EEG370 (Digital Communication systems)

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Assignment (4)

Question # 1.

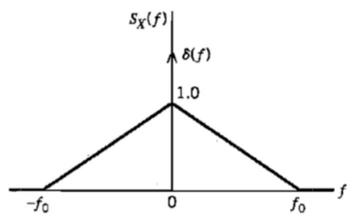
Q4-a] If the following analog signal x(t) is converted to digital signal and it is placed as an input to A/D converter,

$$x(t) = 3\ Cos\ (\ 2\pi . 20000. t\ )$$

1. Plot one cycle of the analog signal x(t).
2. Calculate and show, in the same graph, quantization levels and the sampled signal (discrete) If the signal is sampled at **quarter of the maximum allowable sampling timings** over one cycle of the signal **with 2 bits quantizer**.
3. What are the first **10 bits** of the output digital signal.

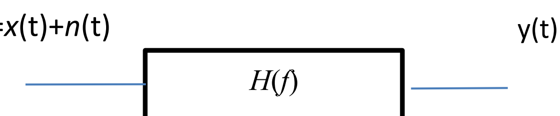
Question # 2

A signal $x(t)$ is passed through an AWGN channel that add the noise $n(t)$ to the transmitted signal. The received signal is ***r*(t)=*x*(t)+*n*(t).** if the power spectral density of the transmittted signal is as shown in the following figure. With **fo= 12 KHz** and the AWGN has a PSD = 0.5 W/Hz ,



The received signal is then filtered as shown, with a filter transfer function =

$$\boldsymbol{H1(f) = 2\ \Pi\left(\frac{f}{12k}\right)}$$



1. Determine and sketch the autocorrelation function $Rx(\tau)$ of x(t) showing the location of best sampling to get uncollelated samples ?

2. Find the following SNR at the output of the receiver filter

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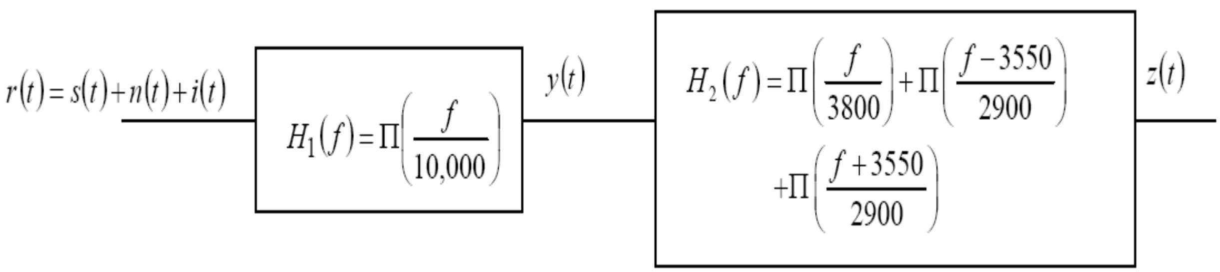
Question # 3

(1) A signal $s(t)$ having power spectral density $\Phi_s(f) = 5\Pi\left(\frac{f}{10{,}000}\right)$ is passed through a channel in which additive white Gaussian noise $n(t)$ and interference $i(t)$ are present, resulting in a received signal of $r(t) = s(t) + i(t)$. You may assume that the signal, noise and interference are all independent and that the noise has power spectral density $\Phi_n(f) = 0.1$, and the interference has power spectral density

$$\Phi_i(f) = 100\Lambda\left(\frac{f-2000}{100}\right) + 100\Lambda\left(\frac{f+2000}{100}\right).$$

The received signal is then filtered twice, first to bandlimit the signal and then to excise the interference, according to the following block diagram:



(a) Find the Signal to Interference and Noise Ratio (SINR) of $r(t)$

(b) Find the SINR of $y(t)$.

(c) Find the SINR of $z(t)$.

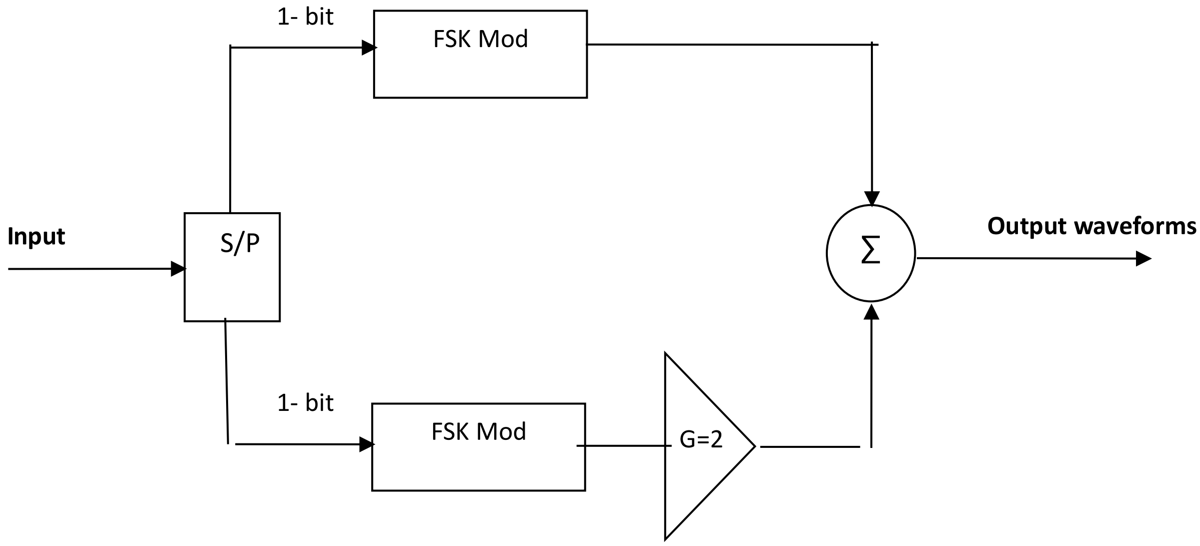
Question # 4

A communication system transmits one of the following signals:

$$s_i(t) = \cos(2\pi f_c t + i\frac{\pi}{4}) \qquad 0 \le t \le T \qquad i=1,2,3,4 \qquad f_c T = I$$

1. Define the used basis functions.
2. Express the four signals in terms of the defined basis functions.
3. Sketch to scale the signals in S.S

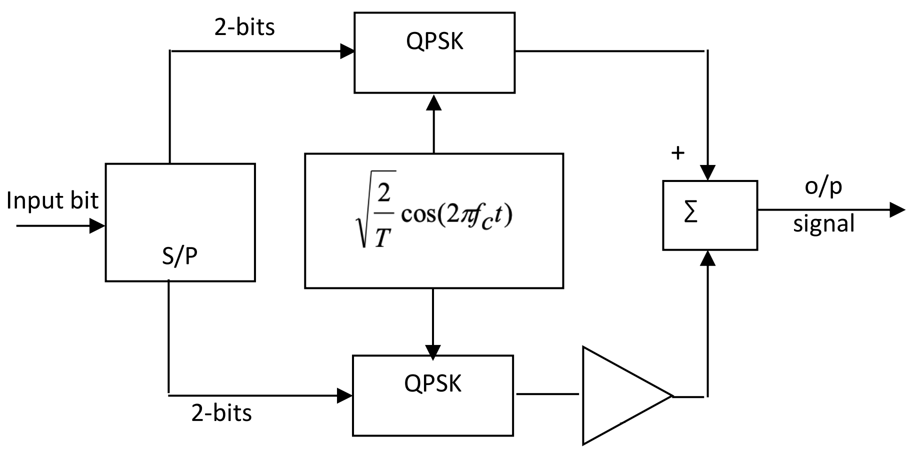
Question # 5



The above Tx consists of two identical CBFSK modulators. An amplifier of Gain G=2 is inserted in the lower arm, then the outputs the two arms are added coherently to form the output waveform.

1. Write down expressions for the possible output waveforms.
2. Draw the S.S. and define the D.Rs and D.Bs.
3. Assign a bit scheme for the output signals in S.S.
4. Calculate the average transmitted energy.

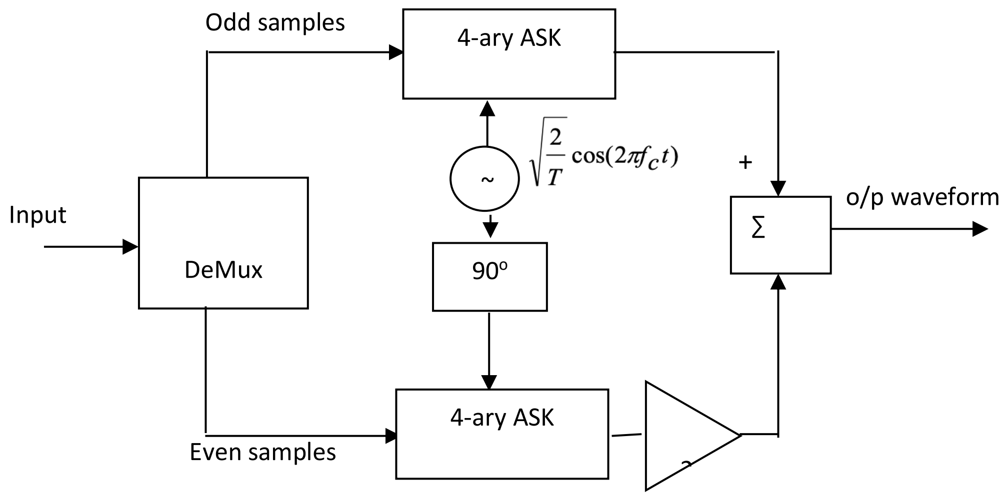
Question # 6



The above communication system transmits equally likely symbols each consists of 4-bits. An amplifier is inserted in the lower arm of Gain G=3 the input bit is in NRZ "L" with amplitudes ± 1 volts for digits 1 and 0, the bit duration is 1 sec. The noise is assumed to be AWGN with PSD = $\frac{N_0}{2} = 1$ W/Hz.

1. Write down the equations of the possible output signals.
2. Sketch to scale the output signals in S.S. showing the bits assigned to each message point, then define the D.R's and D.B.'s.
3. Find the average energy of the transmitted symbol.
4. Suggest an implementation for the receiver.

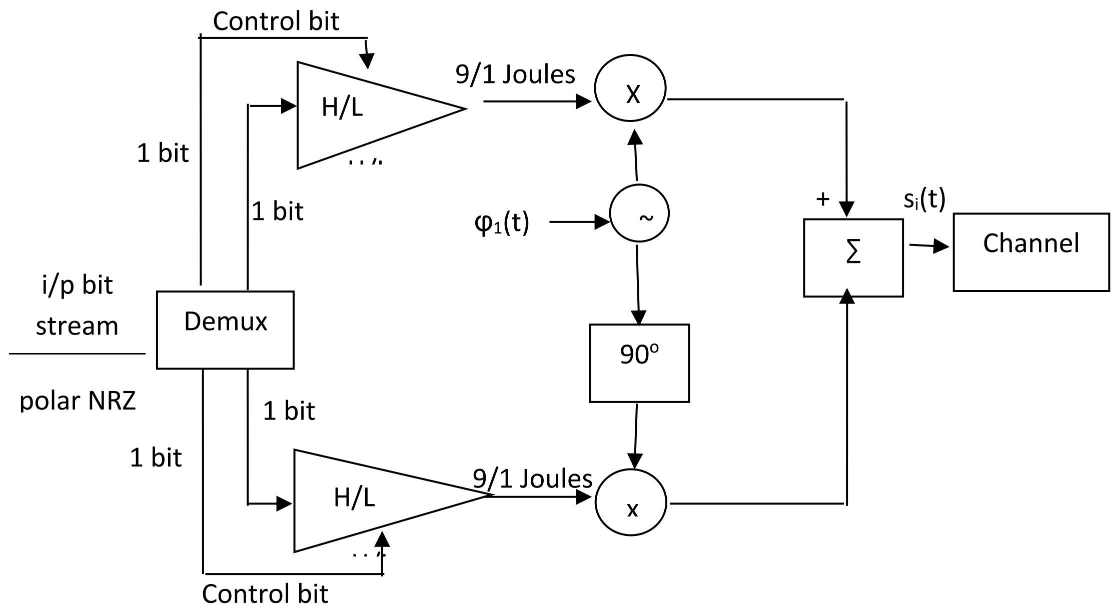
Question # 7



The above communication transmitter is used to emit one of 16 equally likely messages over AWGN channel with zero mean and two sided PSD= 1 w/Hz. The quantizers used in the 4-ary ASK modulators are mid-riser with output $\pm\frac{a}{2}$, $\pm\frac{3a}{2}$. An amplifier of gain = 2 is inserted in the lower arm. Assuming the o/p symbol duration T= 2 Sec. a = 2 volts and f_c = 100.25Hz.

1. Write down a close form for the output waveforms.
2. Sketch to scale the output messages in S.S and draw the D.R.s and D.Bs, then assign a bit scheme for each transmitted message.
3. Find the average transmitted energy for the system under consideration.
4. Design an optimum receiver showing each stage of detection.

Question # 8



The above diagram shows a transmitter for all equally-likely messages in the presence of AWGN with zero mean and two sided PSD $= \frac{N_o}{2}$ W/Hz. The transmitter consists of two identical arms. Each arm consists of an amplifier followed by a multiplier, then the o/p of the two arms are added coherently to formulate the o/p waveform. The state of the amplifier is H when the control bit is "1" and L when the control bit is "0" such that the o/p symbol energy is either 9 or 1 Joules respectively.

1. Determine the ratio H:L
2. Sketch to scale the signals in S.S. for each arm separately and assign a bit scheme for the o/p of each arm.
3. From 2. construct the S.S. for the o/p waveforms and assign a bit scheme for each message.
4. Design a Rx for the given case showing each stage of detection.