## COMMUNICATIONS LAB. Experiment 7 : Pulse Width Modulation / Demodulation

OBJECTIVES

Recognize pulse amplitude and pulse width modulated signals, and do simple experiments.

### GENERAL INFORMATION on Pulse Width Modulation/Demodulation

Pulse-width modulation (PWM) is a digital modulation technique in which the width of a pulse carrier is changed according to the instantaneous value of the information signal. Pulse-amplitude modulation (PAM) is a form of signal modulation where the message information is encoded in the amplitude of a series of signal pulses. For an example message signal, PWM and PAM signals are illustrated in the following figure.
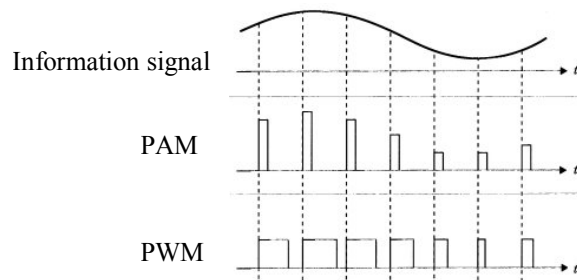
In PWM, how long a rectangular pulse stays "on" within a constant period is determined by the value of the information signal. The "on-off" behavior changes the average power of the signal. Duty cycle is the ratio of the duration of the "on" event to the total period of the rectangular pulse train, and is given by

$$Duty\ Cycle = \frac{On\ Time}{Period} \times 100\%$$

An example signal with different duty cycles is given in the following figure.
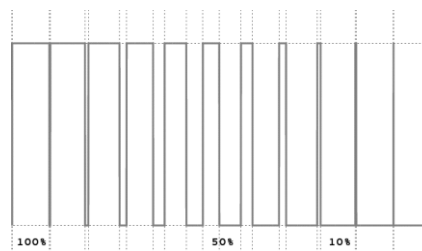
Pulse width modulators and demodulators make use of various techniques. The monostable multivibrator circuits and digital circuits having counters with adjustable output control comparators (or any programmable device that can realize this) can be used to generate the PWM signal. To recover the original message signal from PWM signal, a demodulator is needed in the receiver circuit. There are two common techniques used for pulse-width demodulation. One method is that the PWM signal is first converted to a pulse-amplitude modulation (PAM) signal and then passed through a low-pass filter. Another technique involves a product detector followed by a low-pass filter. Just a low pass filter alone may approximate the information signal, depending on the application's constraints.

EXPERIMENT

1. **Pulse Width Modulation**

    a) Connect *"DC supply"* to *"Vm"* on the PWM modulator part of the training kit.
    b) Adjust Clock Frequency to 120kHz using *"CLK"* .Then, adjust *"DC Supply"* to *"-5V"* for the message signal.
    c) Observe "*Vm*" and *"CLK"* of the PWM modulator using "*Channel 1*" and *"Channel 2"* of the oscilloscope. Save the result observed on the screen to your USB flash drive.
    d) Then, connect *"PWM output"* to the oscilloscope instead of *"CLK"* and observe *"Vm"* and *"PWM output"* of the Pulse Width Modulation at same time. Save the screen observed on the oscilloscope to your USB flash drive.

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e) Adjust DC Supply to *"0V"* and observe "Vm" and "PWM output" of the PWM modulator using *"CH1"* and *"CH2"* of the oscilloscope. Save the screen observed on the oscilloscope to your USB flash drive.

f) Repeat e) but change DC Supply voltage to *"+5V"* using *"DC Supply"* potentiometer.

g) Measure *"Duty Cycle"* for these different *"Vm"* voltages and note down your comments for your report .
(** *Push the "Measure" button and then use "Display All" function.*)

h) Calculate theorical *Duty Cycle* and compare to theorical and practical value on your report.

i) Change the clock frequency using "CLK" and observe the change on oscilloscope display. Save the screen observed on the oscilloscope to your USB flash drive and note down your comments.

j) Connect the sinusoidal message signal generated by *"FG1"* function generator to the *"Vm"* input on the Pulse Width Modulator.

k) Adjust the message signal to obtain a 110Hz and 7Vpp <u>sinusoidal</u> signal.

l) Observe *"Vm"* and *"PWM"* output on the oscilloscope and save the result observed on the screen to your USB flash drive and note down your comments.

m) Then, adjust the message signal to obtain a 110Hz and 7Vpp <u>triangle</u> signal.

n) Observe *"Vm"* and *"PWM"* output on the oscilloscope and save the result observed on the screen to your USB flash drive and note down your comments.

3. Pulse Width Demodulation

o) Repeat a), b) and connect PWM output to Pulse Width Demodulation input, then, connect CLK on the Modulator to CLK on the demodulator and observe "Vm" and "Vo" on the "CH1" and "CH2" of the oscilloscope. Save the screen observed on the oscilloscope to your USB flash drive.

p) Adjust the voltage of the Vm to *"0V"* and *"+5V"* , respectively. Observe the differences between each voltage on the oscilloscope and save these different screens to your USB flash drive.

q) Adjust the message signal to obtain a 50Hz and 7Vpp sinusoidal signal. And observe *"Vm"* and *"Vo"* on the *"CH1"* and *"CH2"* of the oscilloscope. Save the result observed on the screen to your USB flash drive.