Communication Theory

Spring-2023

Assignment 1 Deadline: 27^{th} Feb, 5pm

Instructions:

- All questions are compulsory.
- Clearly state the assumptions (*if any*) made that are not specified in the questions.
- The simulation code and output must be clearly explained.

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1. Determine the Fourier transform of each of the following signals.
   - $sinc^3 t$
   - $t * sinct$
   - $te^{-\alpha t} cos(\beta t)$
2. Consider the following two passband signals:

$$u_p(t) = sinc(2t)cos(100\pi t) \tag{1}$$

$$v_p(t) = sinc(t)sin(101\pi t + \frac{\pi}{4}) \tag{2}$$

   - Find the complex envelopes u(t) and v(t) for u_p and v_p. respectively, with respect to the frequency reference $f_c = 50$ Hz.
   - What is the bandwidth of $u_p(t)$ and $v_p(t)$?
   - Find the inner product $< u_p, v_p >$
   - Find the convolution $y_p(t) = u_p * v_p$
3. An AM signal has the form

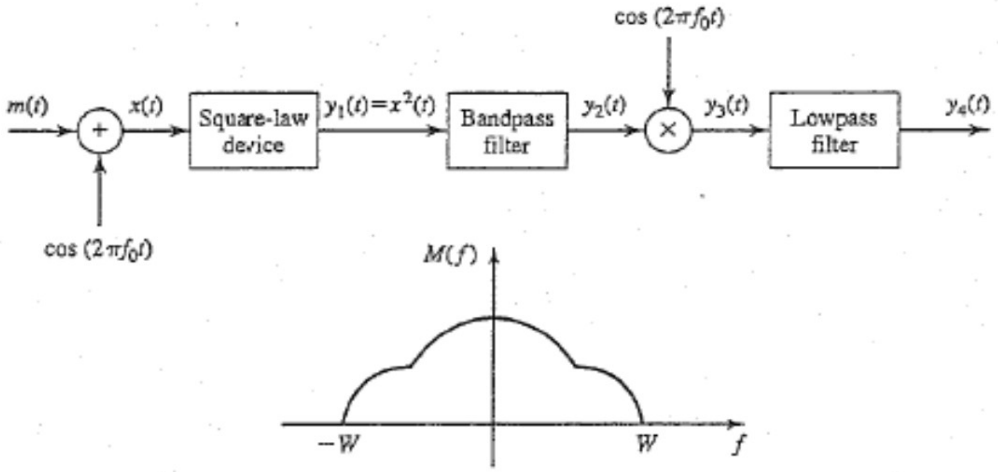
$$u(t) = [20 + 2cos3000\pi t + 10cos6000\pi t]cos2\pi fct \tag{3}$$

   where $f_c = 10^5 Hz$.
   - Sketch the (voltage) spectrum of u(t).
   - Determine the power in each of the frequency components.
   - Determine the modulation index.
   - Determine the power in the side bands and the total power.
4. Explain the SSB modulation technique in detail.

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

   - 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?
   - The above obtained signal is passed through an envelope detector. Sketch the output, and comment on how it is related to the message.
   - What is the smallest value of A such that the message can be recovered without distortion from the AM signal $u_A M(t) = (A + m(t))cos(300\pi t)$ by envelope detection?
   - 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 so as to let through only frequencies above 150 Hz.

6. The message signal m(t)whose spectrum is shown in the Figure is passed through the system shown in the same Figure. The bandpass filter has a bandwidth of 2W centered at f_0 and the lowpass filter



has a bandwidth of W. Plot the spectra of the signals x(t), $y_1(t), y_2(t), y_3(t)$ and $y_4(t)$. What are the bandwidths of these signals?

MATLAB Simulation

7. (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 figure 1.

   (b) Generate and plot the DSB-SC waveform using the message and carrier signals from part (a). Plot the geneterated DSB-SC waveform and its spectrum on Figure 2 using sub-plots. Highlight the upper and lower envelopes of the DSB-SC waveform using different colors.

   (c) Perform the coherent demodulation of the DSB-SC waveform generated in part (b) when the frequency and phase offsets are :
   (i) $\triangle f = \triangle\theta = 0$,

(ii) $\triangle f$=0 and $\triangle\theta = \pi/3$
(iii) $\triangle f$= 5 Hz and $\triangle\theta$ =0.
Plot the actual message and the demodulated waveforms in Figure 3 using subplots.

(d) Generate and plot conventional AM (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 in Figure 4 using subplots. Highlight the upper and lower envelops using different colors in all four subplots. Record your observation about the significance of modulation index in the report.

(e) 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.

(f) Generate and plot the spectrum of DSB-FC waveform along with the spectrum of DSBSC in a single figure using subplot.

All the Best!