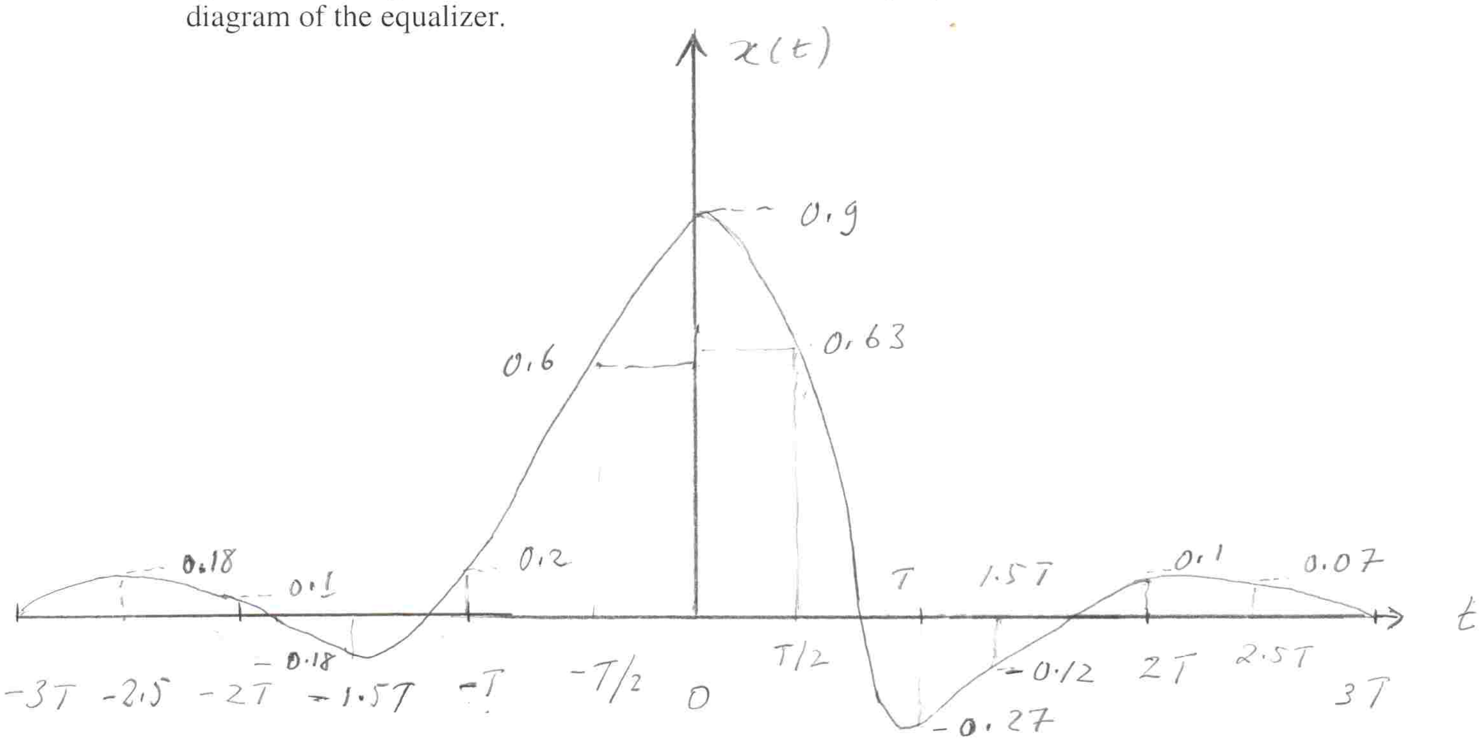
Anadolu Üniversitesi – EE Department – EEM 468 (MT2)

Student Name :
Student Number :
Duration : 90 Minutes
Questions

Date : 06.05.2008
Open book exam

1. (50 Points) The OP of a matched filter demodulator, $x(t)$, is shown below. Write for the whole **X** matrix if the FIR filter delay is T and $T/2$. Identify in each case the number of taps. Find the tap coefficients c_{-1}, c_0 and c_1 if a three tap equalizer is used. Draw the block diagram of the equalizer.



$t=-2.5T$, $t=-2T$, $t=-1.5T$, $t=-T$, $t=-0.5T$

$x(t)=$ 0.18 , 0.1 , −0.18 , 0.2 , 0.6

$t=0$, $t=0.5T$, $t=T$, $t=1.5T$, $t=2T$, $t=2.5T$

0.9 , 0.63 , −0.27 , −0.12 , 0.1 , 0.07

Solution : The full matrix in the case of

$$q(mT) = \sum_{n=-N}^{N} c_n\, x(mT - n\tau) \quad \text{, where } \tau = T \text{ , } N = 3$$

thus $m, n = 0, \mp 1, \mp 2, \mp 3$

$t = -6T$

$$X_T = \begin{array}{c c}
\left[\begin{array}{ccccccc}
0.9 & 0.2 & 0.1 & 0 & 0 & 0 & 0 \\
-0.27 & 0.9 & 0.2 & 0.1 & 0 & 0 & 0 \\
0.1 & -0.27 & 0.9 & 0.2 & 0.1 & 0 & 0 \\
0 & 0.1 & -0.27 & 0.9 & 0.2 & 0.1 & 0 \\
0 & 0 & 0.1 & -0.27 & 0.9 & 0.2 & 0.1 \\
0 & 0 & 0 & 0.1 & -0.27 & 0.9 & 0.2 \\
0 & 0 & 0 & 0 & 0.1 & -0.27 & 0.9
\end{array}\right]
&
\begin{array}{c} m \\ -3 \\ -2 \\ -1 \\ 0 \\ 1 \\ 2 \\ 3 \end{array}
\\
\begin{array}{cccccccc} n & -3 & -2 & -1 & 0 & 1 & 2 & 3 \end{array} &
\end{array}$$

3×3

$t = +6T$

Note that the above X matrix spans the time range of $t = -6T$ to $+6T$

When $q(m) = \sum_{n=-N}^{N} x(mT - n\tau)$ and $\tau = T/2$

X again becomes 7×7 matrix but spans a time range of $-4.5T$ to $+4.5T$

Q1 of EEM MT2 (6.05.2008) cont. (2)

$$X_{T/2} = \begin{array}{c} \\ \\ \end{array}\begin{array}{cc}
\left[\begin{array}{ccccccc}
-0.18 & 0.1 & 0.18 & 0 & 0 & 0 & \overset{t=-4.5T}{0} \\
0.6 & 0.2 & -0.18 & 0.1 & 0.18 & 0 & 0 \\
0.63 & 0.9 & 0.6 & 0.2 & -0.18 & 0.1 & 0.18 \\
-0.12 & -0.27 & 0.63 & 0.9 & 0.6 & 0.2 & -0.18 \\
0.07 & 0.1 & -0.12 & -0.27 & 0.63 & 0.9 & 0.6 \\
0 & 0 & 0.07 & 0.1 & -0.12 & -0.27 & 0.63 \\
\overset{t=4.5T}{0} & 0 & 0 & 0 & 0.07 & 0.1 & -0.12
\end{array}\right] &
\begin{array}{c} m \\ -3 \\ -2 \\ -1 \\ 0 \\ +1 \\ +2 \\ +3 \end{array} \\
\begin{array}{cccccccc} n & -3 & -2 & -1 & 0 & +1 & +2 & +3 \end{array} &
\end{array}$$

For the three tap equalizer case (when $\tau = T$) we take the part of the X_T matrix bordered

$$X_{3T} = \begin{bmatrix} 0.9 & 0.2 & 0.1 \\ -0.27 & 0.9 & 0.2 \\ 0.1 & -0.27 & 0.9 \end{bmatrix}$$

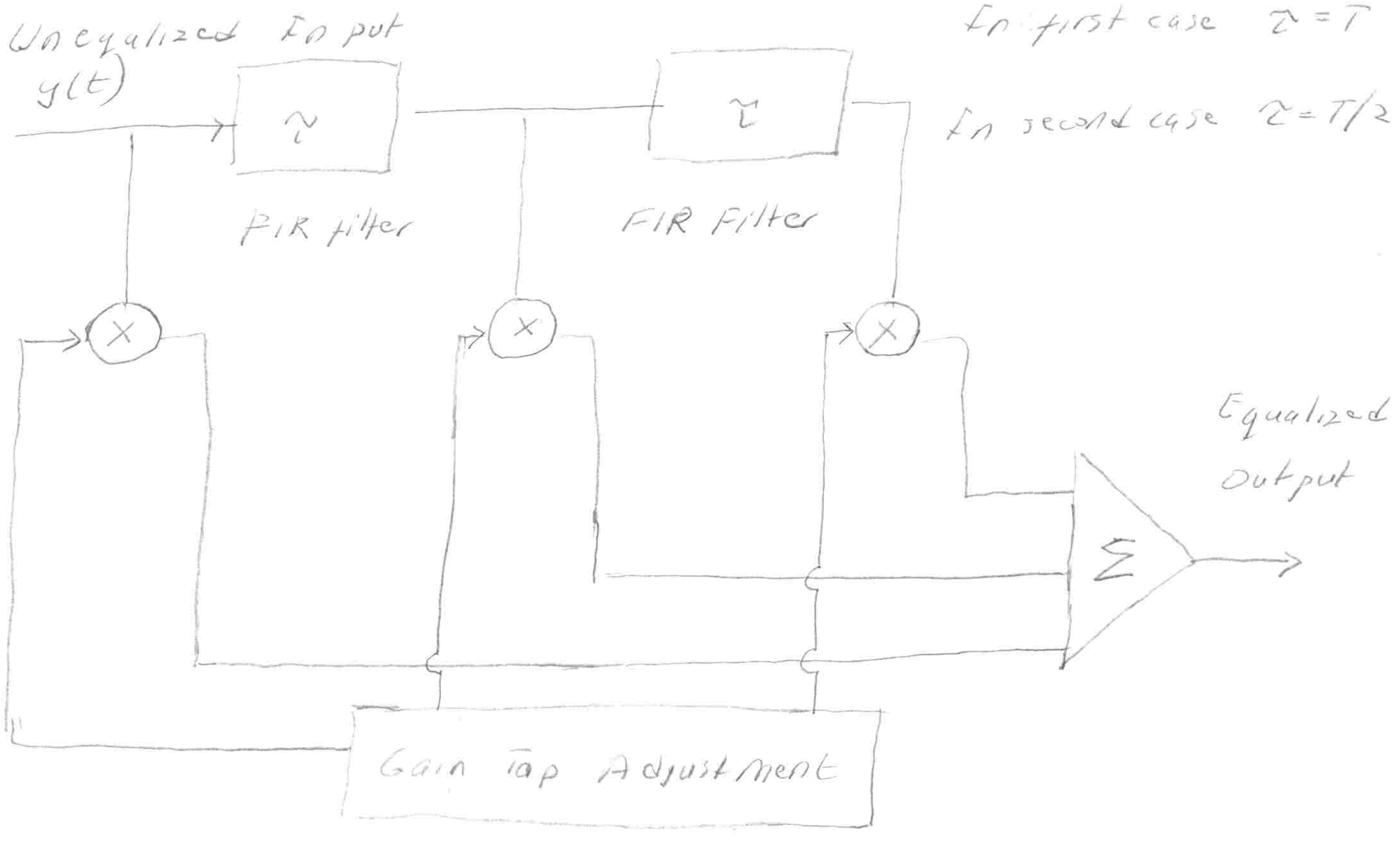
By setting $$\begin{bmatrix} c_{-1} \\ c_0 \\ c_{+1} \end{bmatrix} = X_{3T}^{-1} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -0.2499 \\ 0.9656 \\ 0.3174 \end{bmatrix}$$

For the case of $\tau = T/2$, by taking the inner 3×3 matrix block of $X_{T/2}$

$$X_{3T/2} = \begin{bmatrix} 0.6 & 0.2 & -0.18 \\ 0.63 & 0.9 & 0.6 \\ -0.12 & -0.27 & 0.63 \end{bmatrix}$$

Again by setting $\begin{bmatrix} c_{-1} \\ c_0 \\ c_{+1} \end{bmatrix} = X_{3T/2}^{-1} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -0.2182 \\ 1.0045 \\ 0.3890 \end{bmatrix}$

In both cases the block diagram is



2. (50 Points) Answer the following questions as **True** or **False.** For the **False** ones give the correct answer or the reason. For the **True** ones justify your answer.

a) For an all pass (unlimited) channel, we do not need raised cosine filtering, but it can be used to eliminate ISI : False, an unlimited channel does not create ISI under any circumstances, so no need to use raised cosine

b) In a band-limited channel, we need raised cosine filtering, but it does not completely remove ISI : True since we use a limited number of taps, in theory we should use unlimited number of FIR filters and corresponding number of taps to remove ISI completely

c) Channel with a response of $C(f)$ always introduces amplitude and phase distortions :

Not necessarily if $C(f) = 1$ (or a constant) then there is no amplitude and phase distortion

Additionally when channel is bandlimited and flat $\Rightarrow$

d) ISI occurs when the symbol rate exceeds the channel bandwidth : True

Symbol Rate $= \frac{1}{T}$, if $\frac{1}{T} > 2W$, no choice of filter to satisfy Nyquist criteria (pp. 494 of Proakis 2002)

e) Coding increases bandwidth requirements : True

Since Coding demands that within the previously allocated time slot more bits are to be transmitted and the message signal bandwidth is completely contained within $C(f)$, and setting

Assuming

$$C(f) = |C(f)|\, e^{-j\theta_c(f)} \quad \text{where } [C(f) = C_r(f) + j\,C_i(f)]$$

$$\theta_c(f) = \tan^{-1}\frac{C_i(f)}{C_r(f)}, \qquad \tau(f) = -\frac{1}{2\pi}\frac{d\theta_c(f)}{df}$$

If $\tau(f) =$ constant (i.e. independent of frequency)

then there is no amplitude or phase distortion

f) A step index fibre can be single mode or multimode : True

Depending on V (normalized fibre frequence)

If $V \leq 2.4$: Single mode

If $V > 2.4$: Multimode

g) Maxwell's equations are inadequate, Helmholtz equation is required to describe propagation in fibres : False

Helmholtz equation describes propagation in fibres, but it is derived from Maxwell's equations

h) Channel equalization is always applied with five tap equalizers and can eliminate ISI completely : False

The number of taps depends on where $z(t)$ (nearly) falls to zero.

i) Sinc pulses are a special form of raised cosine pulses : True

When, α (roll-off factor) $= 0$, raised cosine characteristics approach sinc pulse.

j) For channel equalization, the technique of MSE is applied to take into account the effect of noise in channel equalization : True

Equalization without (M)MSE enhances noise, whereas MMSE attempts to take into account noise characteritics

k) Linear block codes are always at the rate of $k/n = 2/5$: False

Linear block codes can be at any rate so long as $k < n$.