UTKU ACAR 250206062

LAB-7 REPORT

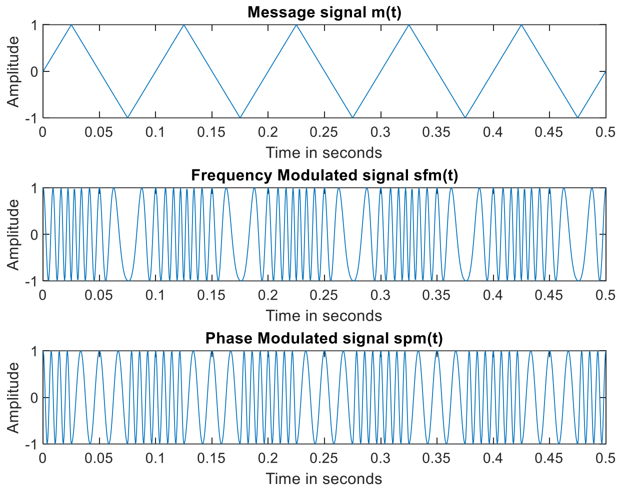

Figure 1: 2.1.d

As we can see in figure 1 our first graph is given input which has pi/2 rad phase difference to the regular sawtooth (the amplitude is 1 at t=0 instead of 0 at t=0) and it is 10 Hz wave. Second graph shows us how frequency modulation works. It gives more pulses when the integral is high (increases when we got near to the positive peaks and decreases while we are getting closer to negative peaks). The third graph is phase modulated wave and this type of modulation gives more pulses (more frequent) while the change(derivative) is high but in positive direction while we are getting decline from positive peak we got less frequent pulses.

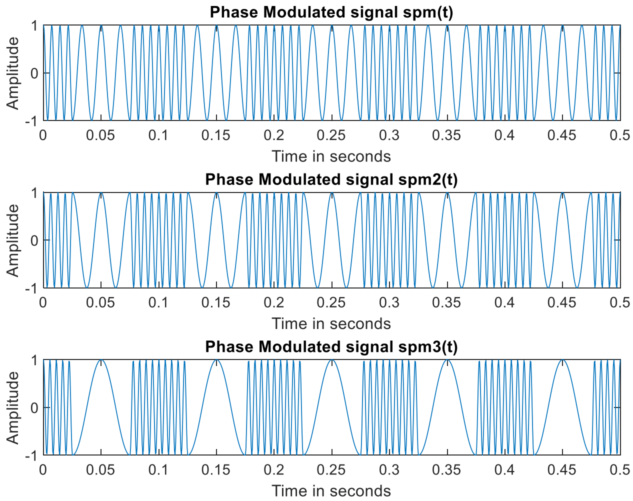

Figure 2: 2.1.f

As we can see from figure 2 there are changes the frequencies while we increase K_p values. We can clearly understand that the increasement in K_p results more frequent pulses when the derivative is high and with the same manner when the derivative gets lower than the pulses become less frequent (number of waves decreases with decreasing derivative)

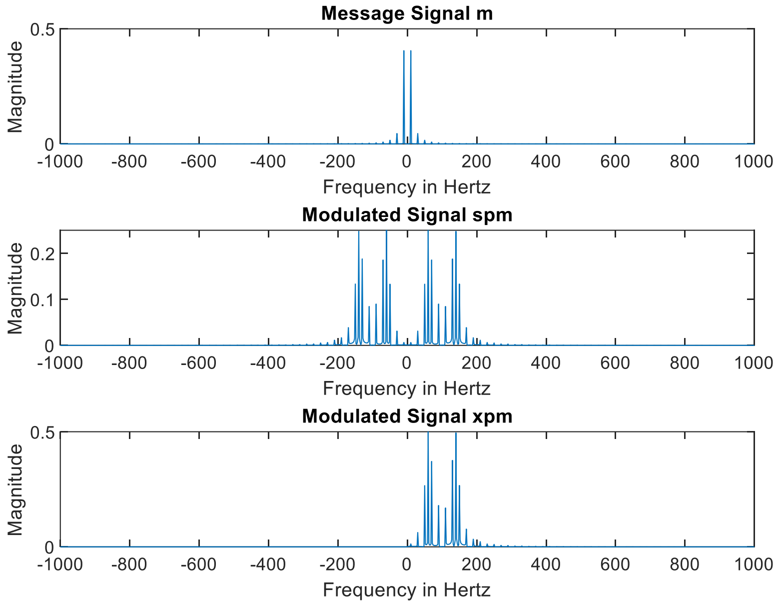

Figure 3: 2.2.c

As we expected the first graph on figure 3 can be explained by Fourier transform and it has various components, but we can focus on the -10 and 10 Hz components with 0.4 magnitude is the dominant component It halves magnitude and gives impulses in both negative and positive frequency axis due to signal's frequency. The coefficients can be found with Fourier series. If we compare second and third graph we can see that third graph is second graph without negative frequencies. That can be explained by Hilbert transform. We use Hilbert transform for finding the analytic signal which means that neglecting negative frequencies due to some mathematical symmetry theorem which says that the negative frequencies are useless and if we take Hilbert transform of something we get complex signal, but we can easily separate the signal into real and imaginary parts. So, the negative parts in second graph are neglected in the third graph. But the magnitudes are got doubled. So, we can think as we fold the frequency axis and the negative components got summed with corresponding positive components. Imaginary part of the xpm is nothing but 90-degree phase difference of our spm signal.

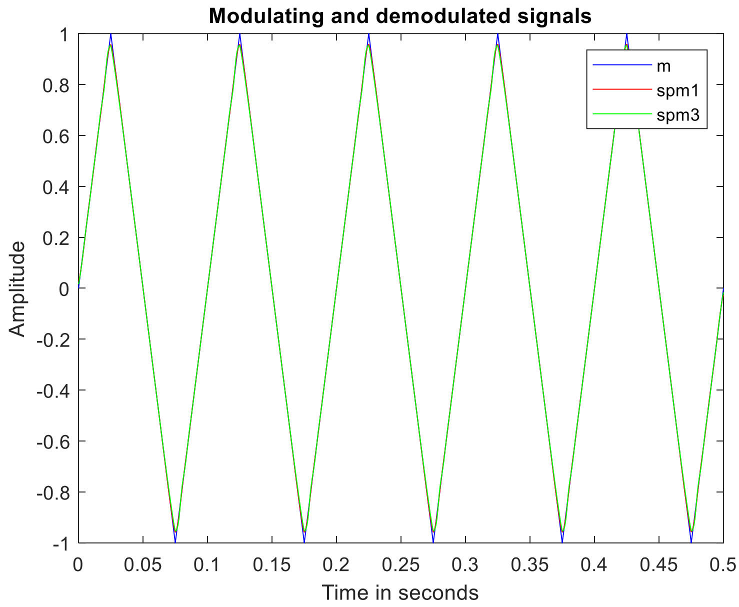

Figure 4: 2.2.f

Since we have extracted the phase(instantaneous) from Hilbert transformed modulated signal, we can easily extract carrier's component which is 2*pi*fc*t (inside of the cosine of the carrier wave) from the instantaneous phase and get message signal but with modified amplitude with respect to K_p when this coefficient is 2*pi we get sawtooth wave which has peaks at roughly -6 and 6 and when coefficient is 4* pi we get again sawtooth wave but it has peaks at -12 and 12 . Since these numbers are nearly equal to 2*pi and 4*pi we need to divide to these numbers to get signals which are nearly same with our original message signal and when we did it we got peaks at -0.95 and 0.95 which is very close to -1 and 1. Because we get kp*m(t) from the output of the demodulation, so we need to divide it to K_p to get m(t) which is our message signal.

I have also realized something when we increase Kp more like 5*pi or 6*pi. For 5*pi the demodulated signal becomes distorted and for 6*pi our output gets really off the grid it gets to upside like stairs. It behaves like we give more offset to it as we increase the time.

Note: Some of the used functions and meaning:

-unwrap(.): Smoothing the signal (adds -+2*pi if necessary)

-angle(.): Extract the phase from the signal (compute the angle between the positive x-axis and ray in xy axis)

-phase(.): same as using angle than unwrap consequently

-cumsum(.): sums up the values