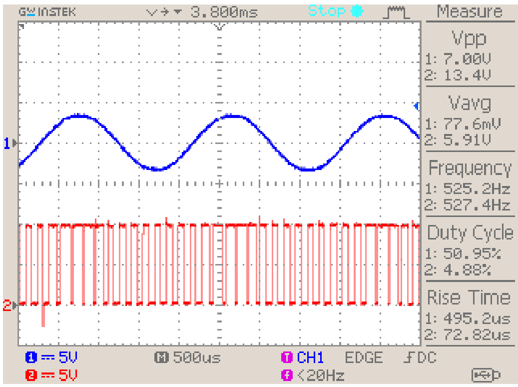
4- Do J1 pins a short circuit. Define the signal at IC2 integration's output. Adjust P potentiometer. Write down the change of the signal at the output.



When the middle pin of P potentiometer is in the middle, the input signal is seen above and the output signal is seen below. Duty cycle ratio of the output signal has changed. Shortly, P potentiometer changes the duty cycle ratio of the output signal.

5- Adjust the duty cycle ratio of IC2 output signal to "0", the time duration to half of the pulse time by P potentiometer. Apply sine as a data signal, frequency F=500Hz and amplitude VPP=10V. Observe the signal at the out pin and interpret it.

NOTE: It may be necessary to adjust the amplitude of the data signal for PWM signal at the out pin to be seen in every time section.



The output signal is PWM signal. In positive alternations of the data signal, the frequency of PWM signal decreases, and in negative alternations of the data signal, the frequency of PWM signal increases. This change doesn't affect the operation.

EXPERIMENT: 5.3
EXAMINATION OF PULSE WIDTH DEMODULATOR

PREPARATION INFORMATION

Although pulse width demodulation can be done by many methods, two methods are used the most. These are the demodulation of PWM signal by PAM (**Pulse Amplitude Modulation**) conversion and the demodulation done by using multiplication sensor. PAM is a modulation type resembling greatly to the amplitude modulation. In this modulation type, the carrier is a square wave and the amplitude of the carrier is changed depending on the data signal.

In our experiment set, multiplication sensor demodulator is examined. MC 1496 integration, which we use as an amplitude and DSB amplitude modulator/demodulator, is used as PWM sensing demodulator.

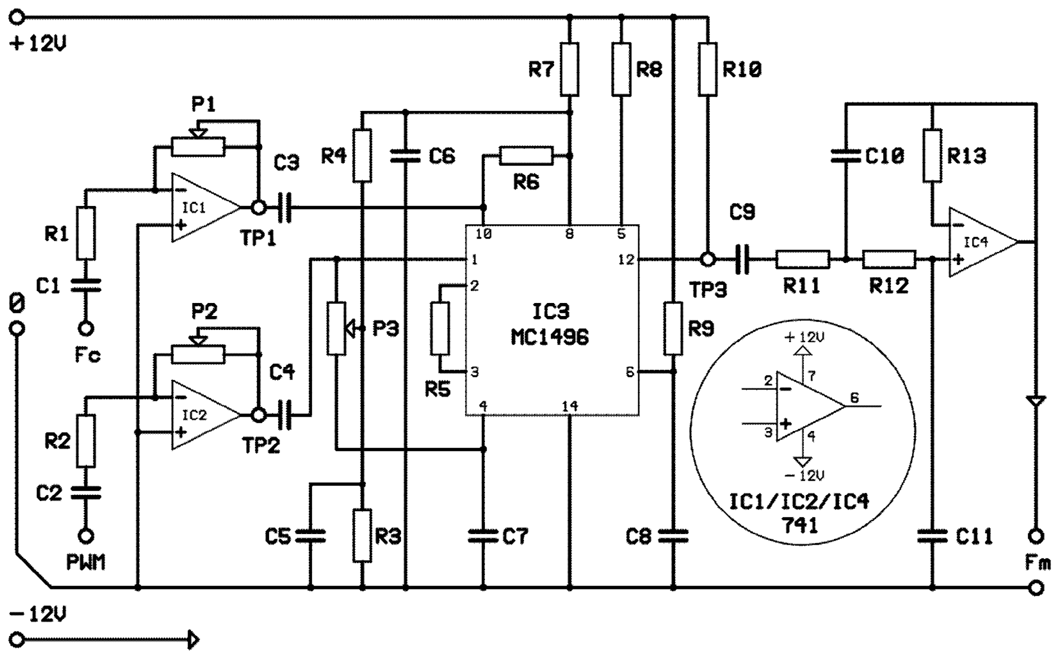


Figure 5.3.1

IC1 and IC2 operational amplifiers (op-amp) in the circuit are used to adjust the amplitudes of PWM signal and carrier signal (Fc). The input signal voltages are between VPP=300mV-1400mV for MC 1496 integration to work properly. MC 1496 integration works linearly between these limits. The gains of the relevant amplifiers are adjusted by P1 and P2 potentiometers. PWM signal is applied at pin no. 1 and 4, the carrier signal is applied at pin no. 8 and 10. R5 resistor controls MC 1496 integration's gain. The output signal of MC 1496 integration is again a pulse train. This signal passed through the second circuit, which is made of IC4, C9, C10, C11 and R11, R12, R3 circuit components, and low pass filter and the data signal (Fm) is obtained again.

EXPERIMENTAL PROCEDURE

Mount Y-0024/005 module to its place. Make the circuit connections as shown in Figure 5.3.2. Apply energy to the circuit.

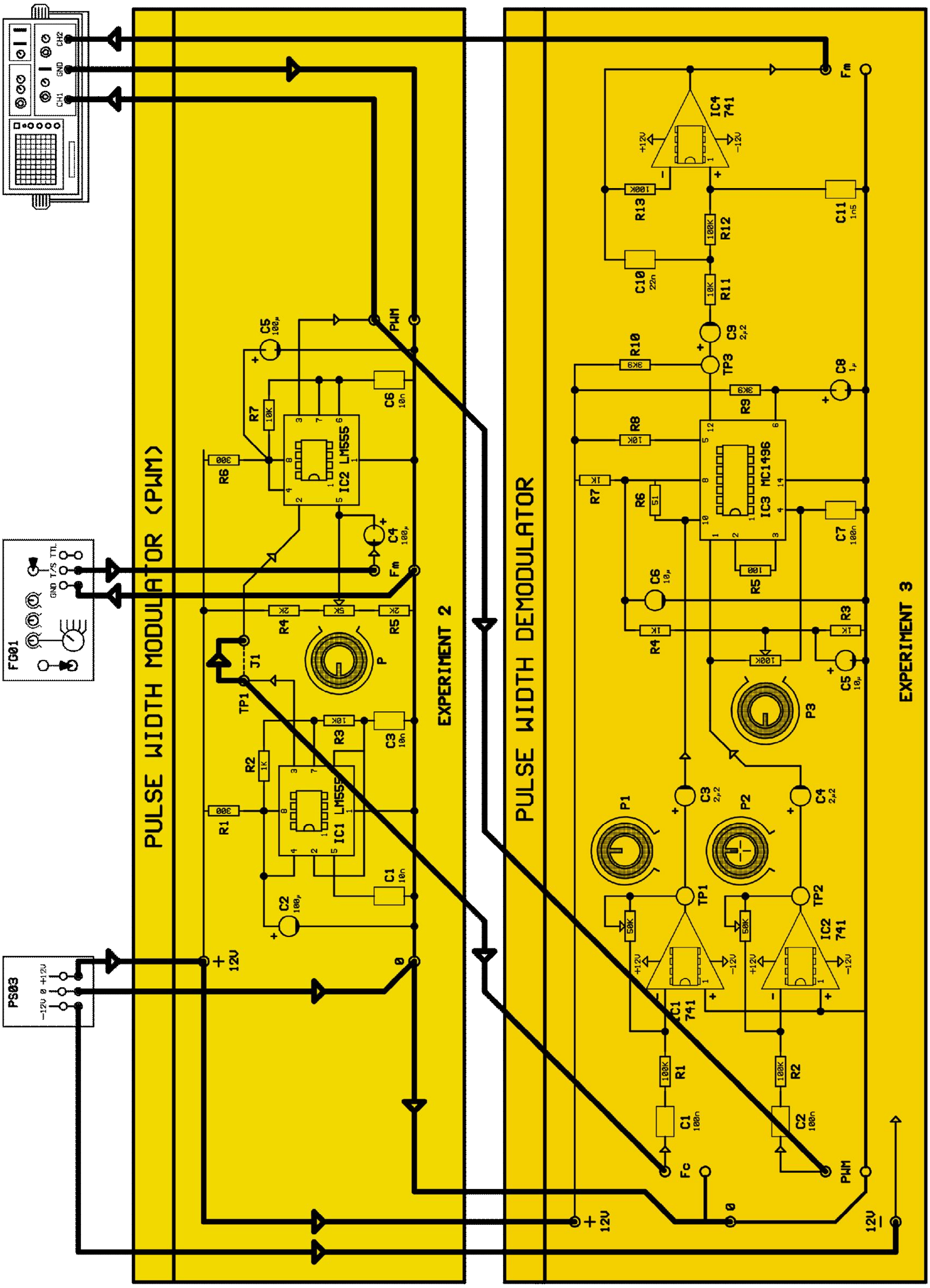
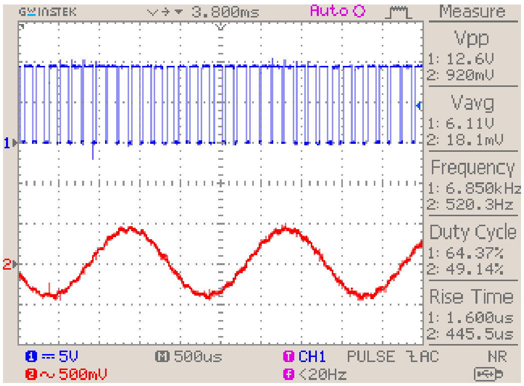


Figure 5.3.2

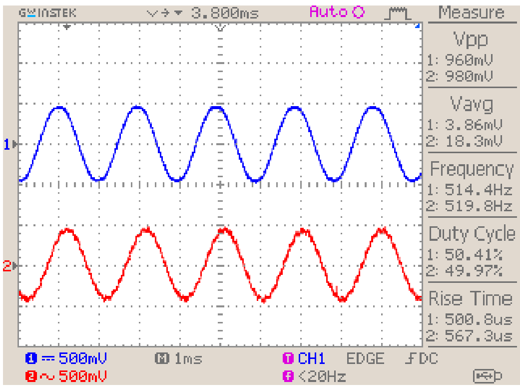
The output signal of experiment 2 is used as PWM signal. The signs required for experiment 2 are; data signal (Fm) sine, frequency F=500Hz and amplitude VPP=1V. By P potentiometer, if positive time is “2” units, adjust PWM pulse shape negative, or if the time period in negative, adjust to ”1” unit.

1- Adjust P1, P2, P3 potentiometers to the middle point. Adjust the three potentiometers slowly and obtain the data signal. Draw the shape of the data signal and define it.



There is noise on the data signal. Still, the signal is usable.

2- Take CH1 channel of oscilloscope to the data signal (Fm) input of experiment 2. Observe the data at the input and data signal obtained as a result of demodulation at the same time in oscilloscope. Change the data signal’s frequency to Fm=500Hz-1KHz. Write down the reaction of the data signal that you obtained at the output.



The output signal follows the data signal at the same frequency. There is change in the amplitude of the output signal, although a little.