ECE F311 COMMUNICATION SYSTEMS

Experiment 9

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Section: P1

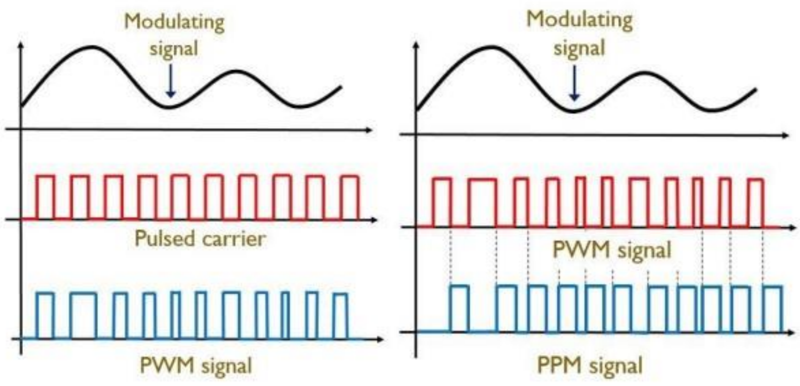
Title: Pulse Width and Pulse Position Modulation

Aim: This experiment is intended to make the student perform experiment on Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM) using MATLAB.

A – Theory

Pulse width and pulse position modulation schemes are analog pulse modulation schemes, wherein a certain characteristic of the pulse-shaped carrier is varied in accordance with an analog message signal. Specifically, for PWM, the width (ON time) of the carrier is varied in accordance with the message keeping the ON time plus OFF time fixed. On the other hand, for PPM, it is the distance between consecutive pulses that varies with the message signal, keeping the pulse width constant. Figure 1 shows a typical message signal generating PWM and PPM signals. PWM signals are typically used in application that require variable power to be delivered. For instance, PWM signals are used to control the speed of motors. PPM signals are typically used in low-power, shortdistance RF communication systems that rely on non-coherent detection such as RFID tags, radio control of toys and contactless smart cards.

Figure 1: Portrayal of PWM and PPM signals



B – Generation of PWM and PPM signals:

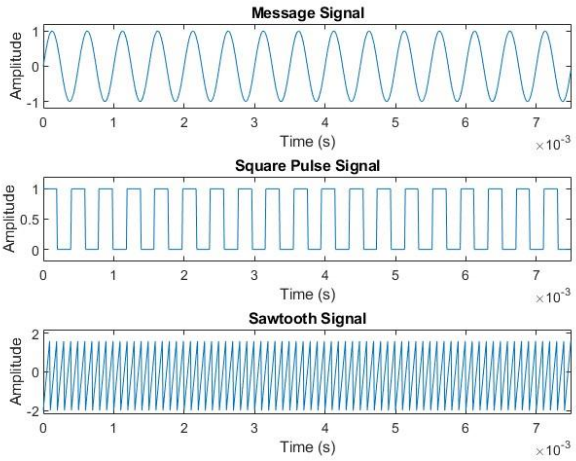
The following steps outline the procedure to generate PWM and PPM signals:

a. Consider the message signal to be a 2 kHz sine wave with excursion between (-1 V and + 1V) and the carrier signal to be a 10 kHz pulse wave with 50% duty cycle and amplitude varying between 0 V and 1 V. Use a sampling frequency that is 10 times the carrier frequency.

b. First, generate a sawtooth waveform having the same frequency as the carrier signal but with an amplitude greater than that of the message signal. For this experiment, let the amplitude of the sawtooth waveform be 2 V. The MATLAB command to generate this is

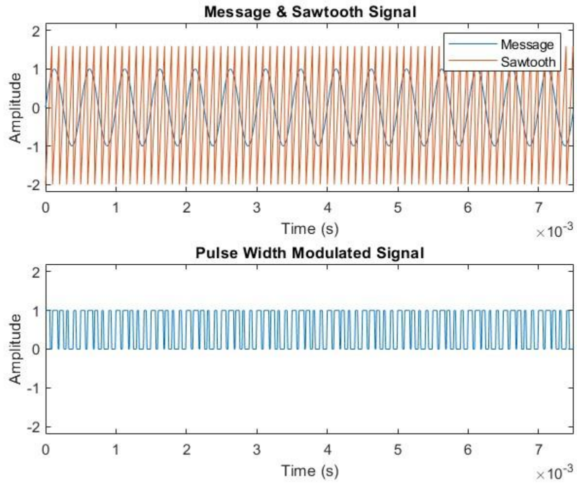
$$\mathbf{A*sawtooth(}\boldsymbol{\omega_c t}\mathbf{)}$$

where ω_c is the carrier angular frequency and A is the required amplitude for the sawtooth waveform.

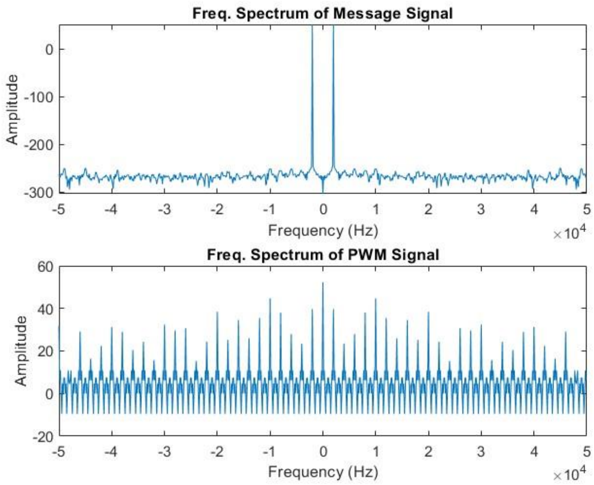


c. Next, the PWM signal is generated by comparing the message signal with the sawtooth signal. Whenever the message signal is greater than or equal in magnitude to the sawtooth signal, the PWM signal takes a value 1 V. At all other instants, the PWM signal is set to 0 V.

d. Plot the message and the sawtooth signals overlapping in the same plot (using the MATLAB command hold on between the two plot commands). To distinguish between them, plot them in different colors. The PWM signal is to be displayed below it in the same figure. Notice the variation in the pulse width in accordance with the message signal. HINT: Use MATLAB command subplot and axis, so that graphs should be comparable.



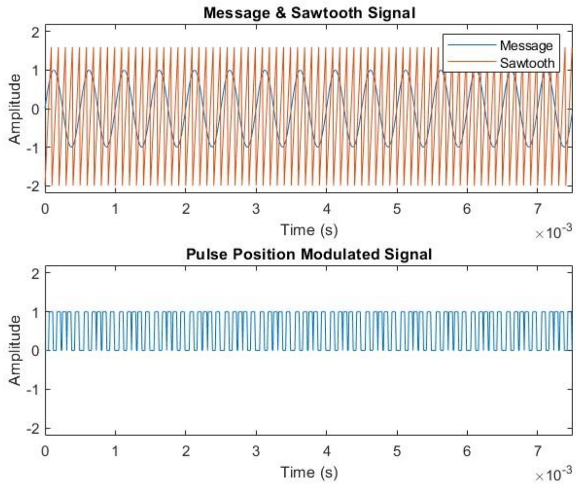
e. Compute and plot the spectrum of the message and PWM signals in dB one below the other. Increase the carrier frequency till about 1000 times the message frequency. What do you observe in the spectrum of the PWM signal as the carrier frequency is increased?



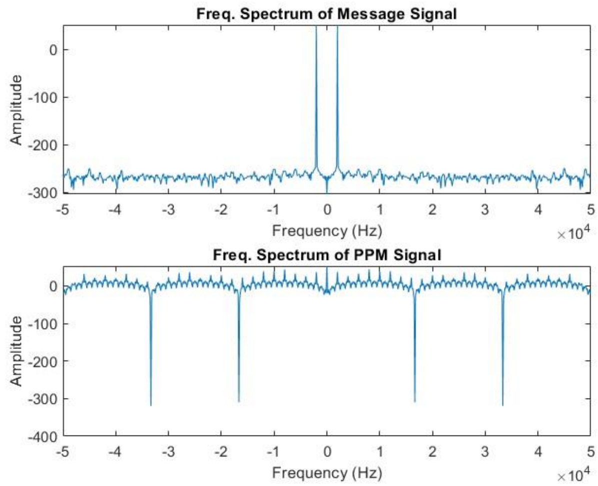
The power in other frequencies increases as the carrier frequency is increased to about 1000 times the message frequency.

f. Next, this PWM signal will be used to generate the PPM signal. Since the PPM signal consists of pulses with fixed pulse width (ON time), set the pulse width of the PPM signal to be 10% of the period of the carrier. That is, if the carrier has a frequency of 1 Hz, the pulse duration would be 100 ms. At each negative (falling) edge of the PWM signal, the PPM signal assumes a value 1 V for a duration of the pulse width and will be 0 V otherwise.

g. Plot the message and the sawtooth signals overlapping in the same plot. To distinguish between them, plot them in different colors. The PPM signal is to be displayed below it in the same figure. Notice the variation in the distance between successive pulses in accordance with the message signal.



h. Compute and plot the spectrum of the message and PPM signals in dB one below the other. Increase the carrier frequency to about 1000 times the message frequency. What do you observe in the spectrum of the PPM signal as the carrier frequency is increased? How does the spectrum vary with a variation in the pulse width?



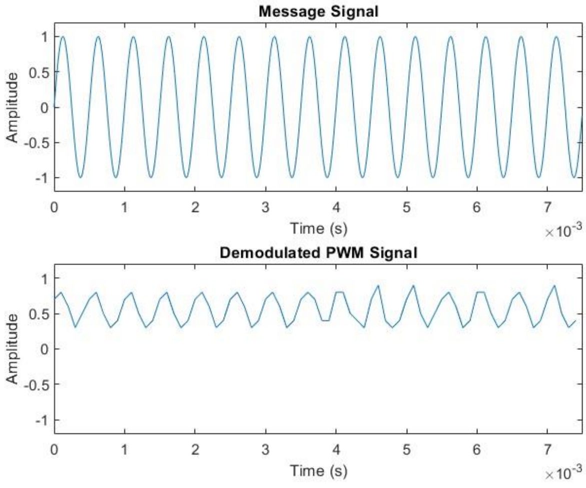
The same situation can be found in PPM. The power in other frequencies increases as the carrier frequency approaches 1000 times the message frequency.

C – Demodulation of PWM and PPM signals:

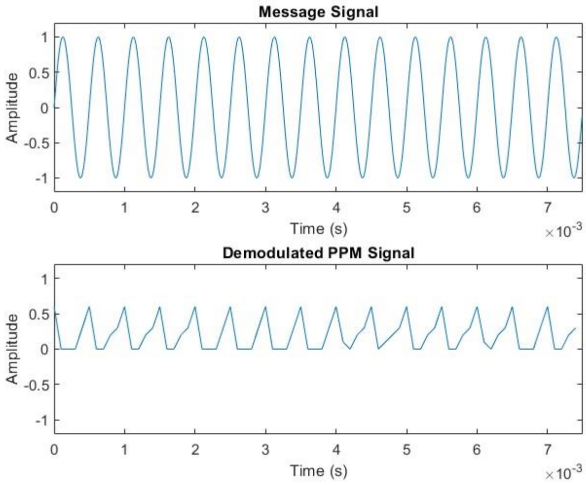
Due to the increased implementation complexity of PWM and PPM demodulators, the MATLAB command ***demod*** will be used to demonstrate their demodulation. This function takes in the modulated signal, carrier frequency, sampling frequency and the type of modulation as input arguments, that exact order.

a. Demodulate the PWM and PPM signals using the ***demod*** command.
b. Plot the message and demodulated signals one below the other. What effect does an increase in carrier frequency have on the demodulated signal? In the case of PPM, comment on the effect of a variation in the pulse duration on the demodulated signal.

PWM Demodulation



PPM Demodulation



The magnitude of the peaks in the demodulated signal will decrease as the pulse duration is increased. The magnitude of the peaks in the demodulated signal will increase as the pulse duration is reduced.

D – Conclusions:

In this experiment, we used MATLAB to plot square waves and sawtooth waveforms. We used the Pulse Width Modulation and Pulse Position Modulation techniques to modulate a sine signal. We compared both modulation techniques as well. The frequency spectrum of the PWM and PPM signals have been plotted. Finally, we plotted the modulated signals after demodulating them.