Assignment 3

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

February 7, 2021

Deadline: 14/02/2021 - 11:55 PM

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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_Assignment1) 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. Figure 1 shows, as a function of time, the phase deviation of a bandpass FM signal modulated by a sinusoidal message.
   (a) Find the modulation index (assume that it is an integer multiple of π for your estimate).
   (b) Find the message bandwidth.
   (c) Estimate the bandwidth of the FM signal using Carson's formula.
2. The input $m(t)$ to an FM modulator with $k_f = 1$ has Fourier transform

$$M(f) = \begin{cases} j2\pi f & |f| < 1 \\ 0 & \text{else} \end{cases}$$

   The output of the FM modulator is given by

$$u(t) = A\cos\left(2\pi f_c t + \phi(t)\right)$$

   where f_c is the carrier frequency.
   (a) Find an explicit time domain expression for $\phi(t)$ and carefully sketch $\phi(t)$ as a function of time.
   (b) Find the magnitude of the instantaneous frequency deviation from the carrier at time $t = \frac{1}{4}$.
   (c) Using the result from (b) as an approximation for the maximum frequency deviation, estimate the bandwidth of $u(t)$
3. Let $p(t) = I_{\left[-\frac{1}{2},\frac{1}{2}\right]}(t)$ denote a rectangular pulse of unit duration. Construct the signal

$$m(t) = \sum_{n=-\infty}^{\infty} (-1)^n p(t-n)$$

   The signal $m(t)$ is input to an FM modulator, whose output is given by

$$u(t) = 20\cos\left(2\pi f_c t + \phi(t)\right)$$

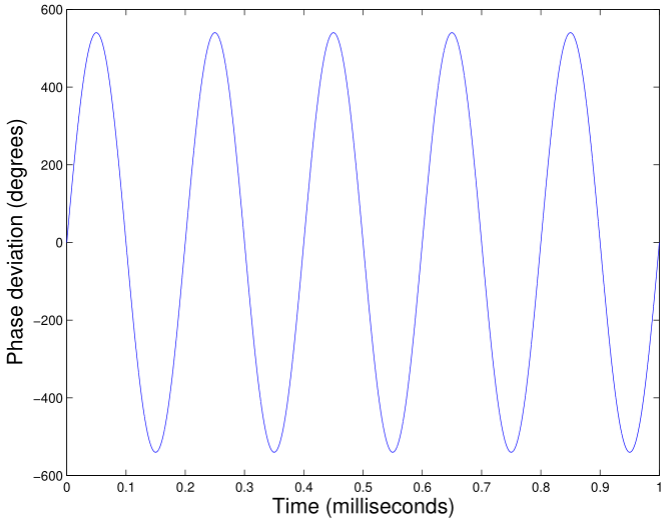

Figure 1: Phase deviation of FM signal for Problem 1

where

$$\phi(t) = 20\pi \int_{-\infty}^{t} m(\tau)d\tau + a$$

and a is chosen such that $\phi(0) = 0$.

(a) Carefully sketch both $m(t)$ and $\phi(t)$ as a function of time.

(b) Approximating the bandwidth of $m(t)$ as $W \approx 2$, estimate the bandwidth of $u(t)$ using Carson's formula.

(c) Suppose that a very narrow ideal BPF (with bandwidth less than 0.1) is placed at $f_c + \alpha$. For which (if any) of the following choices of α will you get nonzero power at the output of the BPF : (i)$\alpha = .5$, (ii)$\alpha = .75$, (iii)$\alpha = 1$

4. [MATLAB Simulation - Angle Modulation]

(a) Generate a sinusoidal message signal of frequency 1 KHz having peak amplitude as 1 and a sinusoidal carrier signal of frequency 10 KHz having peak amplitude of 10. Choose $K_f = 1$.Plot the frequency modulated waveform for the above message signal. Also plot the message and the carrier signal using subplot(3,1).
Note: Do not use the inbuilt function for perform the modulation.

(b) Demodulate the FM wave using the crude discriminator based on differentiation and envelope detection as discussed in class. Plot the rectified FM and the recovered signal in single figure using subplot(2,1).
Note:: You can use inbuilt functions like ***diff*** *for differentiation and* ***fir1, filter*** *filtering.*

(c) Plot the spectrum of the message signal, modulated FM signal, rectified FM signal and the recovered message signal on a single figure using subplot(2,2).
Note: You can use inbuilt functions like ***fftshift and fft*** *for obtaining the spectrum.*

(d) Repeat (a), (b) and (c) if the message signal is as shown below in figure (b).

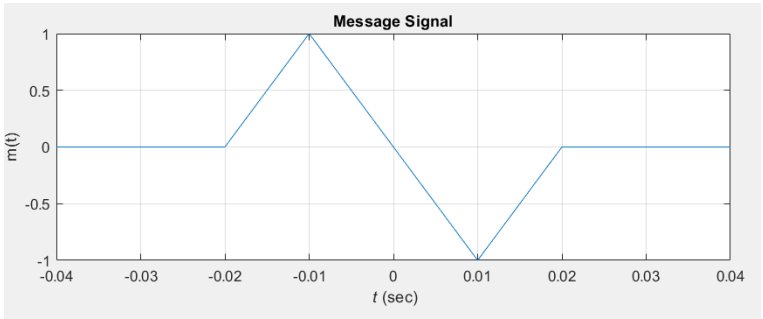

Figure : (*b*)