Assignment 2

Communication Theory - 1 (EC5.203 - Spring 2021)

January 28, 2021

Deadline: 04/02/2021 - 11:55 PM

Submission Format:

- For analytical problems, write on A4 sheets and scan them in pdf format. For simulation code (if any) create simulation as folder name and add .m files. Submit .zip file (Rollnumber_Assignment2) containing pdf file and simulation folder.
- For simulation part, along with the codes, submit a report (pdf format) clearly depicting the generated plots (if any) with answers to questions asked as part of simulation exercise. State the parameter values used for simulation in the report clearly. Marks obtained will depend upon clarity in report writing.

Questions

1. An AM signal has the form

$$u(t) = [\ 20 + 2\cos 3000\pi t + 10\cos 6000\pi t\ ]\cos 2\pi f_c t$$

where $f_c = 10^5$ Hz.

   (a) Sketch the (voltage) spectrum of u(t).

   (b) Determine the power in each of the frequency components.

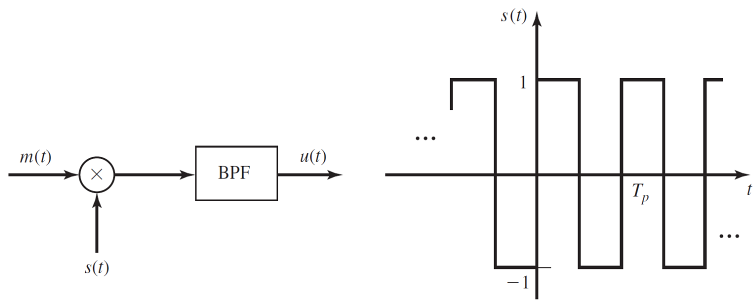
   (c) Determine the modulation index.

   (d) Determine the power in the sidebands, the total power, and the ratio of the sidebands power to the total power.

2. A DSB-SC signal is generated by multiplying the message signal $m(t)$ with the periodic rectangular waveform shown in Figure (a) and filtering the product with a bandpass filter tuned to the reciprocal of the period T_p, with bandwidth 2W, whereW is the bandwidth of the message signal. Demonstrate that the output $u(t)$ of the BPF is the desired DSB-SC AM signal.

$$u(t) = m(t)\sin 2\pi f_c t$$

where $f_c = 1/T_p$



$Figure : (a)$

3. Show that in generating a DSB-SC signal as in Problem 2, it is not necessary that the periodic signal be rectangular. This means that any periodic signal with period T_p can substitute for the rectangular signal in Figure (a).
   Hint: Assume that $s(t)$ is a periodic signal with period T_p, i.e. $\sum_n x(t - nT_p)$. Then $v(t) = m(t)s(t)$

4. Consider a message signal $m(t)$ with spectrum $M(f) = I_{[-2,2]}(f)$.

   (a) Sketch the spectrum of the DSB-SC signal $u_{DSB-SC} = 10m(t)\cos(300\pi t)$. What is the power and bandwidth of u?

   (b) The signal in (a) is passed through an envelope detector. Sketch the output, and comment on how it is related to the message.

   (c) What is the smallest value of A such that the message can be recovered without distortion from the AM signal $u_{AM} = (A + m(t))\cos(300\pi t)$ by envelope detection?

   (d) Give a time domain expression of the form

   $$u_p(t) = u_c(t)\cos(300\pi t) - u_s(t)\sin(300\pi t)$$

   obtained by high pass filtering the DSB signal in (a) so as to let through only frequencies above 150 Hz.

   (e) Consider a VSB signal constructed by passing the signal in (a) through a passband filter with transfer function for positive frequencies specified by:

   $$H_p(f) = \begin{cases} f - 149 & 149 \leq f \leq 151, \\ 2 & f \geq 151 \end{cases}$$

   (you should be able to sketch $H_p(f)$ for both positive and negative frequencies)
   Find a time domain expression for the VSB signal of the form

   $$u_p(t) = u_c(t)\cos(300\pi t) - u_s(t)\sin(300\pi t)$$

5. [MATLAB Simulation - Amplitude Modulation]

   (a) Generate a sinusoidal message signal of 2 KHz having peak amplitude as 1 and a sinusoidal carrier signal of 100 KHz having peak amplitude of 2. Plot both the signals on same figure using subplot (2,1).

   (b) Generate and plot the DSB-SC waveform using the message and carrier signals from part (a). Plot the upper and the lower envelope on the same figure with a different colour. Plot the spectrum of the modulated waveform. Use subplot(2,1) to show the two plots in same figure.
   *Hint: You can use **fftshift** and **fft** inbuilt functions for generating the spectrum.*

   (c) Perform the coherent demodulation of the DSB-SC waveform generated in part (b) using the exact same frequency as that of the carrier. Plot the actual message and the demodulated waveform on same figure using subplot(2,1).
   *Hint: You can use **butter** and **filter** inbuilt functions for performing the low pass filtering.*

   (d) Bring out the effect of frequency and phase offset in coherent demodulation. Plot the demodulated waveforms for various values of frequency and phase offset (minimum 3 different cases). Plot all of them in a single figure using suitable subplot. Study about **Quadrature null effect** and include the scenario when the output becomes zero by setting the appropriate offset values. Record your observations about effect of frequency and phase offset in the report.

   (e) Generate and plot conventional AM (often called as Double Side Band - Full Carrier (DSB-FC)) waveform using the message and carrier signal generated in part (a). Generate these waveforms for modulation index of 0.5, 0.8, 1 and 1.5. Plot all of them using subplot(4,1) in a single figure. Plot the upper and the lower envelope on the same figure with a different colour for all the four plots. Record your observation about the significance of modulation index in the report.

(f) What happens if the message is not sinusoidal ? Generate a sawtooth message signal and modulate it using the same carrier as in part (a) using DSB-FC modulation scheme.

(g) Generate and plot the spectrum of DSB-FC waveform along with the spectrum of DSB-SC in a single figure using subplot(2,1).