Analog communication

Lab. General rules

Submission deadline:

This MATLAB assignment should be submitted by 27/3/2020 at 23:59.

General rules:

(1) Students are to be divided into groups of 4-5 students each.

(2) Any copied codes will be awarded "zero" without notification, however doing your best and trying to follow the shown procedure will usually result in above 50% of total mark.

(3) Overall organization of the report/M-files with logical development as well as following the rules described herein is highly appreciated.

1 EXPERIMENT ONE: DOUBLE SIDEBAND MODULATION

1.1 INTRODUCTION

Double Sideband modulation is the easiest and most direct type of analog modulation. In this scheme, the modulated signal is obtained using a direct multiplication of the modulating signal (i.e. the message) by a cosine carrier. This multiplication results in shifting the entire spectrum of the message to a center frequency defined by the carrier frequency. The modulation is said to be double sideband transmitted carrier (DSB-TC) when the carrier is transmitted along the modulation term. If the carrier term is omitted, the modulation is termed double sideband suppressed carrier (DSB-SC). DSB-TC has a significant advantage in the receiver design (i.e. the envelop detector). Also transmitting the carrier independently enables us to extract useful information such as the carrier frequency which can be helpful for carrier synchronization. However, the DSB-TC loses to the other variant (i.e. the SC) in terms of power efficiency.

1.2 AIM

In this experiment, you're required to achieve the following:

1. Get familiar with the concept of DSB modulation, and its parameters.
2. Study the performance of the DSB modulation.
3. Examine different detectors (coherent detector, envelope detector).
4. Study the performance of coherent detection in the presence of frequency or phase mismatch.

1.3 PROCEDURE

1. Use Matlab to read the attached audio file, which has a sampling frequency Fs= 48 KHz. Find the spectrum of this signal.
2. Using an ideal Filter, remove all frequencies greater than 4 KHz.
3. Obtain the filtered signal in time domain, this is a band limited signal of BW=4 KHz.
4. Find the mean square error (MSE) in the band-limited signal. The MSE is defined as

$$MSE = \sqrt{\hat{x}^2(t) - x^2(t)}$$

   Where, $\hat{x}(t)$ is the filtered voice signal, and x(t) is the authentic signal.

   Note that this error should be small for voice signals. You could play the sound back, to make sure only small distortion was introduced.

5. Modulate this carrier with the filtered signal you obtained, you are required to generate both types of modulation. Choose a carrier frequency of 100 KHz. For the DSB-TC, take the DC bias to be twice the maximum of the message.

   Note: : You will also need to modify the sampling frequency of the filtered audio signal, the sampling frequency must be at least 2 times the carrier frequency, In this simulation, use Fs $= 5\ F_c$.

6. For both types of modulations, use envelop detector to receive the message (assume no noise). Note: to obtain the envelope you can use the following matlab command.

$$envelope = abs(hilbert(modulated\ signal))$$

7. For both modulation types, find the error between the received message and the transmitted message. Play the received signal back. What observation can you make of this?
8. For DSB-TC only, repeat steps 6-8 with SNR = 0, 10, and 30 dB. Play back the sound file each time after detection. What conclusions do you make of that?
   Note: To model the noise corruption step you can use the following identity

$$noisy\ signal = modulated\ signal + \sqrt{\frac{P_s}{SNR}} * gaussin\ noise\ of\ unit\ variance$$

   You can also use the matlab function awgn.
   For DSB-SC, perform steps 9-11.
9. Use coherent detection to receive the signal and find the error, SNR=0, 10, 30 dB.
10. Repeat the coherent detection with frequency error, F=100.1 KHz instead of 100 KHz and Find the error SNR=30dB. Do you have a name for this phenomenon?
11. Repeat the coherent detection with phase error = 10^0 and find the error, SNR=30db
12. Calculate the power efficiency for both types of modulation. Comment

1.4 USEFUL MATLAB FUNCTIONS

Audioread ,fft, fftshift, ifft, ifftshift , plot, awgn, upsample, downsample, resample, sound. , Hilbert, abs, max.

1.5 HINT

You are not allowed to use built in functions like **ammod, amdemod**

1.6 REQUIREMENTS

Rar File including the following

- Well commented matlab file.
- Your obtained results (spectrum plots, error values, etc..) ,the code and your personal conclusions should be included in a report.