Communication Systems: Homework #2

Due on Mehr 30, 1396 at 7:30am

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Problem 1

The output of a system, $y(t)$, is given by $y(t) = 2x(t) + 0.3x^2(t) + 0.03x^4(t)$, where $x(t)$ is the input. If a pure sine wave is applied to this system find the second, third and fourth order harmonic distortion of the system output.

Problem 2

Design a taped delay line equalizer for the channel

$$H_c(f) = exp[-j\,(\omega T - \alpha sin(\omega T))]$$

assuming that $\alpha = 0.1$. Plot the channel and equalizer transfer function.

Problem 3

Let $x(t)$ represent a bandpass signal and $m(t)$ denote a low-pass signal with non-overlapping spectra. Show that the Hilbert transform of $c(t) = m(t)x(t)$ is equal to $m(t)\hat{x}(t)$

Problem 4

A 900 km repeater system consists of m identical fiber optic cable sections with attenuation $\alpha = 0.24dB/km$ and m identical amplifiers. Find the required number of sections and gain per amplifier so that $P_{out} = P_{in} = 2.5dBm$ and the input power to each amplifier is at least $30\mu W$.

Problem 5

Find the Hilbert transform of following signals:

1. $x_1(t) = 4cos(3\omega_0 t) + 0.2sin(\omega_0 t) + 0.8cos(5\omega_0 t)$
2. $x_2(t) = \frac{1}{4+t^2}$

Problem 6

The first three Butterworth filters can be described as follows:
$N = 1:\ \ H_1(f) = \frac{1}{1+j2\pi f}$
$N = 2:\ \ H_2(f) = \frac{1}{(j2\pi f)^2+\sqrt{2}(j2\pi f)+1}$
$N = 3:\ \ H_3(f) = \frac{1}{(j2\pi f)^3+2(j2\pi f)^2+2(j2\pi f)+1}$

Problem 6 continued on next page. . .

1. For each of these filters, find the ratio of -60dB to -6 dB bandwidth. (This ratio is often used as a convenient way to measure the filter selectivity)
2. If we insist that the deviation from the requirements for distortion-less transmission are to be no greater than 1%, determine the maximum bandwidth normalized to 3-dB bandwidth , that may be handled by each of these filters:
   (a) On the basis of the magnitude of the frequency transfer function
   (b) On the basis of the phase of the frequency transfer function

Problem 7

In an optical fiber communication system, the band from 1.4nm to 1.65nm can be used. Find out how much bandwidth is available in this band. (Assume speed of light in fiber is $2 \times 10^8 m/s$). If transmission of an analog video signal requires 4.2MHz of bandwidth, how many video channels can be transmitted in this band?

Problem 8

(Computer Assignment) Use MATLAB to do the following:

- Plot the frequency response and group delay response of a low pass Bessel filter of degree N=1, Passband gain=20 and 3-dB frequency of 4000 Hz.
- Find the ratio of -60dB to -6 dB bandwidth
- If we insist that the deviation from the requirements for distortion-less transmission are to be no greater than 2 percent, determine the maximum bandwidth normalized to 3-dB bandwidth, that may be handled by this filters:
  - On the basis of the magnitude of the frequency transfer function
  - On the basis of the phase of the frequency transfer function
- Repeat the above for N=12 and N=18

Problem 9

(Computer Assignment) A 4-tap equalizer has these tap values: {a0, a1, a2, a3} (a0 is the tap for zero delay, a3 is the tap for 3T delay). Using a minimum of 200 points, plot the magnitude of the transfer function and its phase assuming T=1 for each of these cases:

Problem 9 continued on next page. . .

1. {a0, a1, a2, a3} = {-1, +1, -1, +1}
2. {a0, a1, a2, a3} = {-2, +1, +1, -2}
3. {a0, a1, a2, a3} = {+1, -3, +0, 3}
4. {a0, a1, a2, a3} = {+1, -3, +2, -2}