CT Report-2

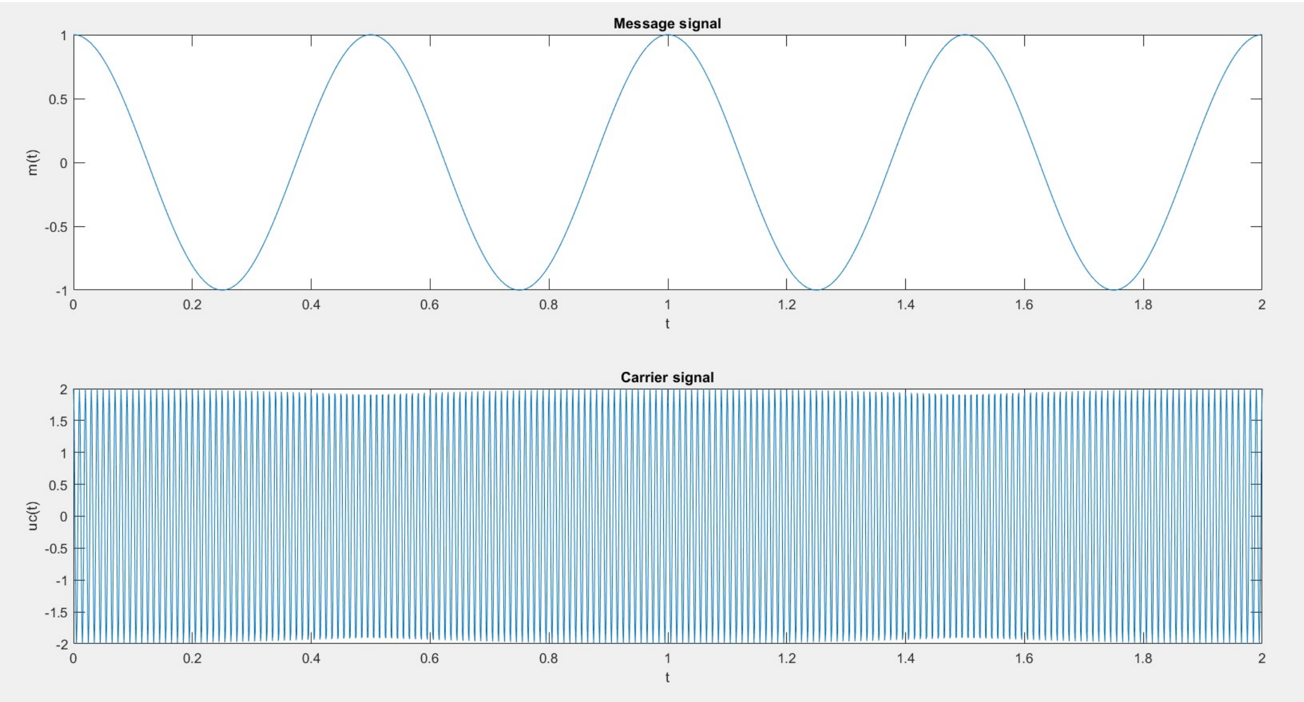
Question-a

We need to generate a message signal with A_m=1 and f_m=2kHz.

We need to generate a carrier signal with A_m=2 and f_c=100kHz.

Note that these values are carried on for the rest of the questions and will not be mentioned again.

Plots



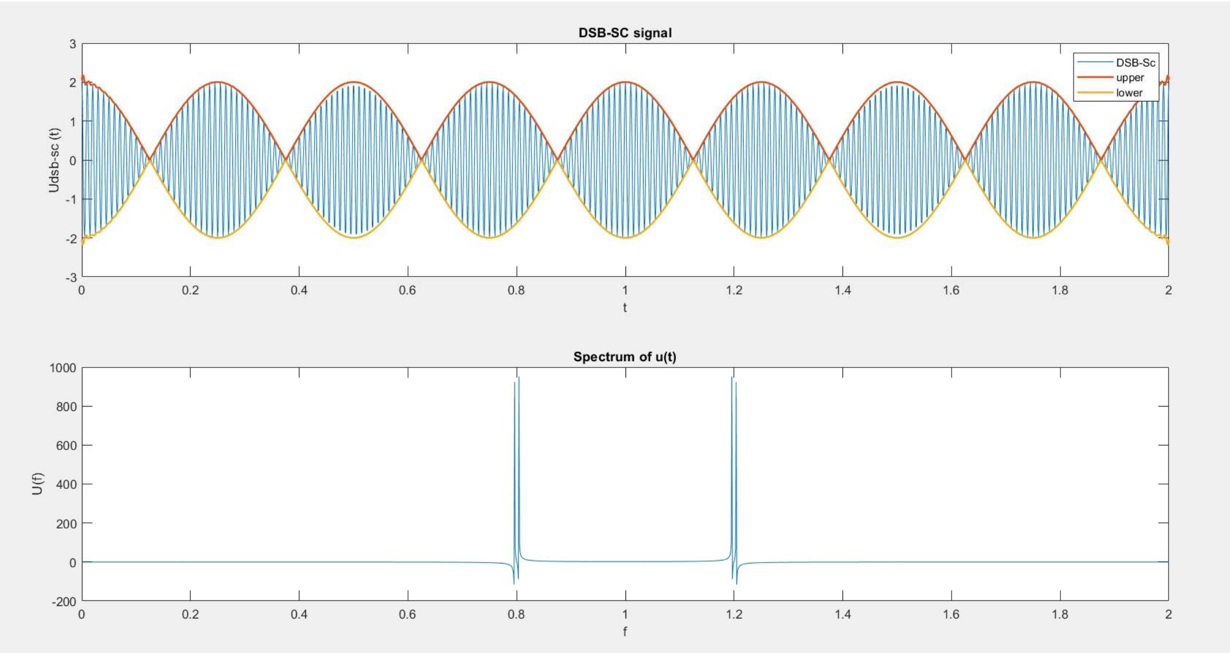
Explanation

This part is self explanatory. We just had the message signal=cos($2\pi f_m t$) and carrier signal =2 cos($2\pi f_c t$). Clearly, both the graphs obtained above are cosines.

Question-b

In this part, we need to plot the U_{DSB-SC} waveform using the results in the above question. We also need to highlight the values of envelopes.

Plots



Explanation:

- We know that the DSB-SC signal $U_{DSB\text{-}SC}(t)=m(t)*u_c(t)$. Clearly the first plot indicates the u(t). It is just a waveform and there is nothing much to explain about the shape as it is just the multiplication of a lower frequency sinusoid with a higher frequency sinusoid.
- The envelope is formed by the message signal (The shape of the envelope). The oscillations in between the envelopes correspond to the carrier signal. An important point to note is that the envelope constitutes the entire information and the carriers job as the name suggests is just carrying the message.
- The upper envelope and lower envelope are clearly plotted in the top figure. |m(t)| gives the upper envelope whereas -|m(t)| gives the lower envelope.

- The second plot corresponds to the spectrum of u(t). U(f) can very easily be obtained as the Fourier transform of cosine is two delta functions. So totally, we have two delta functions convolved with two delta functions giving rise to four delta functions.

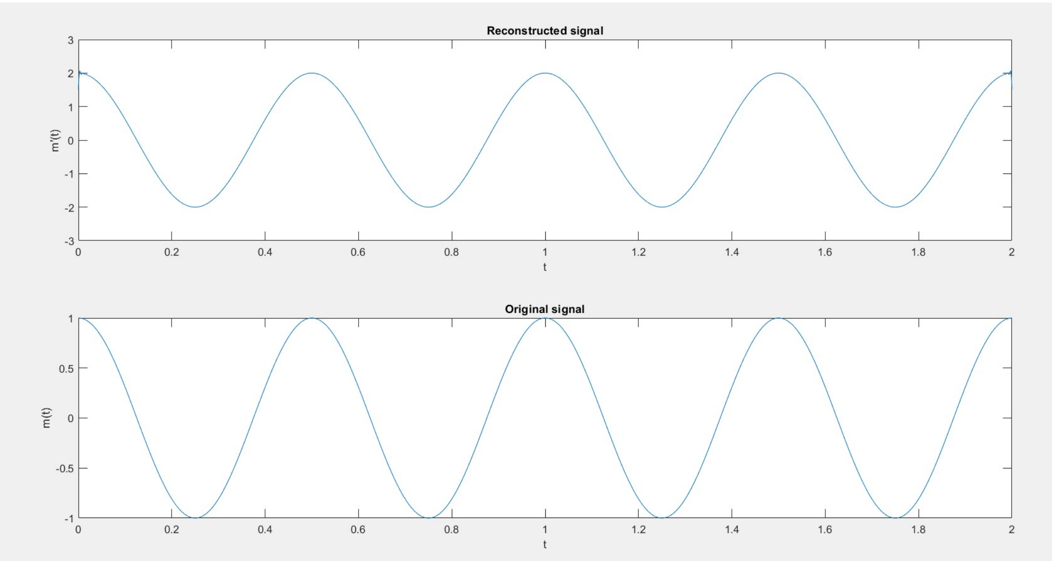
$$U_{DSB}(f) = \frac{AA_m}{4}\{\delta(f - f_c - f_m) + \delta(f - f_c + f_m) + \delta(f + f_c + f_m) + \delta(f + f_c - f_m)\}$$

So the spectrum has 4 points where the value is non-zero which can be easily seen from the figure. Also another point to note is that fc-fm and fc+fm on both side are very close to each other because fc>>fm.

Question-c

We are expected to demodulate the u(t). This should be done by coherent demodulation i.e. multiplying with the frequency same as carrier. Later we need to pass it through low pass filter.

Plots



Explanation

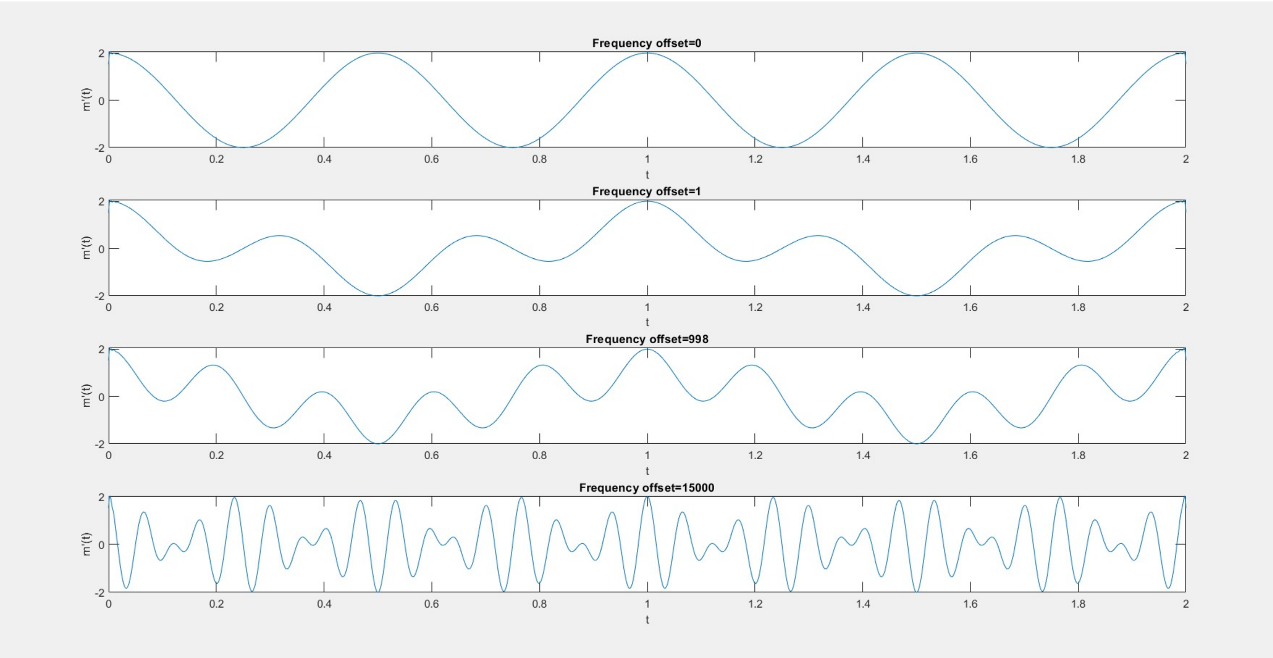
- We have taken the signal u(t) and multiplied with $2\cos(2\pi f_c t)$. Then we passed the signal through the low pass filter. This means that the higher frequencies get eliminated. Also, a point to note is that we have used lowpass function directly instead of butter and filter.
- We observe that the reconstructed signal is exactly the same as the original message signal except for a scaling factor of 2. This scaling factor arises due to the fact that we have carrier amplitude Ac=2. So we can say that the coherent demodulation method is an extremely effective method to get back the message signal without any loss of information.

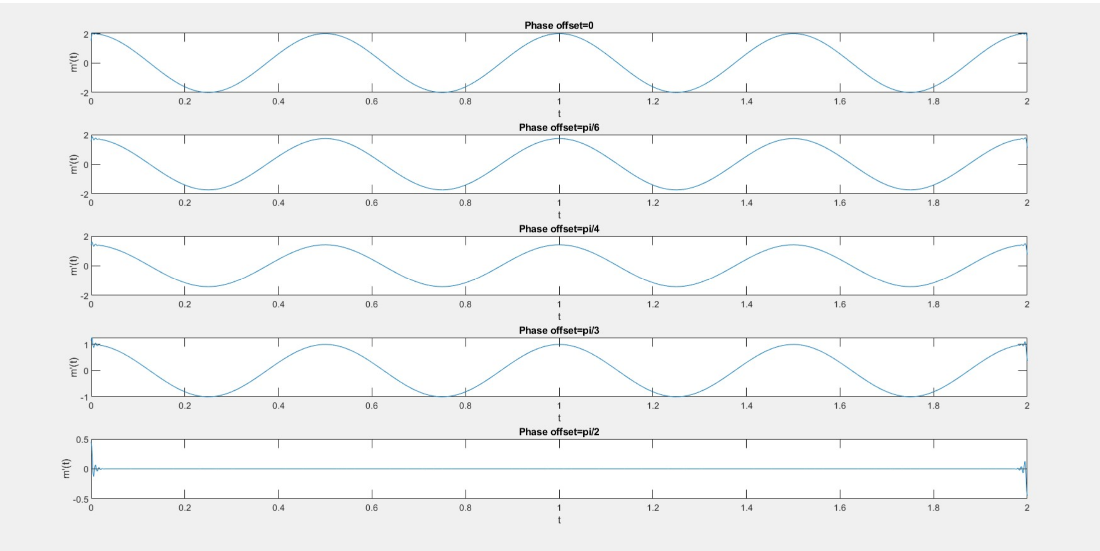
However, certain problems arise whose solutions we address in the next solution.

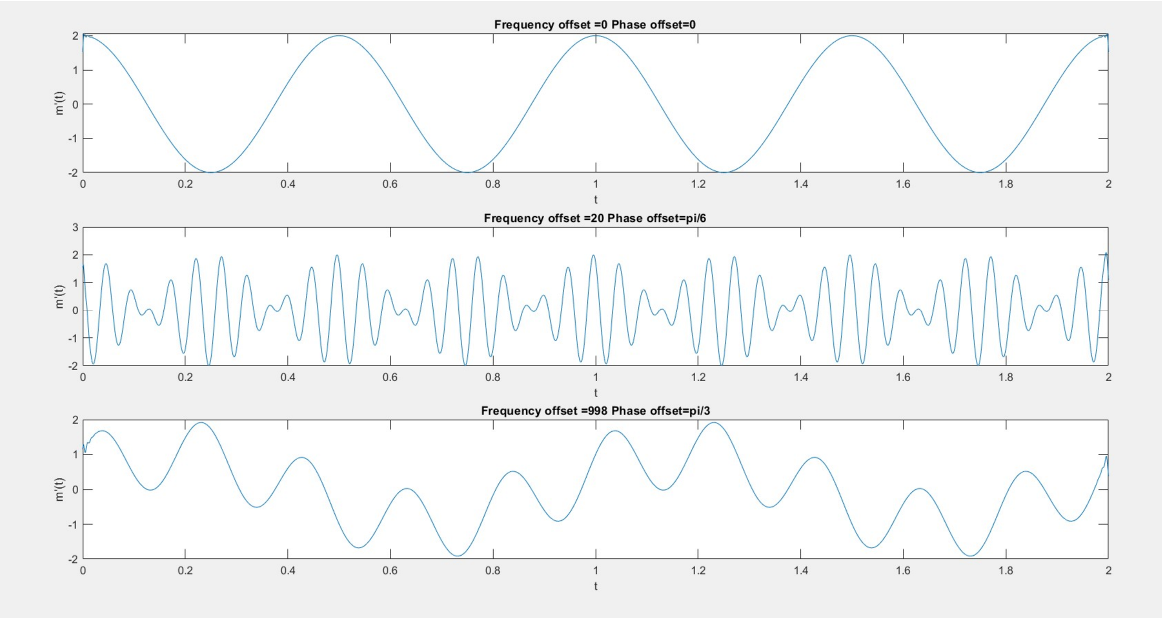
Question-d

We need to do coherent modulation here as well but there is an offset for frequency and phase.

Plots







Explanations:

- We tried to initially keep the phase offset to be 0 and change the frequency offset.
- We have clearly observed that as the value of frequency increases and we use coherent demodulation, the frequency of the obtained signal also increases slightly meaning that the information in the message signal is lost

- For the second figure we kept frequency offset as 0 and changed the phase offset from 0 to pi/2. We noticed that the amplitude of the obtained signal decreases. This is due to the fact that the obtained message signal will be of the form Am(t)cos(phi(t)) where phi(t) is the phase offset.

- For the third figure, we changed both the parameters and found the results of first and second process when combined gives the third figure.

- The final signal obtained will be of the form Am(t)cos(Theta_(t)). The additional Theta_(t) here is the combination of both frequency offset and phase offset
- Theta_(t)=2*pi*df *t+ phi(t).

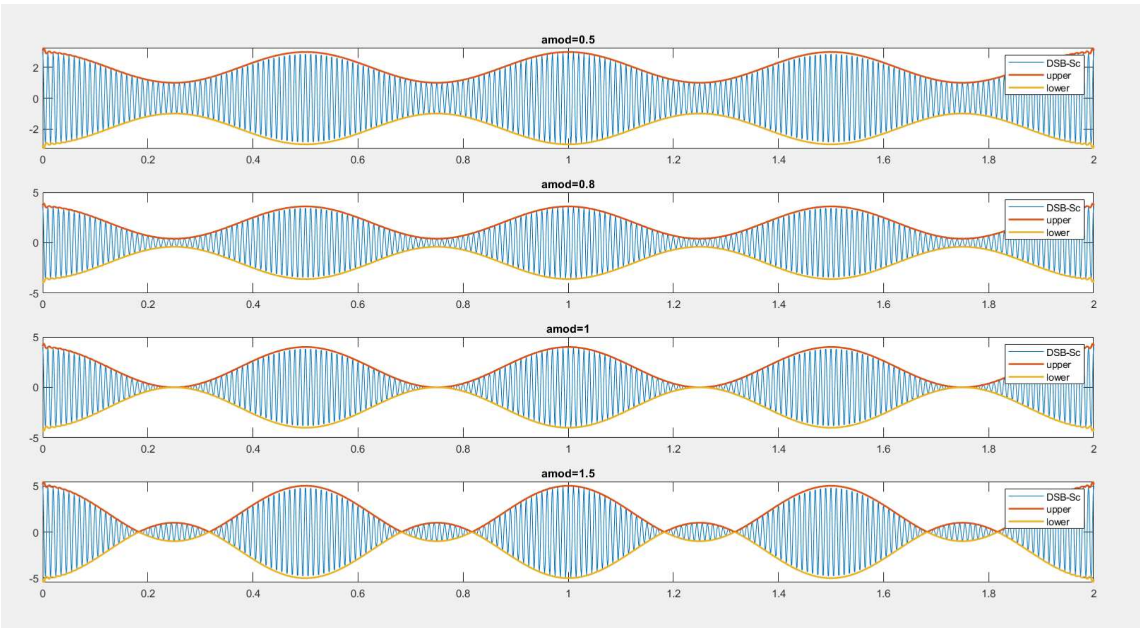
If Theta_(t)=pi/2, then the final obtained signal is 0. A specific case of this is when the frequency offset is 0 and phase offset is pi/2, then we get the final signal to be 0.

The whole process mentioned above is what is called the Quadrature phase offset.

Question-e

We are asked to find the graphs of UDSB-FC also called as the conventional amplitude modulation for different values of modulation index.

Plots



Explanation:

- We know that for conventional amplitude modulation, what we do is we take the signal uam(t)=(Ac+m(t))cos(2 πf_ct).
- The definition of Modulation index is amod=(A/Ac)*|min m(t)| where Ac is the amplitude of carrier signal and A is the amplitude of the message signal.

- This amod is an extremely crucial value. We can obtain the message signal if and only if amod<1. The reasoning can also be obtained from the figures. When amod<1, the values of the upper and lower envelopes do not intersect. If they intersect, which is for the other case, due to the intersection, the signal gets corrupted and no matter what we do we cannot obtain it back.

Question-f, g

We are asked to generate a sawtooth message signal instead of the sinusoid and observe.

```
fs=1001;
fc=100000;
t=0:1/fs:2;
Am=1;
Ac=2;
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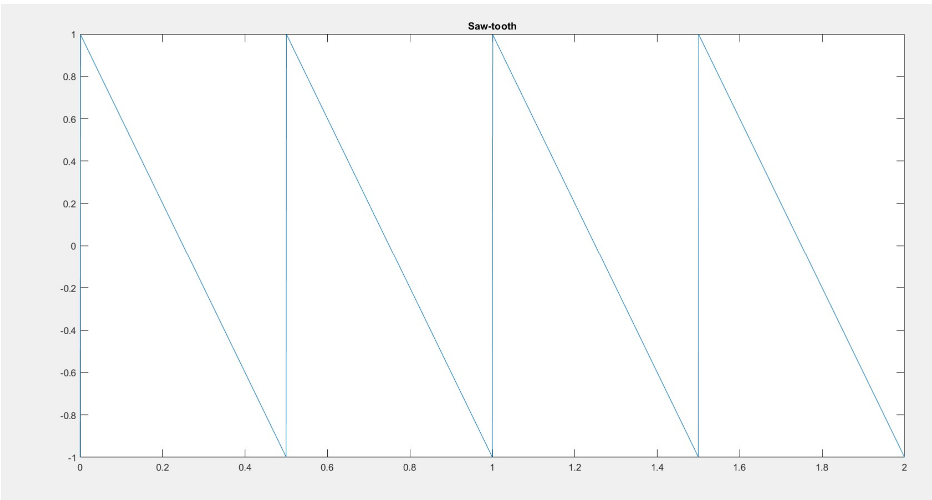
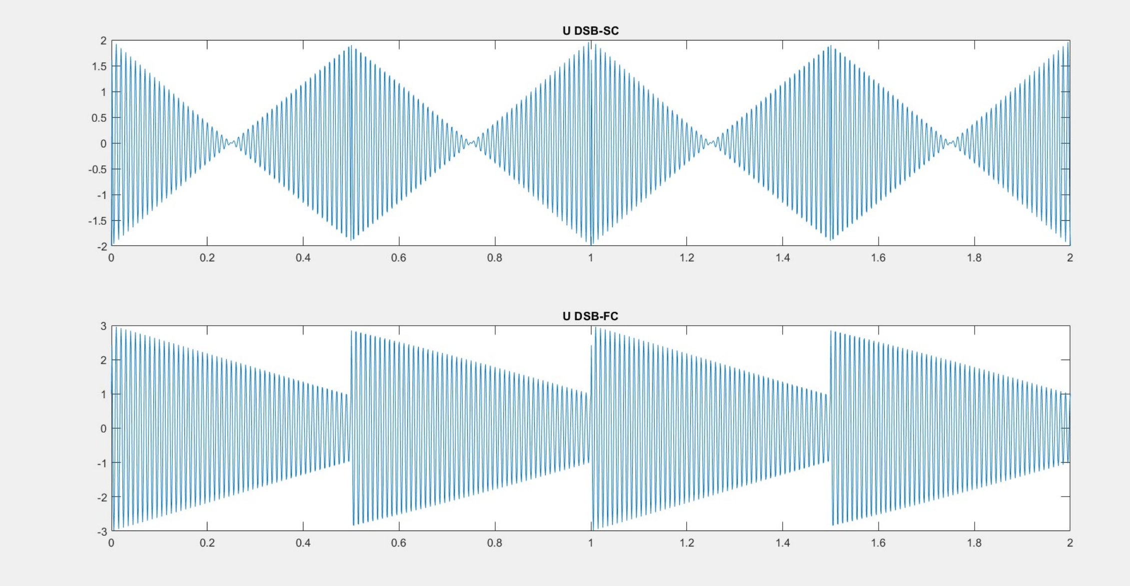
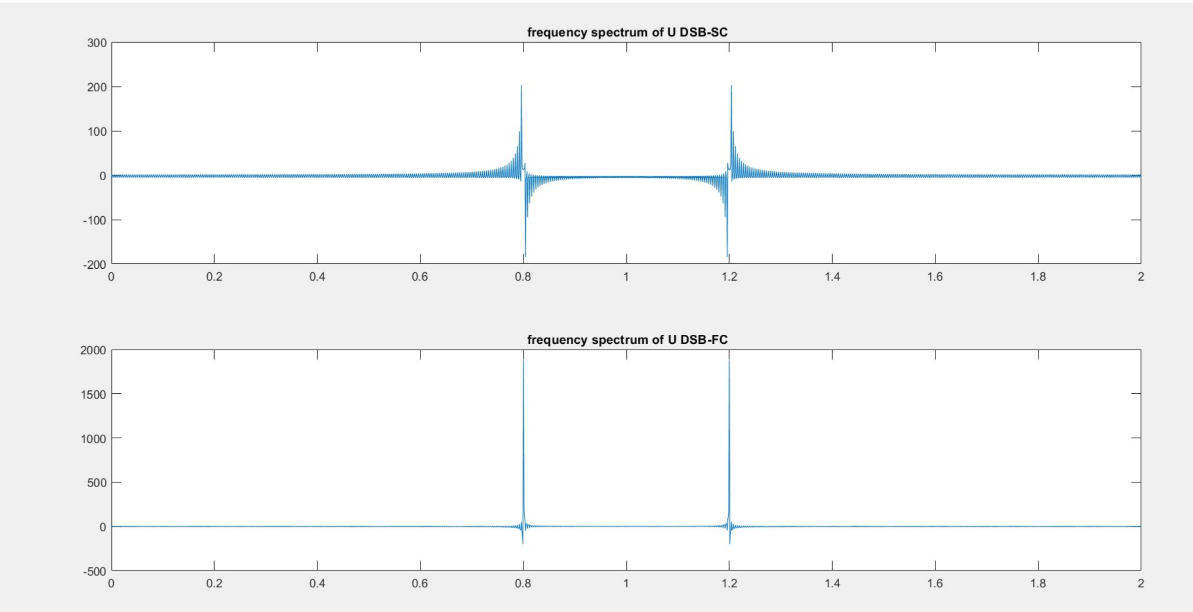
Plots







Explanation:

- The first figure is the saw tooth message signal that we have generated.
- We notice that the plots for DSB-SC and DSB-FC can be compared with that of the sinusoid as we have a slight change in the signal.
- Finally, we have generated the plots in the frequency spectrum. Due to the close relation with a sinusoid on one side, we see that the plots are similar to that and we find impulses in the spectrum.