Doppler effect

When a radio wave and a receiver is moving, the frequency of received signal will not be same as of transmitted signal.

When they are moving toward each other, the frequency of received signal is higher than source frequency.

When they are moving away from each other, the frequency of received signal is lower thwn source frequency.

Thus frequency of received signal is

$$f_R = f_C \pm f_D$$

f_D →Doppler shift f_C →Carrier frequency

$f_D = \frac{v}{\lambda} \cos\theta$ λ → wavelength

v → speed of mobile

f_D depends on,

- Relative velocity
- Frequency of transmission
- Angle (direction of arriving signal)

Ex. If v=60 Km/Hr. BS height – 30mt and MS is 1Km away from BS f=900MHz. What is received frequency at MS.

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{900 \times 10^6} = 0.33\ mt$$

$$v = 60 \times \frac{1000}{3600} = 16.67\ mt/sec$$

$$\theta = \tan^{-1}\left(\frac{30}{1000}\right) = 1.72°$$

$$f_D = \frac{v}{\lambda}\cos\theta = \frac{16.67}{0.33}\cos(1.72°) = 50.49\ Hz$$

BS height ↑ →cos(θ) → ↓ → f_D → ↓

$$f_R = f_C + f_D = 900 \text{ X } 10^6 + 50.49$$

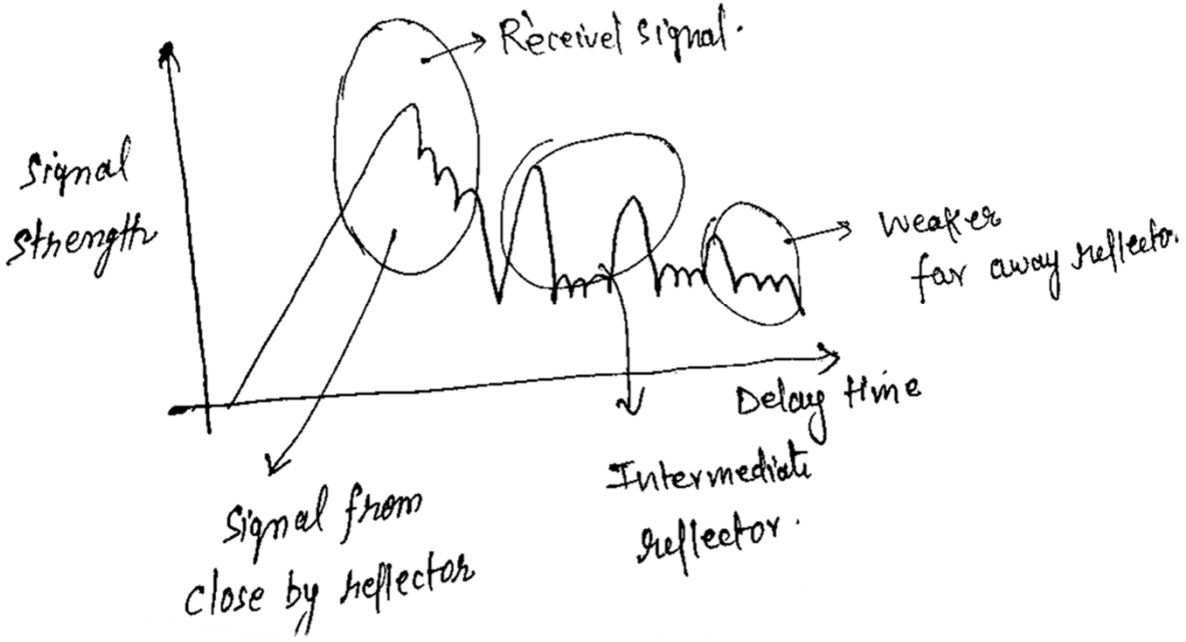
Terminology:

1. Level crossing rate – Average number of times per second the signal envelope crosses the level in positive going direction.
2. Fading rate – Number of times signal envelope crosses middle value in positive going direction per unit time.
3. Depth of fading – Ratio of mean square value and minimum value of faded signal.
4. Fading duration – Time for which signal is below given threshold. If it is long, call will drop.

Delay spread –

Each multipath signal travels different path length. So, time of arrival for each path is different.

1. A simple pulse will be spread in time when it reaches at receiver, this effect will spread out the signal and is called as delay spread.
2. It is property of communication channel.



Transmitted narrow pulse.

Delay spread will not effected by frequency of transmitted signal.

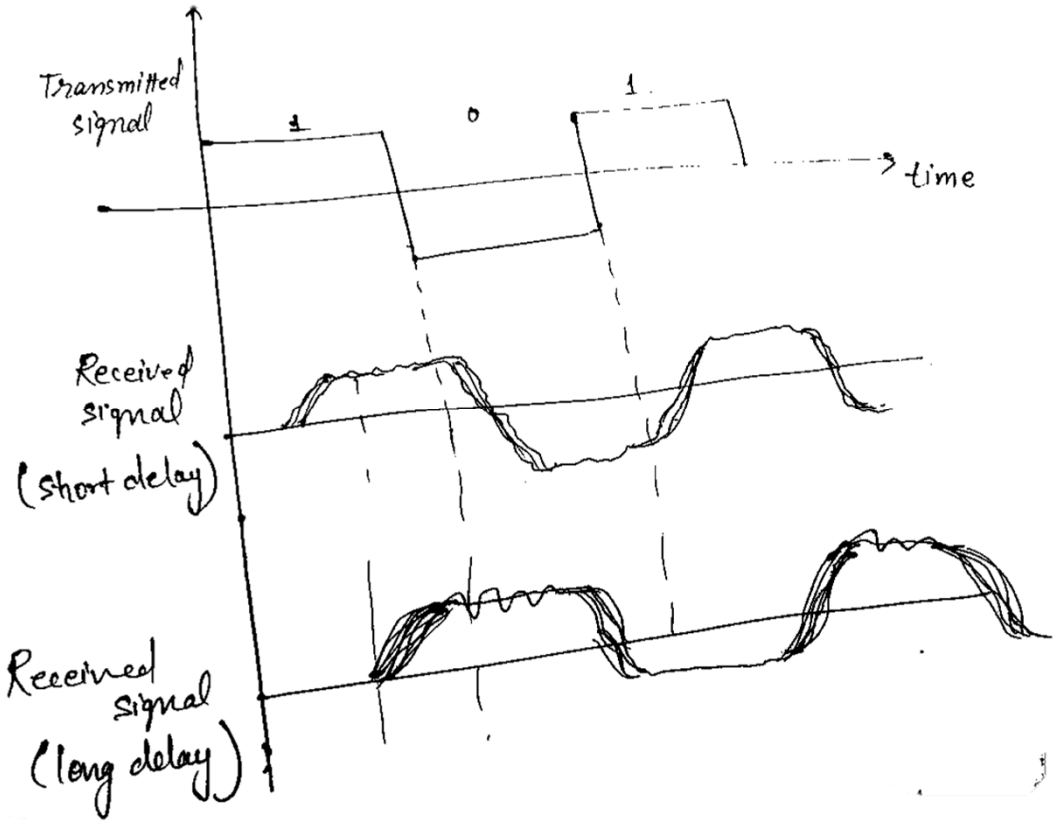
ISI (Inter Symbol Interference)

- If delay spread of channel is comparable with symbol length we get ISI.
- Second multipath is delayed and receiver during next symbol.
- ISI has impact on burst error rate of channel.

For low BER $R < \frac{1}{2\tau_d}$

R → Digital T_x rate (Data rate)

τ_d → Delay spread



Channel model parameters

1. Impulse Response
2. Frequency Response
3. Amplitude Fading
4. Arrival time
5. Path Loss
6. RMS delay spread
7. Power delay profile
8. Coherence Bandwidth
9. Number of significant multipath components

1. Arrival time – Time at which multipath component of pulse arrived.
2. Path Loss – The ratio of transmitted signa power to received signal power as a function of distance. It determines coverage area of system.
3. RMS delay spread – It is the square root of second central moment of power delay profile.it determines the frequency selectivity of channel fading.
4. Power delay profile – Average received power as function of excess delay.
5. Number of multipath components – That are within 10dB of peak multipath component.
6. Coherence Bandwidth – It is bandwidth over which signal propagation charactersticsare correlated.