Department of Electrical Engineering, IIT Madras

EE419: Digital Communication Systems

Date: Nov 20, 2008 | 6 Questions, 6 Pages | Time: 3 hours

Write your important steps and answers in the space provided. Continue writing on other side of paper, if necessary.

RollNo.: **Name:**

1. Answer each of the following questions. Write in the prescribed places only and be as brief and as specific as possible.

   (a) Why are raised cosine pulses used in digital communication systems?

      i.

      ii.

   (b) Why is OFDM popular in digital communication systems?

      i.

      ii.

   (c) Why is channel coding used in digital communication systems?

      i.

      ii.

   (d) Why are fractionally spaced equalizers used in digital communication systems?

      i.

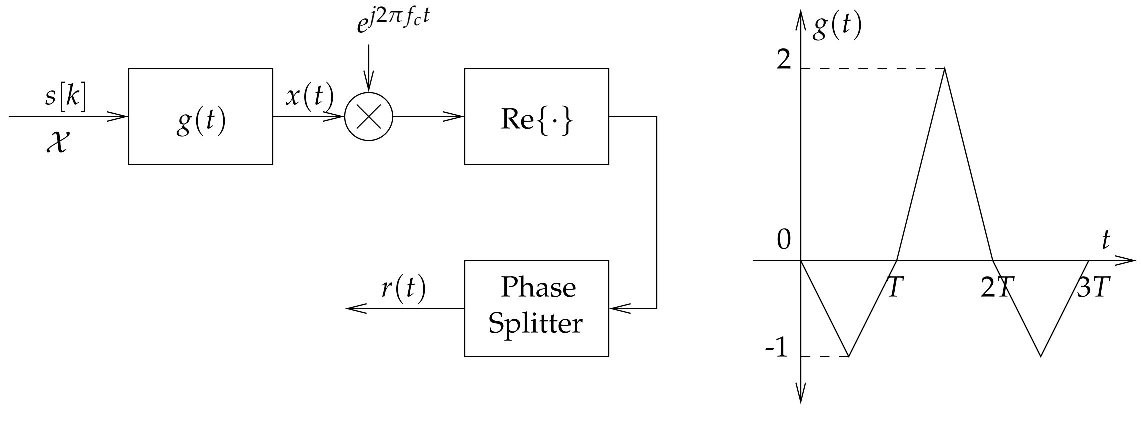
      ii.

   (e) Name two methods used for timing recovery in digital communication systems.

      i.

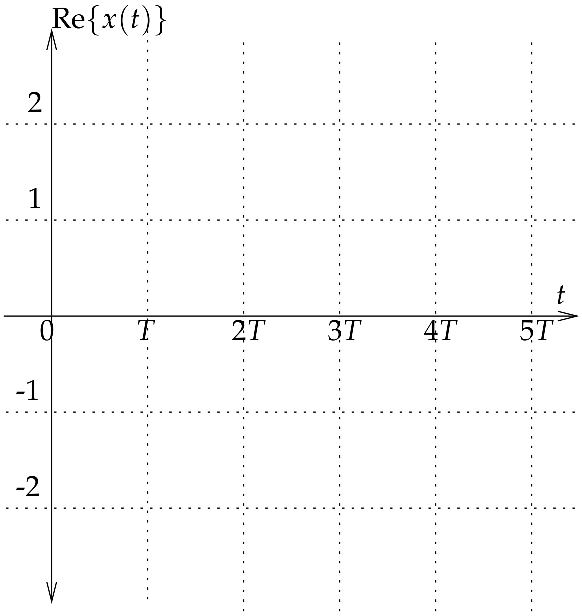
      ii.

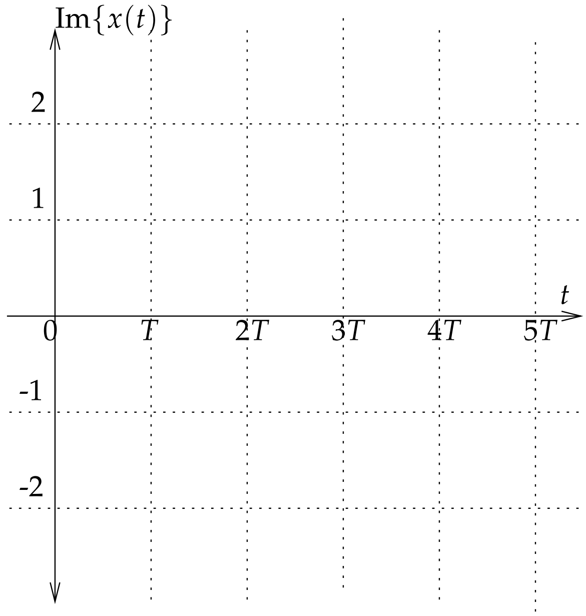
2. Consider the transmitter shown below with the transmit filter response to the right.

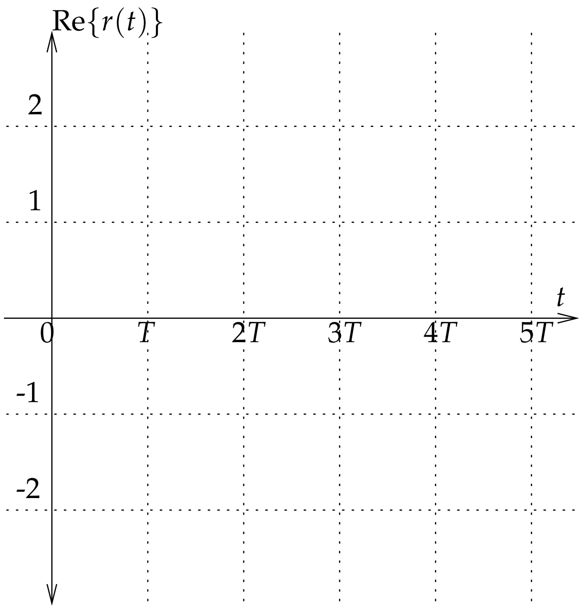


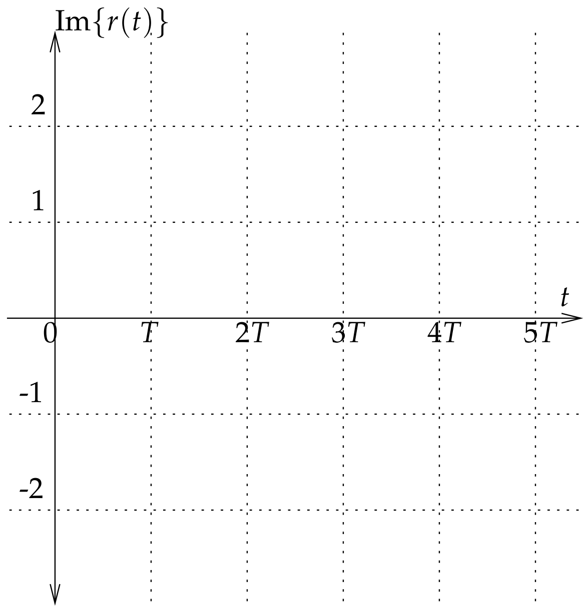
Assume a symbol rate of $\frac{1}{T}$ and carrier frequency $f_c = \frac{3}{T}$. Let $\mathcal{X} = \{1, -1, j, -j\}$ and consider the transmission of the three-symbol sequence $s[k] = \{1, -j, j\}$. The phase splitter nulls all negative frequencies in the signal. (continued in next page)

Make plots of the real and imaginary parts of $x(t)$ and $r(t)$ in the graphs below.









3. A communication system sends four uniformly likely symbols $s = 0, 1, 2, 3$ using the four signals

$$x_s(t) = \sin(2\pi t + s\pi/2),\ 0 \le t \le 1,$$

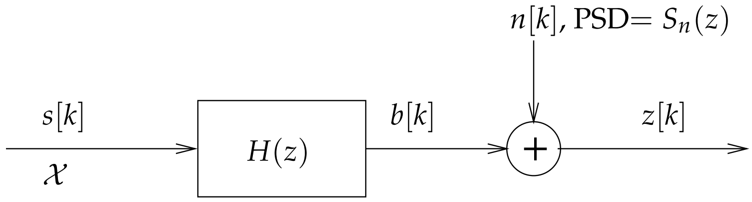
at a rate of 1 symbol/second.

   (a) Determine a basis and draw a signal constellation.

   (b) Derive optimal hard and soft detectors for the symbols.

   (c) Determine the probability of symbol error.

4. Consider the general ISI model shown below.

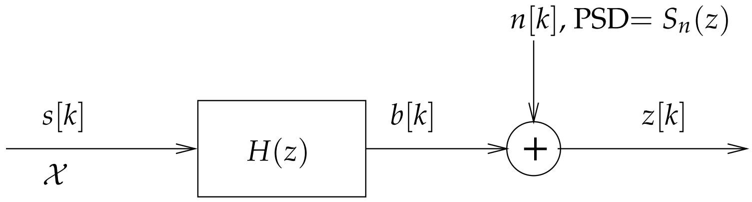


Let $\mathcal{X} = \{-1, 1\}$, $H(z) = (1 - 2z^{-1})(1 - 2z)$ and $S_n(z) = 1$.

(a) Determine the precursor and postcursor filters for the unconstrained ZF-DFE and find its MSE.

(b) Determine the precursor and postcursor filters for the unconstrained MMSE-DFE and find its MSE.

5. Consider the general ISI model shown below.

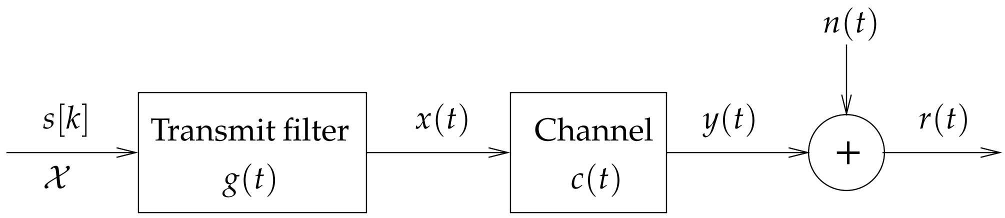


Let $\mathcal{X} = \{-1, 1\}$, $H(z) = (1 - 2z^{-1})(1 - 2z)$ and $S_n(z) = 1$.

(a) Derive the MMSE-LE $C(z) = c_{-1}z + c_0 + c_1 z^{-1}$ and find its MSE.

(b) Derive a ZF-LE $C(z) = c_{-1}z + c_0 + c_1 z^{-1}$ and find its MSE.

6. Consider a communication system model shown below operating at a symbol rate of $1/T$ symbols per second. Assume $\mathcal{X} = \{-1, 1\}$ and data symbols are



equally likely. The transmit filter is $g(t) = 1$ for $0 \leq t \leq T$ and zero outside. The channel response is given by $c(t) = \delta(t) + 0.5\delta(t - \tau)$ i.e. $y(t) = x(t) + 0.5x(t - \tau)$, where $0 \leq \tau \leq T$. The noise $n(t)$ is WGN with PSD 0.1.

(a) Determine the whitened matched filter front-end and the equivalent discrete-time minimum phase channel.

(b) Design the unconstrained ZF-LE for the discrete-time equivalent channel. Compute the MSE.