Assignment 3
Communication Theory

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Question 1 :

Given Matlab code :

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Listing 1: Part 1 - Echo creation

Solution :

Let's break down the MATLAB code and answer each question:

(a) The key FM parameters can be identified as follows:

- Sampling frequency (F_s): The sampling frequency can be inferred from the definition of the time vector t. From $t = 0 : 0.5e^{-6} : 0.005$, we see that the time vector t covers a range from 0 to 0.005 with a step size of 0.5×10^{-6}. So, $F_s = \frac{1}{0.5\times10^{-6}} = 2 \times 10^6$ Hz.

$$\boxed{\implies F_s = \frac{1}{0.5 \times 10^{-6}} = 2 \times 10^6 Hz}$$

- Carrier frequency (f_c): The carrier frequency is given by the argument of the cosine function in s_t. From the code, $f_c = 2000$ Hz.

$$\boxed{\implies f_c = 2000Hz}$$

- Frequency deviation (Δf): Δf is not explicitly given, but it can be inferred from the relationship between β and Δf in FM modulation. We'll calculate it in part (b).

- Modulation index (β): β is not explicitly given, but we can calculate it using the formula $\beta = \frac{\Delta f}{f_m}$, where f_m is the maximum frequency in the message signal m_t. We'll calculate it in part (b).

To determine if it's Narrowband FM (NBFM) or Wideband FM (WBFM), we need to check if $\beta \ll 1$ (NBFM) or $\beta \geq 1$ (WBFM). We'll calculate β in part (b) to answer this question.

As for whether $F_s \gg f_c$, we have $F_s = 2 \times 10^6$ Hz and $f_c = 2000$ Hz, so yes, $F_s \gg f_c$.

(b) To calculate the FM signal bandwidth (B_T), we need to find the maximum frequency component in the modulating signal m_t, which corresponds to its maximum frequency. Then, we calculate $B_T = 2 \times (\Delta f + f_m)$, where f_m is the maximum frequency in m_t.

(c) To address the problem and correct the FM signal waveform, we'll need to adjust a single parameter. Based on the calculations and observations from (a) and (b), we can decide which parameter to modify to achieve the desired result.

Calculations :

$\xrightarrow{\text{Ans. 1}} \underline{\underline{(a)}}$

$$\begin{aligned} t &= 0 : 0.5\left(10^{-6}\right) : 0.005 \\ &= 0 : \frac{1}{2 \times 10^{-6}} : 0.005 \end{aligned}$$

So, $f_s = 2{\times}10^6$ Hz As given $m\_t = \sin(2\pi(1000)t)$ and $st = \cos(2\pi(2000)t +$ $2\pi(5000)$ int -mt)

$$f_c = 2000 \text{ Hz}$$

As we know that

$$\begin{aligned} \Delta f &= \frac{k_f}{2\pi} m_p = \frac{2\pi \times (5000)}{2\pi} \cdot 1 \\ \Delta f &= 5000 \text{ Hz} \\ \beta &= \frac{\Delta f}{B} = \frac{5000}{1000} = 5 \end{aligned}$$

as $k_f \gg 1$ It is WBFM and also $\Rightarrow F_S \gg F_C$ proved

(b) Now Fm signal bard width (using carson law)

$$\begin{aligned} &= 2(5000 + 1000) = 12000 \text{ Hz} \\ &= 12\text{KH}z \end{aligned}$$

Now $FS = 2 \times 10^6$ Hz

$$2\,(f_c + BT/2) = 2(2000 + 6000)$$
$$= 16000 = 16 \text{ Hz}$$
$$\Rightarrow \quad f_s < 2\,(f_c + BT/2) \text{ (yes)}$$

$$\text{and } F_C = 2000 \text{ Hz}$$
$$BT/2 = 8000 \text{ Hz}$$
$$\Rightarrow f_C < B_T/2$$

$\Rightarrow$ If we charge the value of f_m, then the bandwidth of chanel will increase and there will be more spectral dispersion.

(c) As we can see that $f_c < BT/2$. So the frequency less than fo bounded by $f_c = BT/2$ and become negative and causing the phase change in the angle divested of causing modulation in the frequency. $\Rightarrow f_c > BT/2$ for this requirement We set $f_c = 10$kHz for this purpose.

Question 2

Written in code only.