EE 352 Communication Systems I

LAB 4 REPORT

Name: Harun Durmuş **Number: 270206025**

Date: 27.04.2023

Results

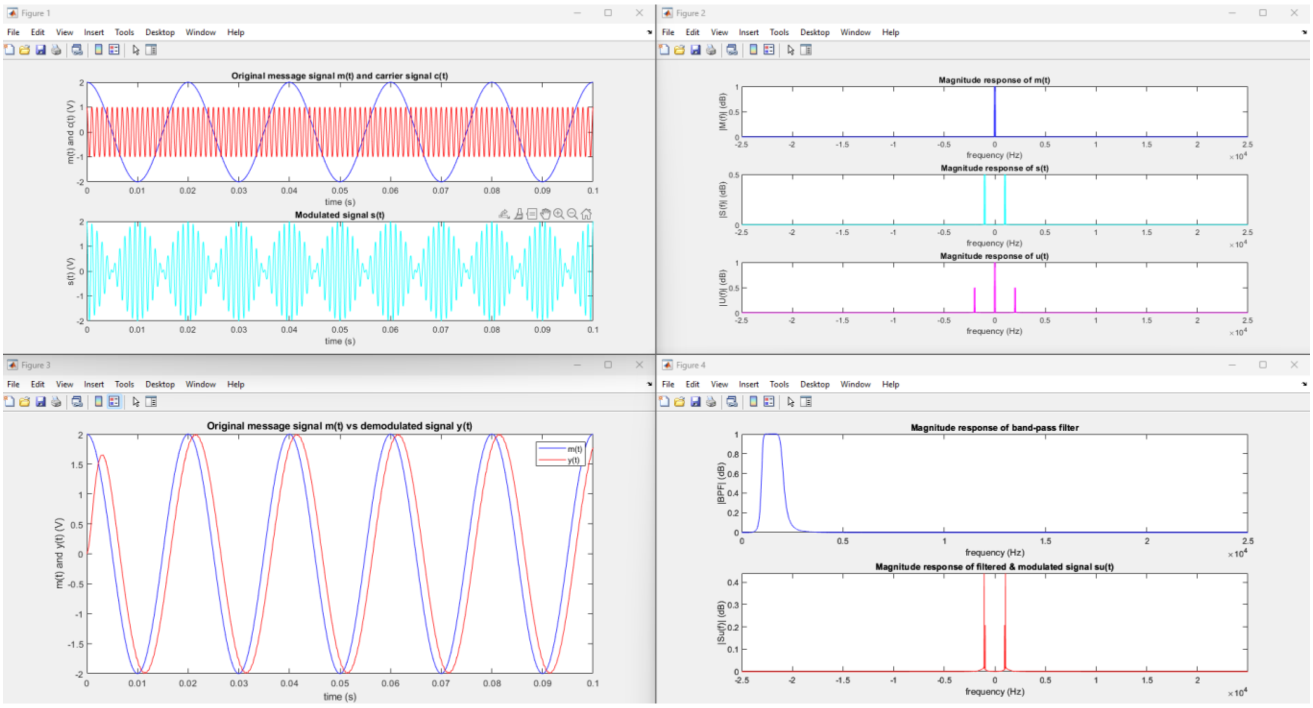

Figure 1,2,3 and 4: Output results of MATLAB code

In figure 1, modulated signal is constructed by modulation of message signal m(t) with carrier signal c(t).

In figure 2, magnitude responses of m(t), s(t) and u(t) are compared. It is observed that original message signal with a noise at 2000 Hz is obtained. Therefore, there is only one step to complete demodulation which is applying a low-pass filter to signal u(t).

In figure 3, after a low-pass filter it is obtained that message signal is obtained back with a small value of phase delay. In order to decrease phase delay, parameters of buttord() function is adjusted.

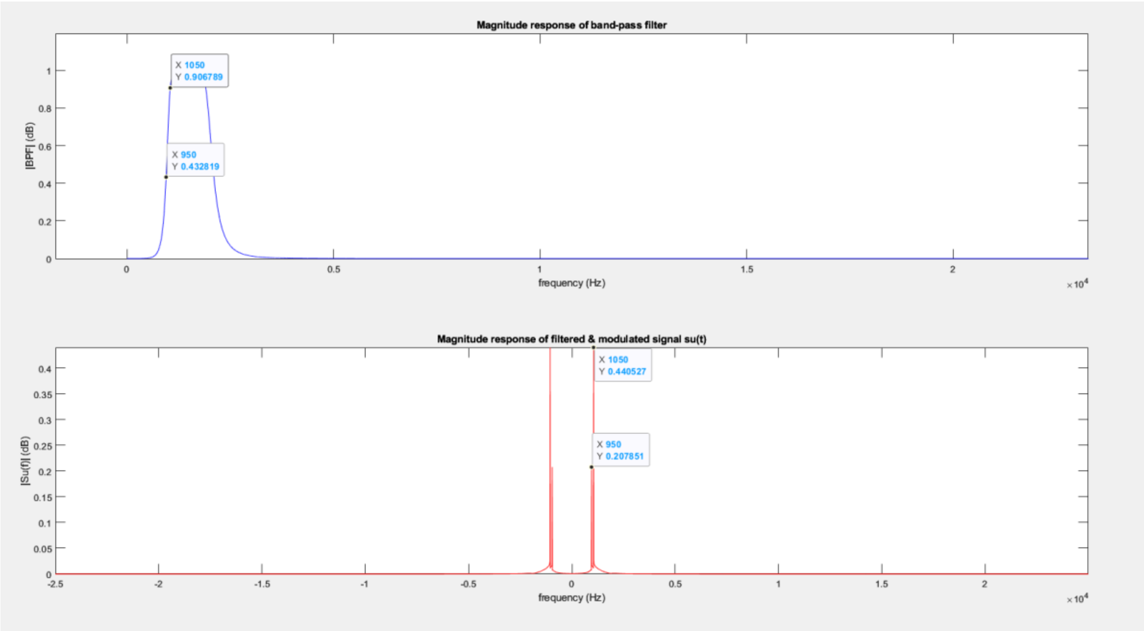

Figure 4: USSB Modulation

In figure 4, magnitude response of band-pass filter and $s_u(t)$ is shown. There was an error in MATLAB code that I created during the lab session. Parameters b1 and a1 that is obtained with butter() function is not used with the correct syntax. That's why there was a wrong response at magnitude response of $s_u(t)$. In figure 4, it is observed that USSB modulation decreases the magnitude of the lower side band. That's why magnitude at 950 Hz is lower than 1050 Hz with USSB modulation.

Answers

Q1. **a)**

$m(t)=A_m*\cos(2\pi f_m t)$ *$\cos(a)\cos(b)=(\cos(a+b)+\cos(a-b))/2$*

$c(t)=A_c*\cos(2\pi f_c t+\Theta_c)$, $\Theta c=0$

$s(t)=(A_mA_c/2)[\cos(2\pi(f_m+f_c)t)+\cos(2\pi(f_m f_c)t)]$

$u(t)=s(t)*x_L(t)$, where $x_L(t)=A_c'*\cos(2\pi f_c t+\Theta)$, $\Theta=0$

$u(t)=(A_mA_cA_c'/4)[\cos(2\pi(f_m+2f_c)t)+2\cos(2\pi f_m t)+\cos(2\pi(f_m-2f_c)t)]$

$y(t)=(A_mA_cA_c'/4)[2\cos(2\pi f_m t)+\mathbf{LPF[\cos(2\pi(f_m+2f_c)t)+\cos(2\pi(f_m-2f_c)t)]}]$

$y(t)=(A_mA_cA_c'/2)\cos(2\pi f_m t)$, to obtain $y(t)\equiv m(t)$

$(A_cA_c')/2=1$, $A_c=1$ so, $A_c'=2$

b)

For DSB-SC modulation and demodulation with a message signal m(t) and carrier signal $c(t) = \cos(2\pi f_c t+\theta_c)$, the modulated signal s(t) can be written as:

$s(t) = m(t) * \cos(2\pi fct+\theta_c)$

The demodulated signal u(t) can be obtained by multiplying the modulated signal s(t) with the carrier signal c(t) and passing it through a low-pass filter:

$u(t) = s(t) * c(t) = m(t) * \cos(2\pi f_c t+\theta_c) * \cos(2\pi f_c t+\theta)$

Assuming $\theta_c= 0$ and $\theta=\pi/6$, we can simplify the equation for u(t) using the trigonometric identity cos(A+B) = cos(A)cos(B) - sin(A)sin(B):

$u(t) = m(t) * \cos(2\pi f_c t) * \cos(\pi/6) - m(t) * \sin(2\pi f_c t) * \sin(\pi/6)$
$u(t) = 1/2 * m(t) * \cos(2\pi f_c t) - \mathrm{sqrt}(3)/2 * m(t) * \sin(2\pi f_c t)$

The demodulated signal y(t) can be obtained by passing the demodulated signal u(t) through a low-pass filter:

$y(t) = LPF\{u(t)\} = LPF\{1/2 * m(t) * \cos(2\pi f_c t) - \mathrm{sqrt}(3)/2 * m(t) * \sin(2\pi f_c t)\}$
$y(t) = 1/2 * m(t) * LPF\{\cos(2\pi f_c t)\} - \mathrm{sqrt}(3)/2 * m(t) * LPF\{\sin(2\pi f_c t)\}$
$y(t) = 1/2 * m(t) * \cos(\pi/2) - \mathrm{sqrt}(3)/2 * m(t) * \sin(\pi/2)$
$y(t) = \mathrm{sqrt}(3)/2 * m(t)$, which means message signal can not be obtained back with a demodulation.

Q2. **a)** $s_u(t)$ is neither exactly USSB signal nor SSB signal because of the behaviour of BPF filter. Since it is not an ideal filter, it is easily can be observed in figure 4 that both upper and lower single side-bands have magnitude. It can be said that $s_u(t)$ is a USSB signal only when magnitude response of the lower side-band is equal to zero. Band-pass filter has a 0.4 amplitude at 950 Hz which represent lower side-band frequency.

b) $s_u(t)$ would be an USSB signal if band-pass filter were an ideal filter. According to the explanation in step a, ideal band-pass filter would make the magnitude value at 950 Hz equal to zero and there would be only upper single side-band magnitude at 1050 Hz.