CT Report-3

Question-a

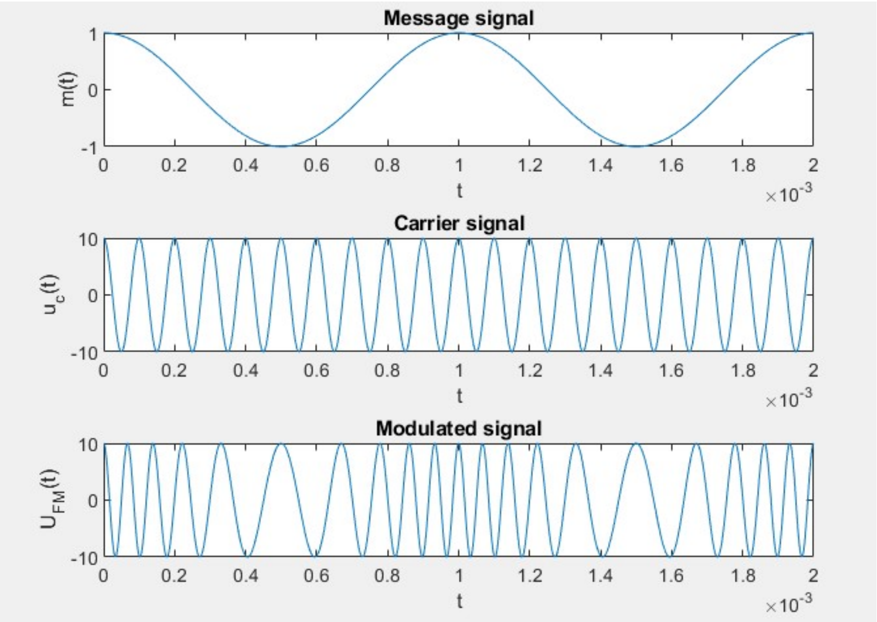
We need to generate a message signal with **A_m=1 and f_m=1kHz.**

We need to generate a carrier signal with **A_c=10 and f_c=10kHz.**

Then we need to generate a frequency modulated signal with Kf=1. However, we choose **Kf=5000** for better distinction between carrier signal and modulated signal

Note that these values are carried on for a), b), c) questions and will not be mentioned again.

Plots



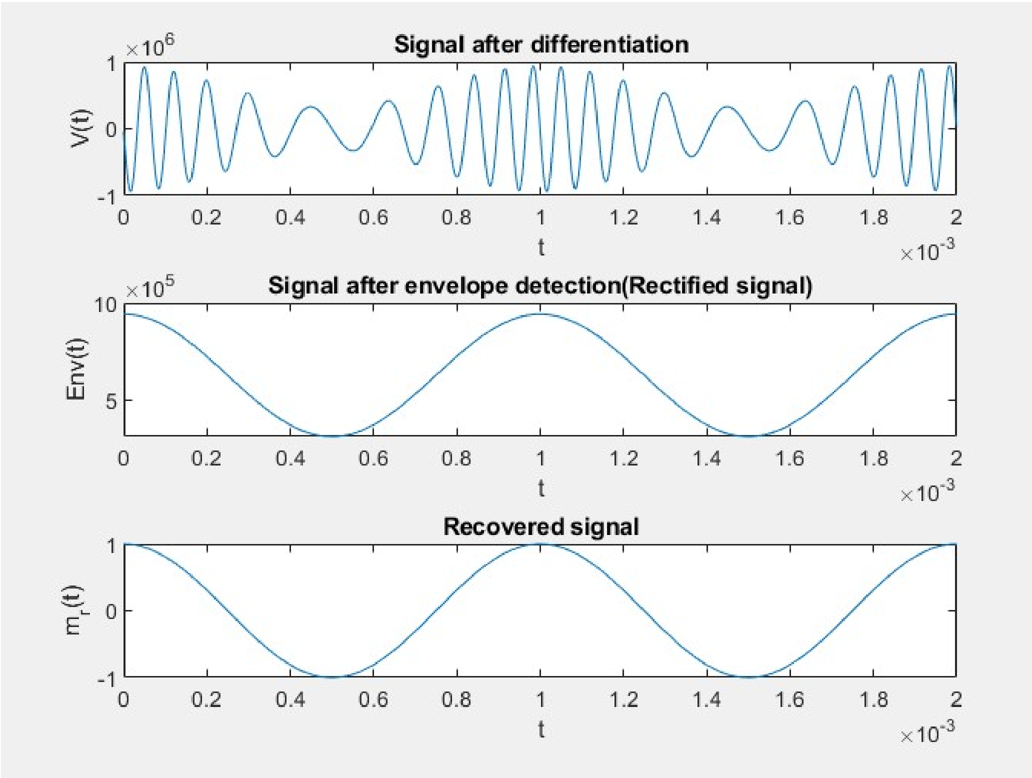
Explanation

- The message signal=**cos(2000 π t).** The carrier signal = **10cos(20000πt).** These two plots are self explanatory.
- The third plot is **U_{FM}(t)=10 cos(20000πt+theta(t)).**
  Where theta(t)=2πK_f*integral(from 0 to t) m(T)dT. Since K_f =5000, the value of theta(t) is very large and hence causes the U_{FM}(t) to be out of phase with the carrier signal.

Question-b

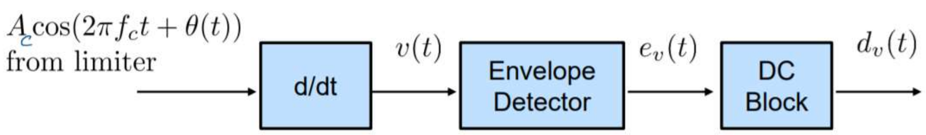
In this part, we need to demodulate the $U_{FM}(t)$ to recover the message signal m(t) using crude discriminator method.

Plots



Explanation:

The crude discriminator block is as follows:



- We have neglected the limiter which clips and filters the output because we do not have any noise in our simulation.

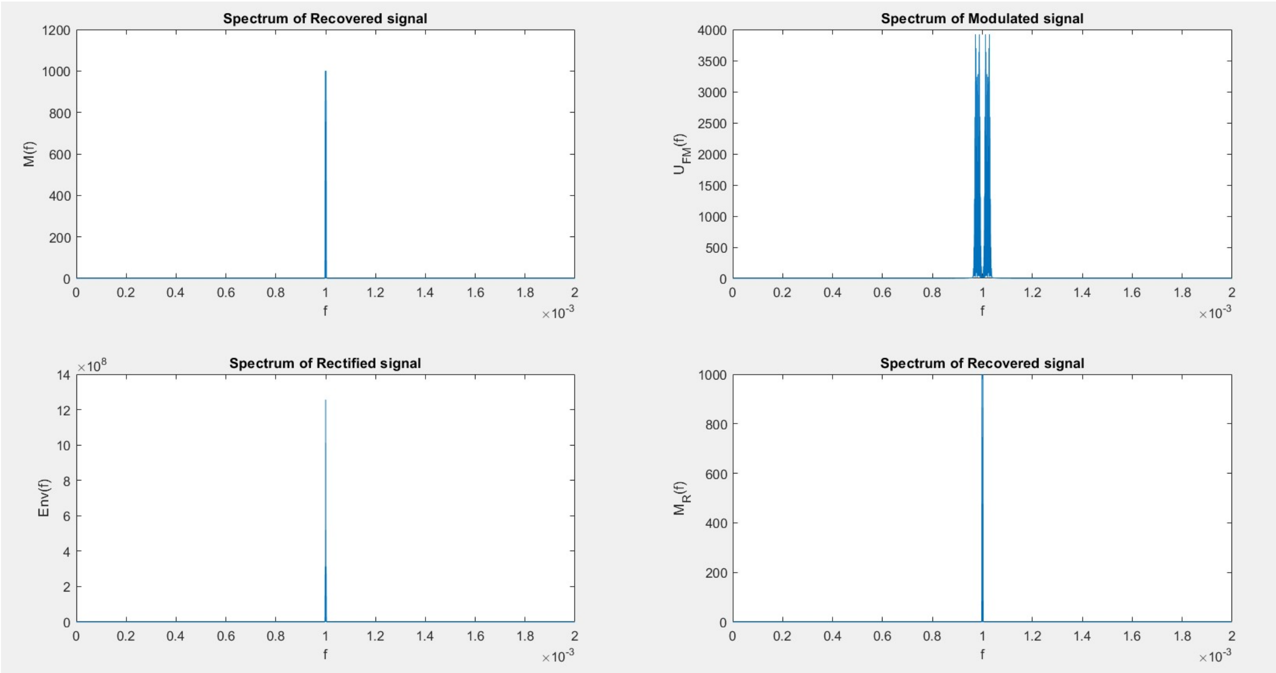
- So we directly pass the value of $U_{FM}(t)$ into the differentiator. We use diff() function in the code which mimics differention in matlab. We take the difference and divide with out time interval(multiply with sampling frequency).
- The output of the differentiator will be **$V(t)=-Ac*(2\pi fc+2\pi K_f m(t))*\sin(2\pi fct+theta\_t)$.** Clearly the graph is in accordance with the equation.
- Now, we pass V(t) into an envelope detector which is realised by the envelope() function in matlab to give **$Env(t)= Ac*(2\pi fc+2\pi K_f m(t))$.** This is the rectified output.
- Clearly, the second figure plots the envelope of the first figure and is in accordance with the equation.
- Now, we use pass this signal into the DC block which is accomplished by using the mean() function in matlab. There we subtract the DC component using mean function and then we divide with $Ac2\pi K_f$ to obtain $m_r(t)$.
- This recovered signal is the **exact message signal** sent and hence we have successfully demodulated the message signal.
- An important point to note is that if we implement the differentiator using diff() properly and divide with the correct value we get the exact message signal. **We do not get any scaling**. In case there is a scaling in the output, then the blocks are not implemented properly.

Question-c

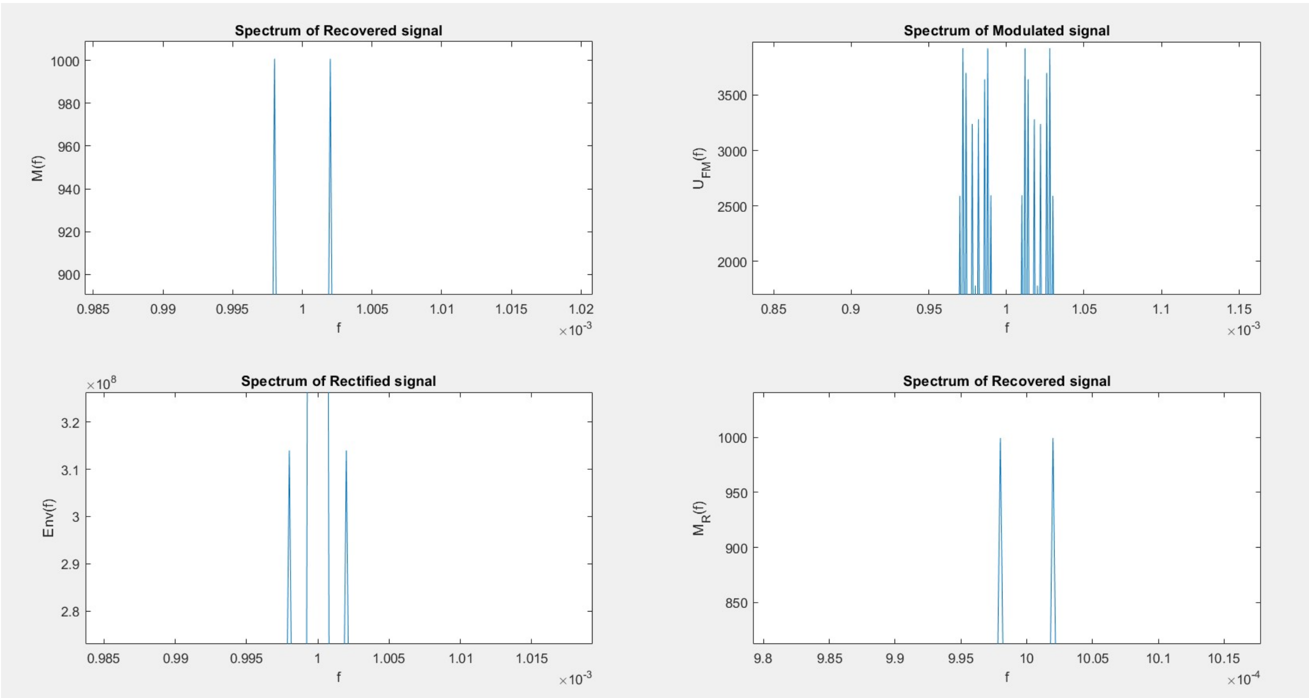
In this part, we are asked to plot the spectrums of message signal, modulated signal, rectified signal and recovered signal.

Plots

i) Actual figures



ii) Zoomed figures



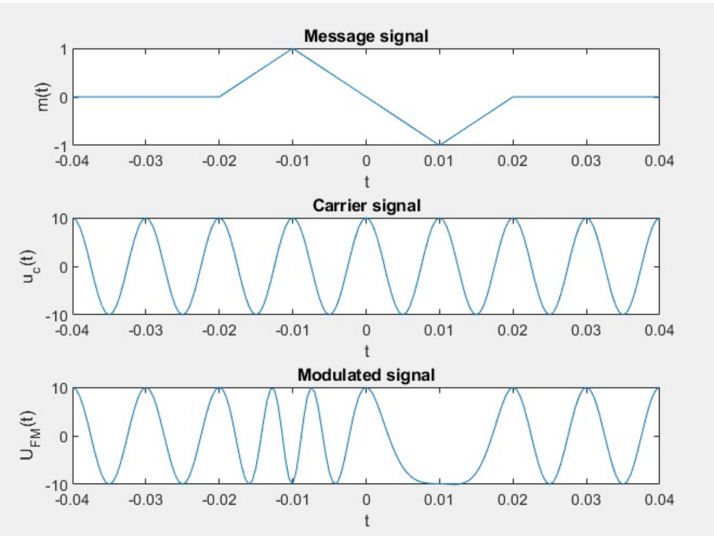
Explanation:

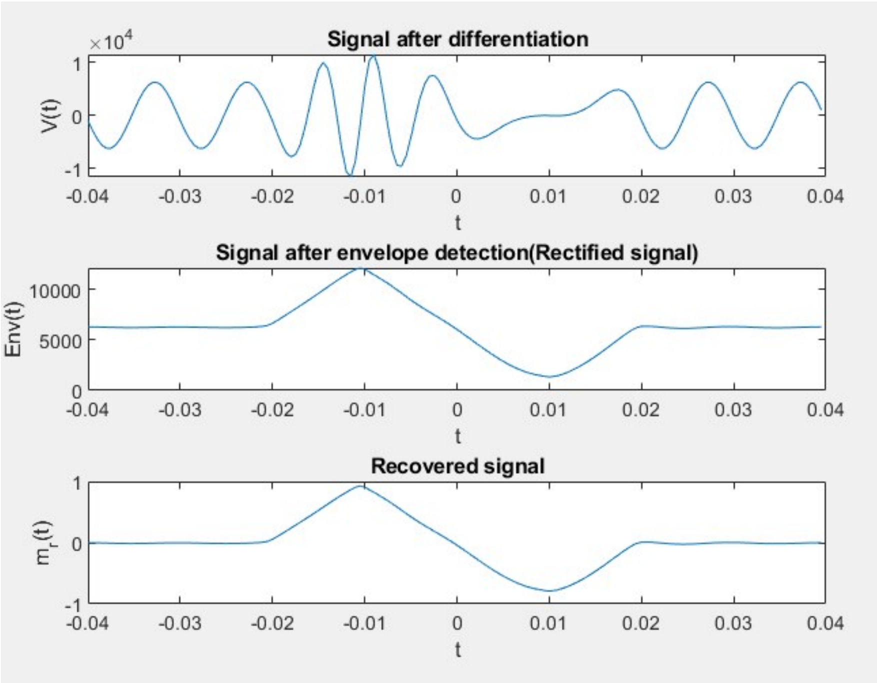
- We have shown two figures as both of them are necessary to gain proper understanding of the graphs. We have used fft() to obtain the fourier transform and fftshift() to see that the values are situated around our middle value 1.
- The message signal is a cosine and hence, we have its fourier transform to be two delta functions. Clearly, we can find the **two delta functions**.
- The modulated signal is the carrier signal with a phase change. Therefore, we see that the signal tries to be a two delta functions but due to the phase change, the non-zero values spread to a few more points and not just 2 points. In short, we get the fourier transform of the uneven signal.
- The filtered signal is of the form Ac*(2πfc+$2\pi K_f$m(t)). So clearly, we have a Huge DC value with cos in the time domain. So we have **3 delta functions**. The **DC value is huge** and dominates due to fc and not visible normally. When we zoom we find 3 deltas. One at 1 which is the fourier transform of constant and 2 deltas on either side representing the fourier transform of cos.
- The recovered signal is a cosine and hence, we have its fourier transform to be two delta functions. Clearly, we can find the **two delta functions**.

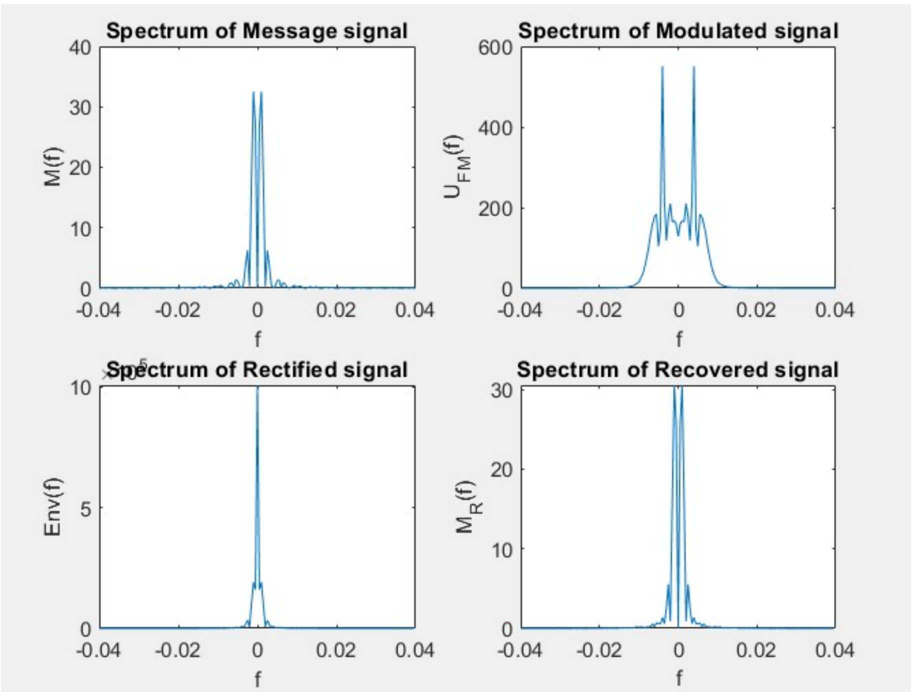
Question-d

Here, we have a different signal and not cosine as message signal. We have to perform all the three steps done for the new signal.

Plots







Explanation:

We have taken the following values

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fc=100;
Am=1;
Ac=10;
Kf=100;
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It might appear strange that we have taken fc=100 which is very less. But this is taken to show the values clearly between the given intervals -0.04 to 0.04. In reality it is in the order of a few hundred KHz. If we take higher values we might not be able to observe the carrier signal and modulated signal nor the difference between them.

- Now for a) part, we can repeat the same code with the message signal changed. The process is same but one change is that we have used the cumsum() function to find the integral. The same precautions taken with diff() need to be taken. We can clearly observe the differences between the phase in carrier signal and modulated signal.
- For b) we perform the demodulation by differentiating, passing through envelope detector and then blocking DC and scaling. We can clearly observe that we have got the recovered signal which is the same as the message signal. The sharp peaks are not preserved due to the fact that we have taken the value of fc to be less. Incase we take high fc, we get extremely precise value.
- For c) we use the fft() and fftshift() to perform the fourier transforms. We observe that the message signal has spectrum as some kind of sinc. This is due to the fact that we have two triangles in the time domain (which can be expressed as convolution of rectangles) and therefore the spectrum is like the sum of two sinc^2 functions. The spectrum of modulated signal and rectified signal are in accordance with our intuition. However they would have been even better and sharp shapes for higher value of fc. Finally, the recovered spectrum is nearly same as the original message signal.