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06/02/2021

EHB 351E
ANALOG COMMUNICATIONS
Final Exam

1. (40 points) The signals $x_1(t)$ and $x_2(t)$ whose frequency spectra are depicted in Figure 1(a) are desired to be transmitted with the aid of a communication system. For this purpose, $x_1(t)$ and $x_2(t)$ are applied to the system illustrated in Figure 1(b) and $x_{AB}(t)$ signal is obtained. In this system, the transfer function of the block on the upper branch is given by $H(f)=\frac{1}{2}\left(\frac{f^2}{10^8}+1\right)$, $|f|\leq 10$ kHz and the carrier frequency of the modulator is tuned to $f_c =$ 150 kHz.

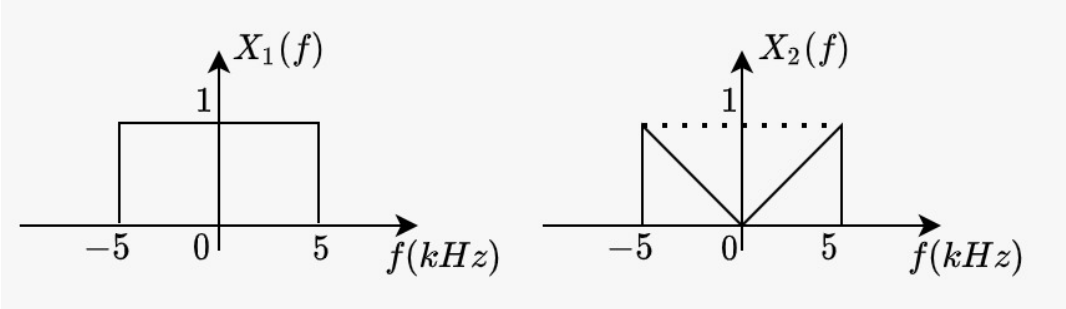

Figure 1(a)

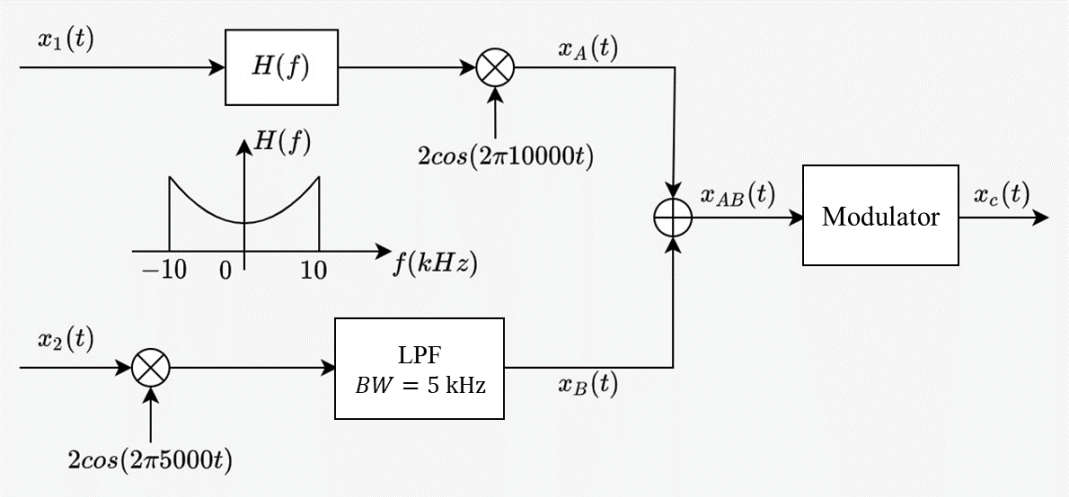

Figure 1(b)

a) Plot the frequency spectra of the signals $x_A(t)$, $x_B(t)$, and $x_{AB}(t)$.

b) If it is desired to transmit using the possible minimum transmission bandwidth in this system, write down which modulation types can be used in the modulator. Find the smallest transmission bandwidth.

c) Write the time domain expression of the modulated signal $x_c(t)$ for one of the possible modulation types that you choose in option (b) and draw the corresponding frequency spectrum.

d) Design the system to obtain $x_1(t)$ and $x_2(t)$ from $x_c(t)$ at the receiver side.

e) Determine what this system can be used for.

Exam Duration:40 minutes
Upload Duration: 5 minutes

FALL 2020

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2. (30 points) Consider the demodulator scheme illustrated in Figure 2 that contains two orthogonal local oscillators where each oscillator has a phase error θ. The conventional amplitude modulated (AM) signal $x_c(t) = A_c(1+mx(t))\cos\omega_c t$ is applied to the given demodulator ($\omega_c = 2\pi f_c$). The frequency spectrum of the baseband information signal $x(t)$ is also shown in Figure 2 and has a bandwidth of W. The bandwidth of the low pass filters (LPF) in the demodulator is equal to W as well and their corresponding gains are equal to 1.

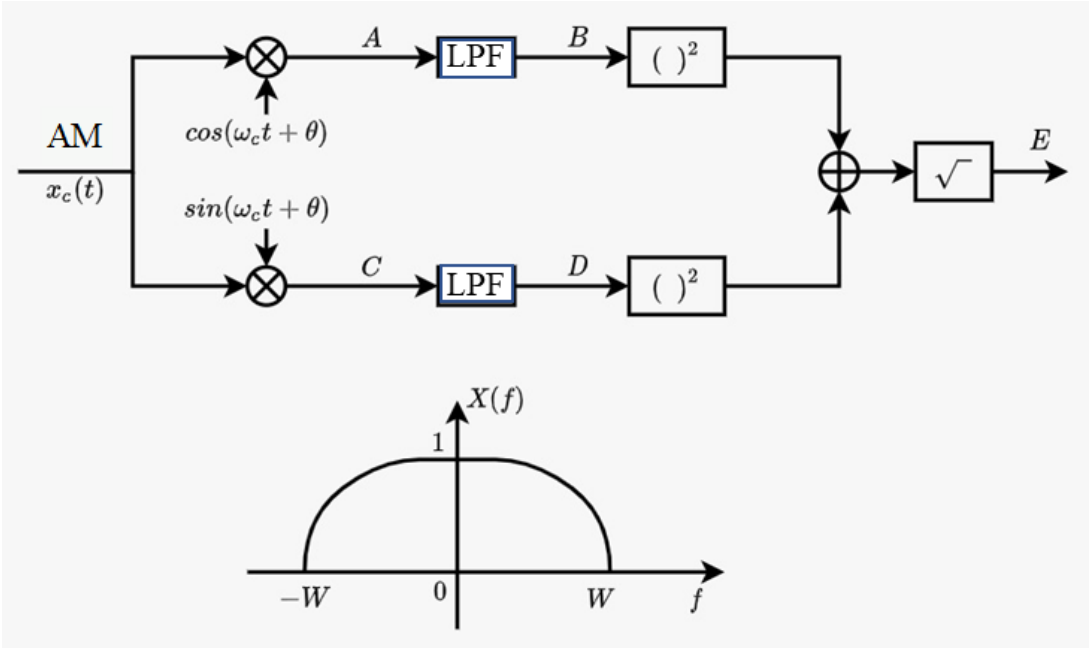

Figure 2

a) Write down the time domain signal expressions seen at the points A, B, C, D and E.
b) Sketch the amplitude and phase spectra of the signals at points A, B, C, D and E.
c) Determine the superiority of this demodulator to the classical AM demodulator with single local oscillator which has θ phase error?

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3. (30 points) The baseband information signal $x(t)$ whose frequency spectrum is shown in Figure 3 will be transmitted by using wideband FM modulation obtained by indirect FM technique ($|x(t)|_{\max} = 1$). The narrowband FM signal is given by $x_1(t) = \cos(2\pi 100\times 10^3 t + 2\pi 30\int x(\tau)d\tau)$ where it is the input to the wideband FM modulator. The maximum frequency deviation of the desired wideband FM signal is $\Delta f' = 14.58$ kHz and the desired carrier frequency of the wideband FM signal is set to $f_c' = 3$ MHz.

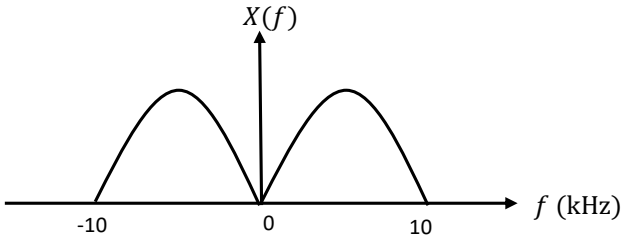

Figure 3

a) What is the minimum number of frequency multipliers in the multiplier stage required if we have only frequency doublers and triplers.
b) Design and sketch the block diagram of the indirect FM-modulator where operating frequency of any oscillator does not exceed 20 MHz and maximum 4 frequency multipliers are allowed for cascade connection to each other (the total number of multipliers can be higher than 4). Determine the system parameters by writing the time domain expressions of the signals at various points.
c) Find the bandwidth of the output signal of the indirect FM modulator.

Exam Duration:40 minutes
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