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- **Topic 8: Signal Transmission - Demodulation**

8.1 Demodulation

LAB 4 - TASK 3 (1/1 point)

In this task, we will share a communication channel using frequeny division mulitplexing.

```
NMSG = 3; % number of messages

% load the signal x and the sample frequency Fs
for c=1:NMSG,
    fname = ['lab04_speech' num2str(c) '.wav'];
    [x,Fs] = audioread(fname);
    if c == 1,
        signal= zeros(NMSG,length(x)); % signal
    end
    signal(c,:)=x';
end

rx_signal=zeros(NMSG,length(x)); % received signal

% get the sample time and the duration of the signal
Ts = 1/Fs; % sample period
```

Correct

Figure 2

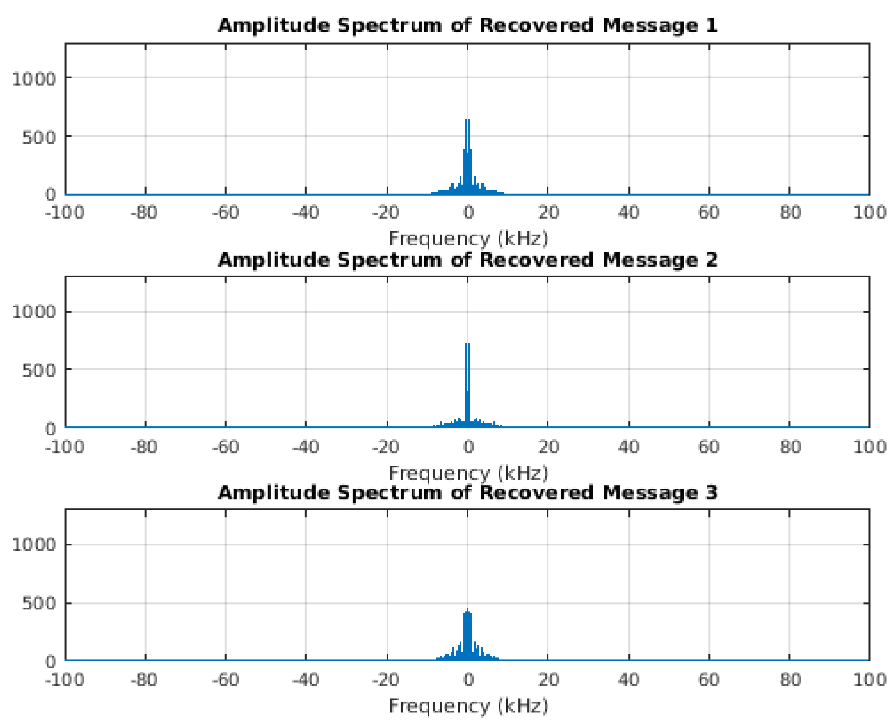


Figure 1

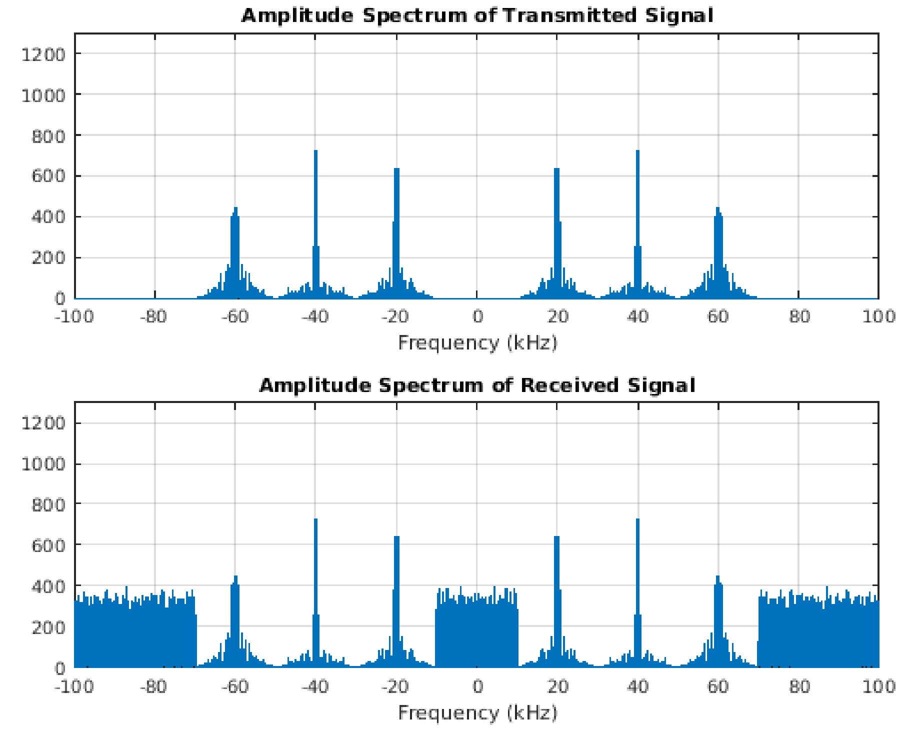
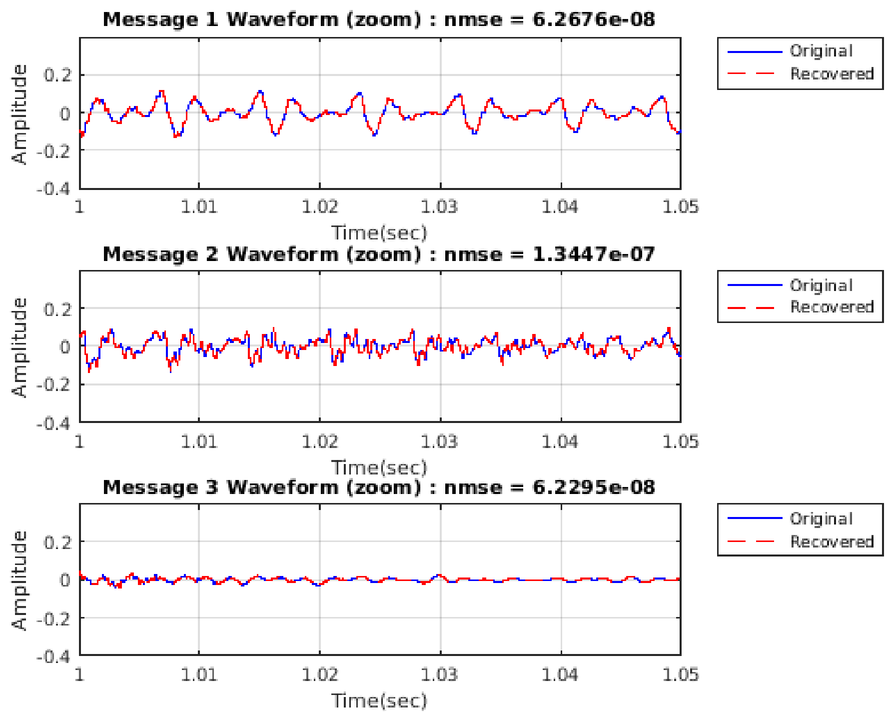


Figure 3



You have used 1 of 10 submissions

INSTRUCTIONS

In this task, you will implement a communication scheme known as frequency division multiplexing (FDM), which is used to share a communication channel between different users. It assigns each user a frequency band, whose width and center are designed so that they do not overlap, hence, avoiding interference. In this example, there are three users that need to share the frequency band between 10 kHz and 70 kHz, because other parts of the frequency spectrum are already occupied. Each user transmits a single message with bandwidth 10kHz. The initial MATLAB code in the above window loads the three signals and stores them inside the variable **signal(i,:)**, where **i** is the index of the message. These messages were acquired with the same sample rate **Fs**, and have the same duration **Tmax**. It should then move the three signals into different frequency bands by modulation, where the carrier frequencies are given by **freq_carrier(i)**, with **i=1..3**, respectively. However, in the initial code, the carrier frequencies are incorrect, so that the spectra are not shifted away from baseband. Then, the modulated signals **xm** are additively combined into the variable **tx_wave** and transmitted simultaneously over the same communication channel. If the carrier frequencies are designed correctly, the messages are sent simultaneously without interference. At the receiver side, the received signal **rx_wave** is processed in order to distinguish the three messages. Each message is recovered by demodulating the received signal with the corresponding carrier frequency and by filtering the result with a low pass filter characterized by the cut-off frequency **freq_cutoff**.

Your task is to choose the carrier frequency of each message (variable **freq_carrier**) and the common cut-off frequency of the low pass filter (variable **freq_cutoff**). If you set these variables properly, the normalized mean squared error (**NMSE**) of the recovered signals should be lower than 10e-5 (see figure 3).

If you run the initial code, you will observe three figures. Figure 1 shows the amplitude spectrum of the transmitted and received signals in subplots 1 and 2, respectively. Due to the incorrect design of the carrier frequencies, the spectra of the three messages overlap and occupy a part of the spectrum already allocated to other users, so that we can not distinguish them in subplot 1. However, once you have fixed the code, you will be able to observe the three message spectra clearly. In subplot 2 we can observe the amplitude spectrum of the received signal. The frequencies below 10kHz and above 70kHz are occupied by other users, while the frequency band between 10 kHz and 70 kHz is free for use by the three users.

Figure 2 shows the amplitude spectrum of the three recovered messages. The three messages are different, so if you correct the code, you should see differences in their amplitude spectra.

Finally, figure 3 compares the original and the recovered messages in the time interval between 1 and 1.05 seconds. Blue lines represent the original messages and red lines the recovered ones. If you design the FDM properly, the plots of the original and the recovered signals should be nearly identical and the NMSE should be less than 10e-5.

Try choosing sub-optimal carrier frequencies, i.e. frequencies that are too close to each other, so that the spectrum used by the three users overlap, or frequencies that are too high or too low, so that the users' spectrum extend into the range below 10kHz and above 70kHz, and observe the effect on the recovered signals.

However, before you check the code, make sure the frequencies are chosen correctly so that there is no overlap.
