DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

PSG COLLEGE OF TECHNOLOGY

(AUTONOMOUS INSTITUTION)

COIMBATORE – 641004

BATCH:12

ASSIGNMENT PRESENTATION (19L602-DIGITAL COMMUNICATION)

ACADEMIC YEAR: 2022-2023

SEMESTER- 6

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Q:15.

In a certain binary communication system that uses Nyquist's criterion pulses, a received pulse $P_R(t)$ has the following non-zero sample values : $P_R(0) = 1$ $P_R(T_b) = 0.1$ $P_R(2T_b) = -0.02$ $P_R(-T_b) = 0.3$ $P_R(-2T_b) = -0.07$

(a) Determine the tap settings of a three-tap, zero forcing equalizer.

(b) Using the equalizer in part (a), find the residual non-zero ISI. Also write a MATLAB program to implement and plot the waveform.

Solution:

$P_R(0) = 1$

$P_R(T_b) = 0.1$

$P_R(2T_b) = -0.02$

$P_R(-T_b) = 0.3$

$P_R(-2T_b) = -0.07$

$$\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} P_R(0) & P_R(-T_b) & P_R(-2T_b) \\ P_R(T_b) & P_R(0) & P_R(-T_b) \\ P_R(2T_b) & P_R(T_b) & P_R(0) \end{bmatrix} \begin{bmatrix} C_{-1} \\ C_0 \\ C_1 \end{bmatrix}$$

$$\begin{bmatrix} C_{-1} \\ C_0 \\ C_1 \end{bmatrix} = \begin{bmatrix} 1 & 0.3 & -0.07 \\ 0.1 & 1 & 0.3 \\ -0.02 & 0.1 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$|A| = 1(1 - 0.03) - 0.3(0.1 + 0.006) - 0.07(0.01 + 0.02)$$

$$= 0.9361$$

$A_{11} = 1 - 0.03$
$= 0.97$

$A_{12} = -(0.1 + 0.06)$
$= -0.106$

$A_{22} = (0.01 + 0.02)$
$= 0.03$

$A_{21} = -(0.3 + 0.007)$
$= -0.307$

$A_{22} = 1 - 0.0014$
$= 0.9986$

$A_{23} = -(0.1 + 0.006)$
$= -0.106$

$A_{31} = 0.09 + 0.07$
$= 0.16$

$A_{32} = -(0.3 + 0.007)$
$= -0.307$

$A_{33} = 1 - 0.03$
$= 0.97$

$$A^{-1} = \frac{1}{0.9361} \begin{bmatrix} 0.97 & -0.307 & 0.16 \\ -0.106 & 0.9986 & -0.307 \\ 0.03 & -0.106 & 0.97 \end{bmatrix}$$

$$A^{-1} = \begin{bmatrix} 1.0362 & -0.3279 & 0.1709 \\ -0.1132 & 1.06076 & -0.3279 \\ 0.0320 & -0.11323 & 1.0362 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} C_{-1} \\ C_0 \\ C_1 \end{bmatrix} = \begin{bmatrix} -0.3279 \\ 1.06076 \\ -0.11323 \end{bmatrix}$$

For residual non zero Interference

$$P_o[k] = \sum_{n=-N}^{N} C_n P_r[k-n] = \sum_{n=-1}^{N=1} C_n P_r[k-n]$$

for $k = -3$.

$$P_o(-3) = \sum_{-1}^{1} C_n P_r[-3-n]$$

$$= C_{-1} P_r[-3+1] + C_0 P_r(-3) + C_1 P_r[-3-1]$$

$$= C_{-1} P_r[-2] + 0 + 0.$$

$$= -0.3279 \times -0.007$$

$$= 0.0022953$$

for $k = -2$,

$$P_0(-2) = \sum_{-1}^{1} C_n P_1[-2-n]$$

$$= C_{-1} P_1[-2+1] + C_0 P_1[-2+0] + C_{+1} P_1[-2-1]$$

$$= ((-0.3279) \times 0.3) + (1.06076)(-0.07)$$

$$= -0.1726$$

for $k = -1$

$$P_0(-1) = \sum_{-1}^{1} C_n P_1[-1-n]$$

$$= C_{-1} P_1[0] + C_0 P_1[-1] + C_1 P_1[-2]$$

$$= (-0.3279 \times 1) + (1.06076) \times 0.3 + (-0.11323 \times -0.07)$$

$$= 0.00174.$$

for $k = 0$.

$$P_0(0) = C_{-1} P_1[+1] + C_0 P_1[0] + C_{-1} P_1[-1]$$

$$= (-0.3279) \times (0.1) + (1.06076)\ 1 + (-0.11323)\ 0.3$$

$$= 0.994001 \simeq 1$$

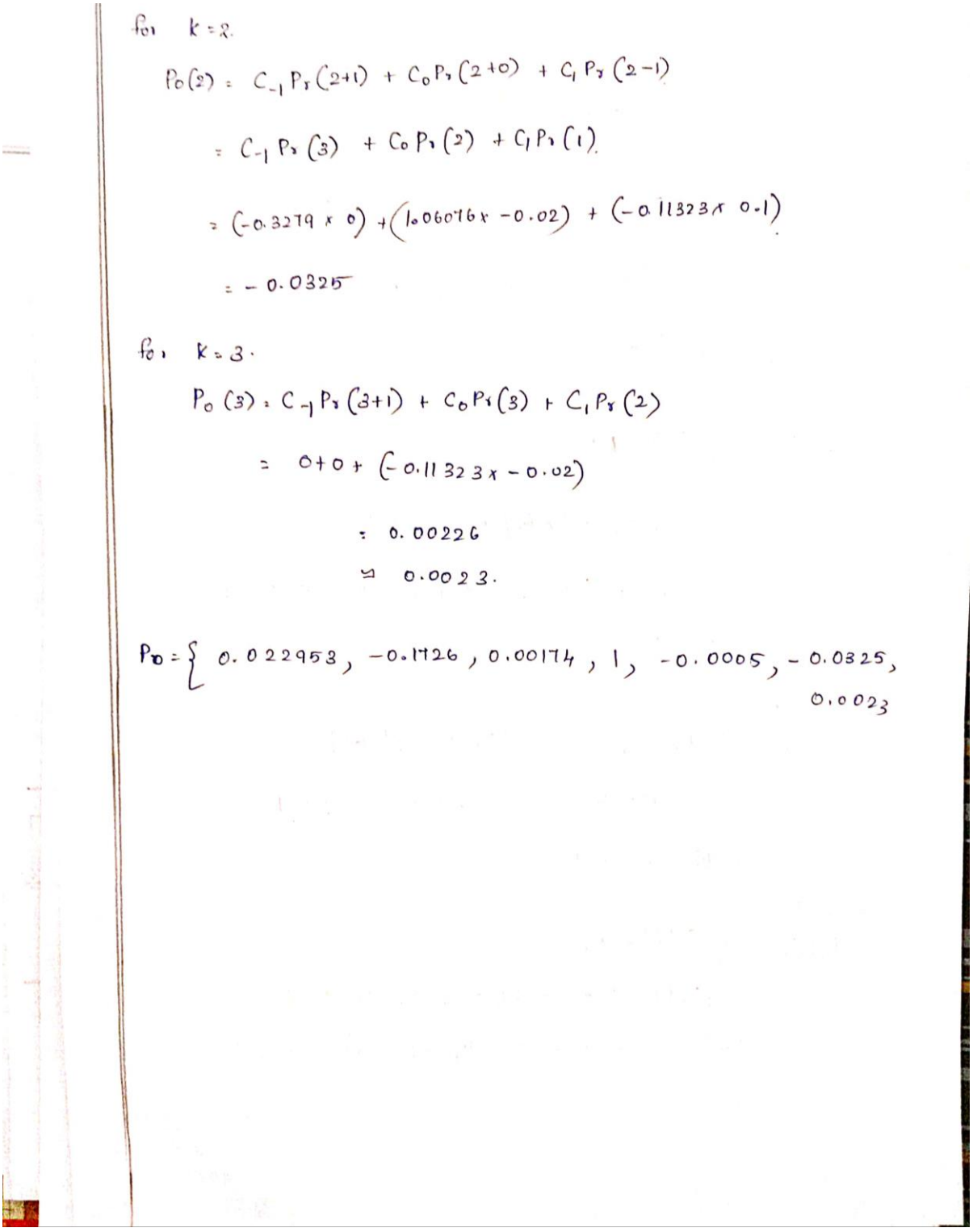
for $k = 1$

$$P_0(1) = \sum_{-1}^{1} C_n P_1[k-n]$$

$$= C_{-1} P_1[1+1] + C_0 P_1[1-0] + C_1 P_1[1-1]$$

$$= (-0.3279 \times -0.02) + (1.06076)\ 0.1 + (-0.11323)\ 1$$

$$= -0.0005 \simeq 0.$$



for $k = 2$.

$$P_0(2) = C_{-1} P_3(2+1) + C_0 P_3(2+0) + C_1 P_3(2-1)$$

$$= C_{-1} P_3(3) + C_0 P_3(2) + C_1 P_3(1)$$

$$= (-0.3279 \times 0) + (1.06076 \times -0.02) + (-0.11323 \times 0.1)$$

$$= -0.0325$$

for $k = 3$.

$$P_0(3) = C_{-1} P_3(3+1) + C_0 P_3(3) + C_1 P_3(2)$$

$$= 0 + 0 + (-0.11323 \times -0.02)$$

$$= 0.00226$$

$$\approx 0.0023.$$

$$P_0 = \{0.022953, -0.1726, 0.00174, 1, -0.0005, -0.0325, 0.0023\}$$

MATLAB IMPLEMENTATION

```
clc;
clear all;
close all;
pr=[-0.07 0.3 1 0.1 -0.02];
m=[pr(3) pr(2) pr(1);pr(4) pr(3) pr(2);pr(5) pr(4) pr(3)];
c=inv(m)*[0;1;0];
pr=[pr 0 0 0 0];
c1=[];y=0;
for i=c
    if(i~=0)
        c1=[c1 i];
    end
end
c=c1;
n=1;
%residue non-zero ISI
for k=-3:3
    y=0;
    for j=-1:1
        in=k-j+3;
        if(in>0)
            y=y+(c(j+2)*pr(in));
        end
    end
    p0(n)=y;
    n=n+1;
end
disp(c);
disp(p0);
 figure(1);stem(pr);
 title('pr');figure(2);stem(c);
 title('c');figure(3);stem(p0);
 title('p0');
```

OUTPUT:

Command Window:

```
    -0.3280
     1.0668
    -0.1132

     0.0230   -0.1731    0.0000    1.0000         0   -0.0327    0.0023

fx >>
```

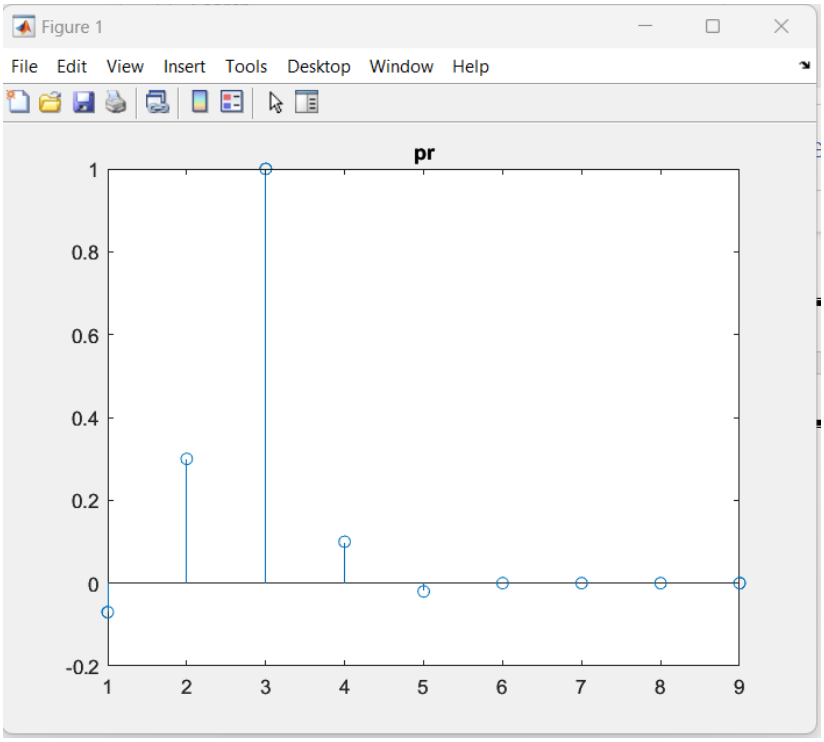


Figure 1
File Edit View Insert Tools Desktop Window Help
pr
1
0.8
0.6
0.4
0.2
0
-0.2
1 2 3 4 5 6 7 8 9

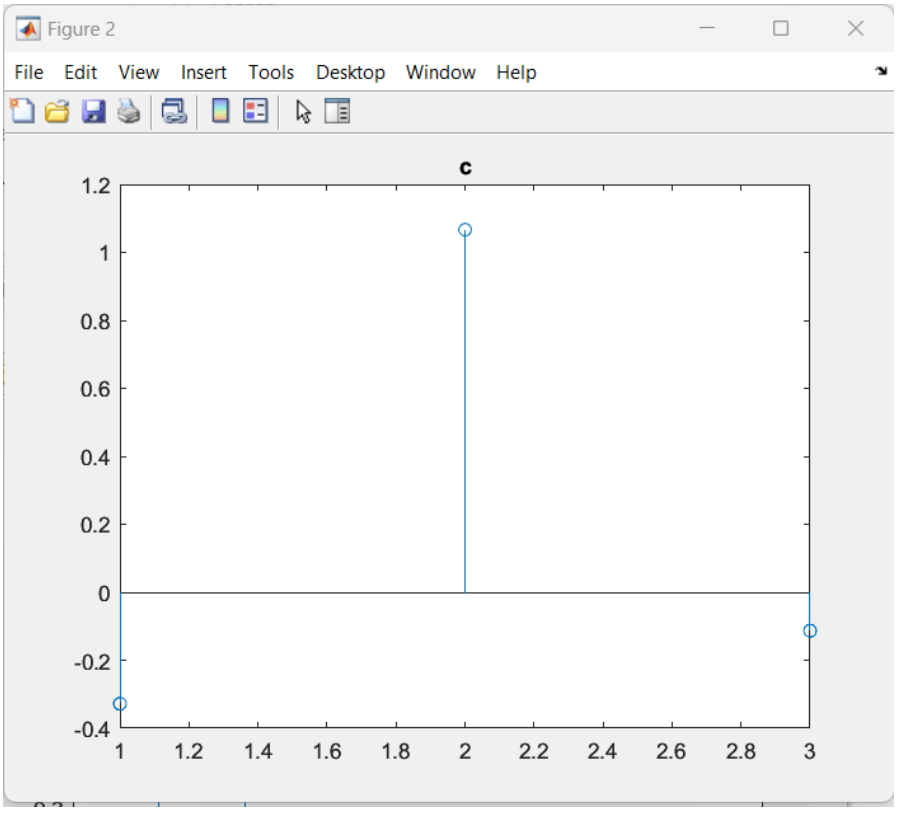


Figure 2
File Edit View Insert Tools Desktop Window Help
c
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3

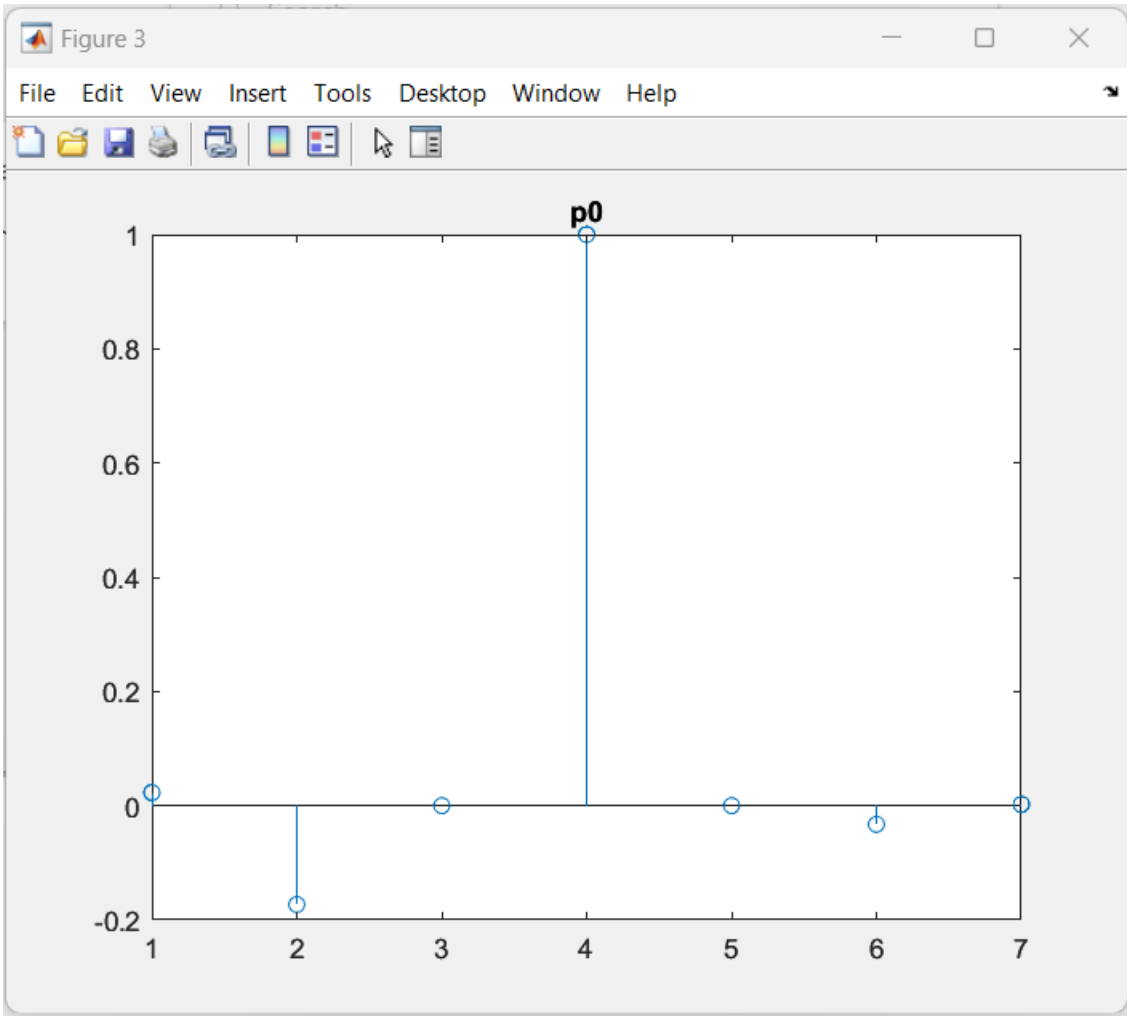


Figure 3
File Edit View Insert Tools Desktop Window Help
p0
1
0.8
0.6
0.4
0.2
0
-0.2
1 2 3 4 5 6 7