Subject Name: Wireless Communication

Subject Code: CSP311M

Name: Charvik Patel

Roll no: 1401079

Practical Number: 6

Aim: Write Matlab code of Inter-symbol interference(ISI) and Doppler shift and observe Difference in eye-diagram.

Brief Theory:

1. **Inter Symbol Interference (ISI):**
   Inter-symbol interference is a signal distortion in telecommunication. One or more symbols can interfere with other symbols causing noise. The main causes of ISI are multipath propagation in channels. This has the effect of a mixture of symbols, which can reduce signal clarity. If ISI occurs within a system, the receiver output becomes erroneous at the decision device.
   Representation in eye-diagram:

   An eye pattern provides a great information about the performance of the system.

   1. The width of the eye opening defines the time interval over which the received signal can be sampled without error from ISI. It is apparent that the preferred time for sampling is the instant of time at which the eye is open widest.
   2. The sensitivity of the system to timing error is determined by the rate of closure of the eye as the sampling time is varied.
   3. The height of the eye opening, at a specified sampling time, defines the margin over noise.
2. **Doppler Shift:**
   Doppler shift is a change in frequency due to the relative change in position or velocity of the receiver antenna

   RMS Delay Spread:

   Mean Excess Delay:

$$\bar{\tau} = \frac{\sum_k a_k^2 \tau_k}{\sum_k a_k^2} = \frac{\sum_k P(\tau_k)(\tau_k)}{\sum_k P(\tau_k)}$$

$$\sigma_\tau = \sqrt{\overline{\tau^2} - (\bar{\tau})^2} \qquad \overline{\tau^2} = \frac{\sum_k a_k^2 \tau_k^2}{\sum_k a_k^2} = \frac{\sum_k P(\tau_k)(\tau_k^2)}{\sum_k P(\tau_k)}$$

Matlab Code:

1. No ISI | No Doppler Shift:

```
%No ISI | No doppler shift
   t = [0, 1, 2, 5]*10^-6; % sample time
   p_dB = [-10, -20, -20, -30]; % power in dB
   p_W = 10.^(p_dB/10); % power in watt
   t_m = sum(p_W.*t)./sum(p_W);
   t_m_sqr = sum(p_W.*t.^2)./sum(p_W);
   sigma_t = sqrt(t_m_sqr - (t_m)^2); % average delay spread
   chan = rayleighchan(10^-5, 0, t, p_dB);
   tx = randsrc(10^3, 1, [-1, 1]);
   fad_channel = filter(chan, tx);
   eyediagram(fad_channel, 5);
   title('No ISI | No Doppler Shift');
```

2. No ISI | Doppler Shift:

```
   %No ISI | doppler shift
   t = [0, 1, 2, 5]*10^-6; % sample time
   p_dB = [-10, -20, -20, -30]; % power in dB
   p_W = 10.^(p_dB/10); % power in watt
   t_m = sum(p_W.*t)./sum(p_W);
   t_m_sqr = sum(p_W.*t.^2)./sum(p_W);
   sigma_t = sqrt(t_m_sqr - (t_m)^2); % average delay spread
   v = 500*5/18; % velocity in m/s
   fc = 128*10^6; % carrier frequency
   lambda = 3*10^8/fc;
   theta = 310*180/pi;%convert to degre
   fd = v*cos(theta)/lambda; % doppler shift
   chan = rayleighchan(10^-5, fd, t, p_dB);
   tx = randsrc(10^3, 1, [-1, 1]);
   fad_channel = filter(chan, tx);
   eyediagram(fad_channel, 5);
   title('No ISI | Doppler Shift');
```

3. **ISI | No Doppler Shift:**

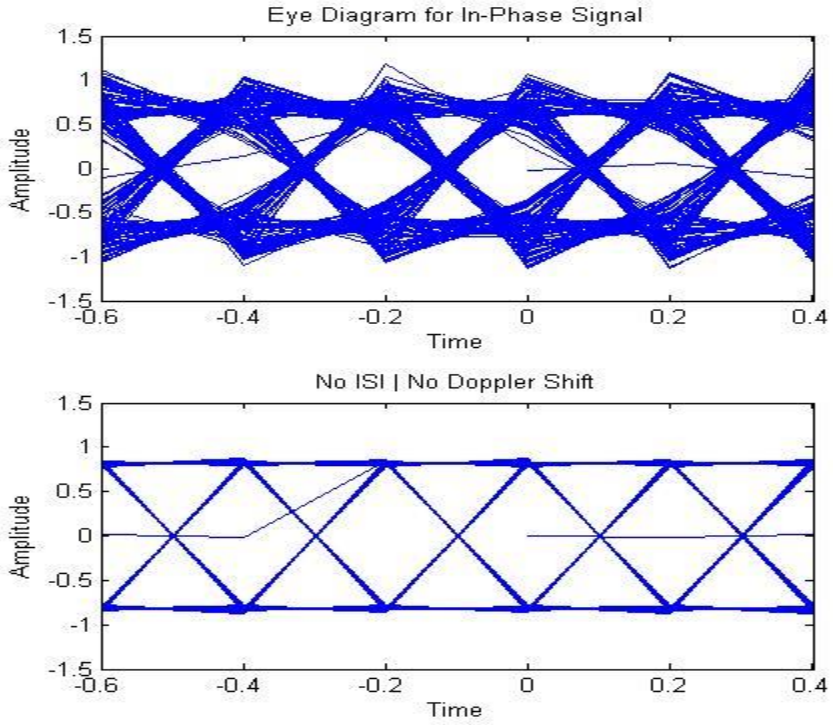
```
%ISI | No doppler shift
t = [0, 1, 2, 5]*10^-6; % sample time
p_dB = [-10, -20, -20, -30]; % power in dB
p_W = 10.^(p_dB/10); % power in watt
t_m = sum(p_W.*t)./sum(p_W);
t_m_sqr = sum(p_W.*t.^2)./sum(p_W);
sigma_t = sqrt(t_m_sqr - (t_m)^2); % average delay spread
chan = rayleighchan(10^-8, 0, t, p_dB);
tx = randsrc(10^3, 1, [-1, 1]);
fad_channel = filter(chan, tx);
eyediagram(fad_channel, 5);
title('ISI | No Doppler Shift');
```

4. **ISI | Doppler Shift:**

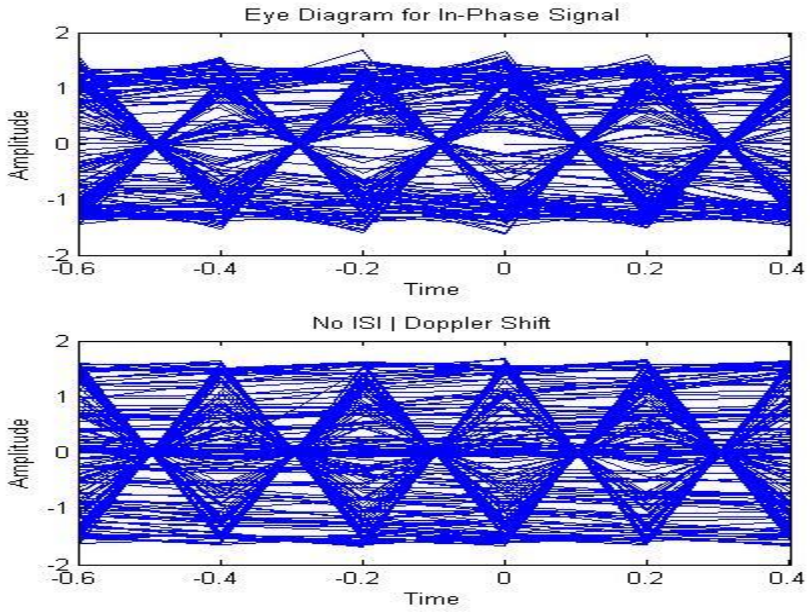
```
%ISI | doppler shift
t = [0, 1, 2, 5]*10^-6; % sample time
p_dB = [-10, -20, -20, -30]; % power in dB
p_W = 10.^(p_dB/10); % power in watt
t_m = sum(p_W.*t)./sum(p_W);
t_m_sqr = sum(p_W.*t.^2)./sum(p_W);
sigma_t = sqrt(t_m_sqr - (t_m)^2); % average delay spread
v = 500*5/18; % velocity in m/s
fc = 128*10^6; % carrier frequency
lambda = 3*10^8/fc;
theta = 310*180/pi;%convert to degre
fd = v*cos(theta)/lambda; % doppler shift
chan = rayleighchan(10^-8, fd, t, p_dB);
tx = randsrc(10^3, 1, [-1, 1]);
fad_channel = filter(chan, tx);
eyediagram(fad_channel, 5);
title('ISI | Doppler Shift');
```

Output:

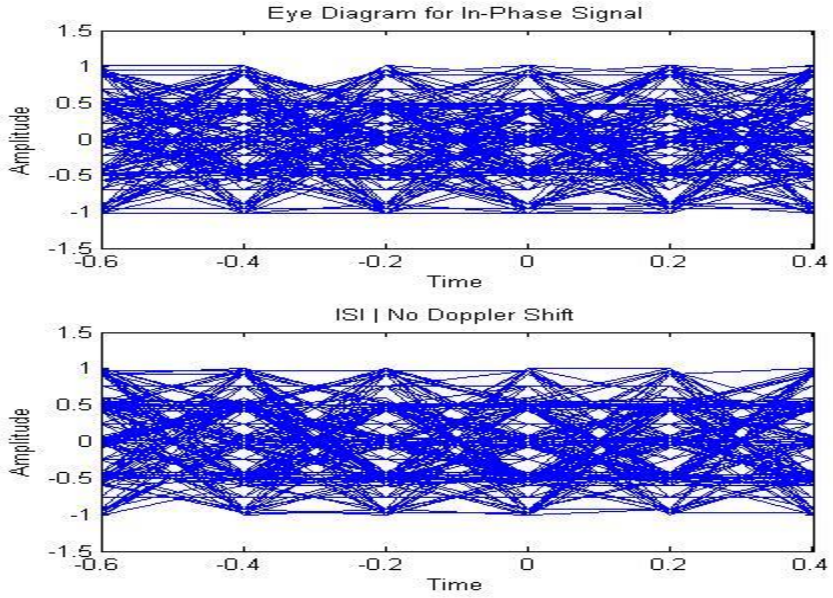
1. **No ISI | No Doppler Shift:**



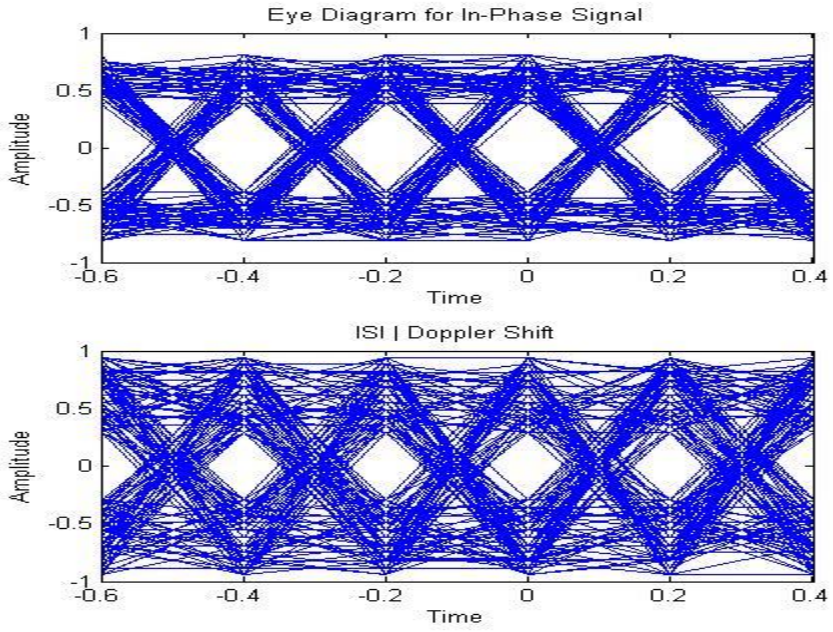
2. **No ISI | Doppler Shift:**



3. ISI | No Doppler Shift:



4. ISI | Doppler Shift:



Result Interpretation:

No ISI | No Doppler Shift: Symbol is not Distorted and eyes are open

No ISI | Doppler Shift: Symbol is slight Distorted and eyes are still open

ISI | No Doppler Shift: eyes are completely closed

ISI | Doppler Shift: eyes are wide open symbol is distorted