Indian Institute of Space Science and Technology
AV312 - Digital Communication
Department of Avionics

Quiz 1 for **Semester V** on **29/08/2015**

Note to the student

1. There are **4 questions** in this question paper on **2 pages**, for a total of **15 marks**.
2. Answer **all** questions.

Question 1 (3 marks): Suppose $m_1(t)$ and $m_2(t)$ are real baseband modulating signals with Fourier transforms $M_1(f)$ and $M_2(f)$. The magnitude responses $|M_1(f)|$ and $|M_2(f)|$ are shown in Figure 1. Suppose $m_1(t)$ has a two-sided bandwidth of $2W_1$ and $m_2(t)$ has a two-sided bandwidth of $2W_2$.

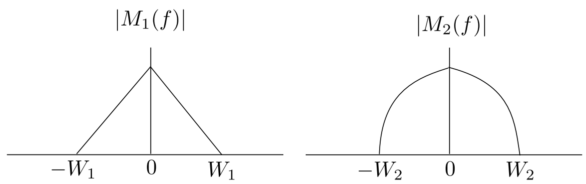

Figure 1: Magnitude spectrums of $m_1(t)$ and $m_2(t)$

Suppose $m_1(t)$ and $m_2(t)$ are transformed to the signals $s_1(t)$, $s_2(t)$ and then $s(t)$ as shown in Figure 2.

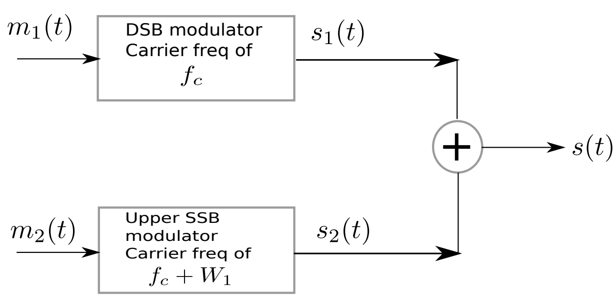

Figure 2: Transformation of $m_1(t)$ and $m_2(t)$ to $s_1(t)$, $s_2(t)$ and then $s(t)$

Draw the magnitude responses of $s_1(t)$, $s_2(t)$, and $s(t)$ (i.e. $|S_1(f)|$, $|S_2(f)|$, and $|S(f)|$).

Question 2 (4 marks): Suppose $m(t)$ is a pulse of amplitude A for $t \in [0, T]$ and 0 otherwise. This pulse is applied to an SSB (upper SSB) modulator to obtain $s(t)$. Show that the envelope of the signal $s(t)$ exhibits peaks at the beginning and end of the pulse.

Question 3 (5 marks): Suppose $s(t)$ is a frequency modulated signal with a carrier frequency of f_c and a effective transmission bandwidth of B_T (i.e., the spectrum of $s(t)$ can be assumed to be non-zero only in $[f_c - \frac{B_T}{2}, f_c + \frac{B_T}{2}]$). Consider the following superheterodyne receiver architecture for demodulating the FM signal $s(t)$.
Assume that the frequency response $H_{RF}(f)$ of the first bandpass filter is as follows:

$$H_{RF}(f) \quad = \quad \begin{cases} 1, \text{ for } f \in [-f_c - \frac{B_T}{2}, -f_c + \frac{B_T}{2}], [f_c - \frac{B_T}{2}, f_c + \frac{B_T}{2}] \\ 0, \text{ otherwise.} \end{cases}$$

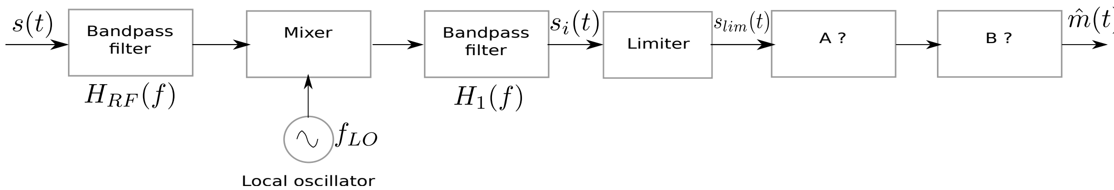

Figure 3: A superheterodyne receiver for demodulating $s(t)$

1. If the intermediate frequency of the IF section shown above is f_{IF}, what is the local oscillator frequency f_{LO} for the superheterodyne architecture?
2. Draw the ideal magnitude response $|H_1(f)|$ of the second bandpass filter shown in the figure (the block labelled with $H_1(f)$).
3. Draw the magnitude spectrum $|S_i(f)|$ for the signal $s_i(t)$ as shown.
4. Draw a representative time-domain function for the signal $s_{lim}(t)$.
5. What blocks would you use at the stages A and B as shown in the figure for demodulating the FM signal.

Question 4 (3 marks): Consider the following idealized model for a PLL. The function $\phi_1(t)$ is the phase for the

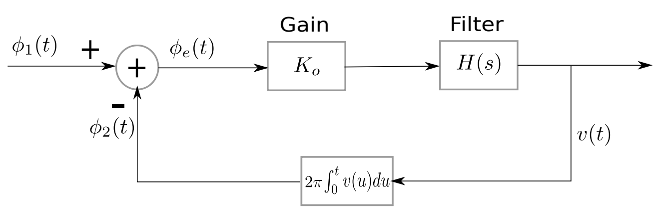

Figure 4: An idealized model for PLL

input signal (assumed sinusoidal) and the function $\phi_2(t)$ is the phase for the signal put out by a VCO in the PLL. The difference between the two phases is the phase error signal $\phi_e(t) = \phi_1(t) - \phi_2(t)$. Suppose the system starts with the PLL in lock, so that the input $\phi_1(t)$ is 0 and therefore $\phi_2(t)$ is 0 for $t < 0$. At $t = 0$ the input phase $\phi_1(t)$ changes; there is a frequency offset of Δf and a phase offset of $\Delta\theta$. For this idealized model, find out the steady state value of the phase error $\phi_e(t)$ if $H(s) = \frac{s+a}{s}$, where a is a positive real number and $H(s)$ is the transfer function of the filter.

Best of luck!