



# Mapping Received Envelope Power into Fading Characteristics

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# Introduction



- Indoor radio communications is one of the major area under consideration in successful implementation of the Personal Communication Services [PCS] .
- These systems however, should be capable of working efficiently in wide range of operating conditions, such as large range of mobile unit (MU) speeds, different carrier frequencies in licensed and un-licensed bands, various delay spreads, and wide dynamic signal to-noise ratio (SNR) ranges.
- Now considering the fact that a relative movement between Transmitter and Receiver or in the environment between them, give rise to a shift in frequency range of the received signal, we are trying to estimate this Doppler shift by the received signal.
- Once the Doppler spread is estimated by the receiver, the receiver may adjust it self to receive data coming with slightly shifted frequency using some iterative process.

# Necessity of Doppler Spread Estimation



1

It provides information about the fading rate of the channel. Which can improve detection and aid into transmission optimization in both physical layer and higher levels.

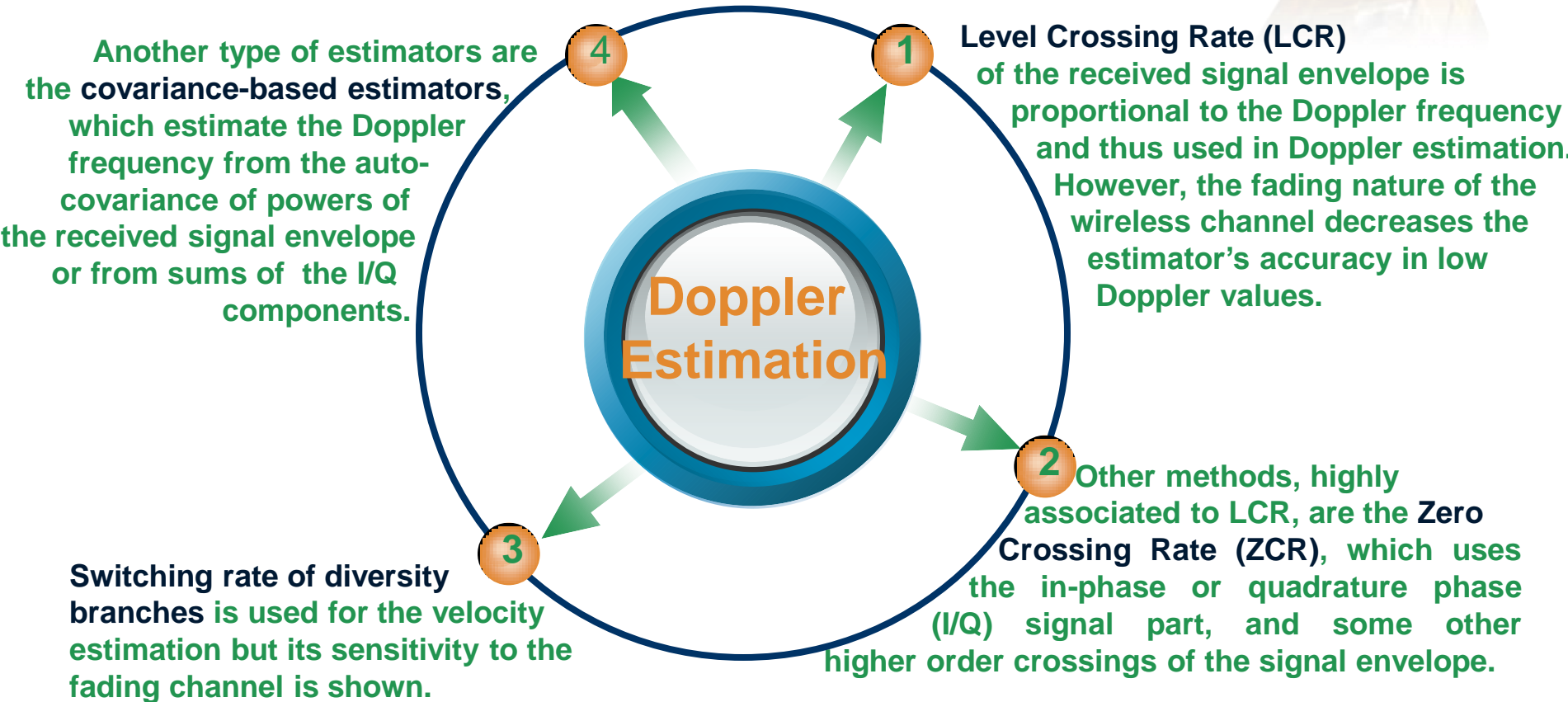
2

Doppler information can help in selection of appropriate transmission characteristics to combat ICI including proper channel estimators to enhance reception.

3

Some Channel estimators can be designed and applied. The rate of appliance can be chosen to improve throughput and an increase in the estimation rate can help to lower BER.

# Previous Work



# Doppler Estimator Novelty



## Novel Points Of Estimator

A more efficient method for estimation as it maps Received power with Fading Characteristics

The variations in frequency of the carrier are converted into variations in amplitude of the wave.

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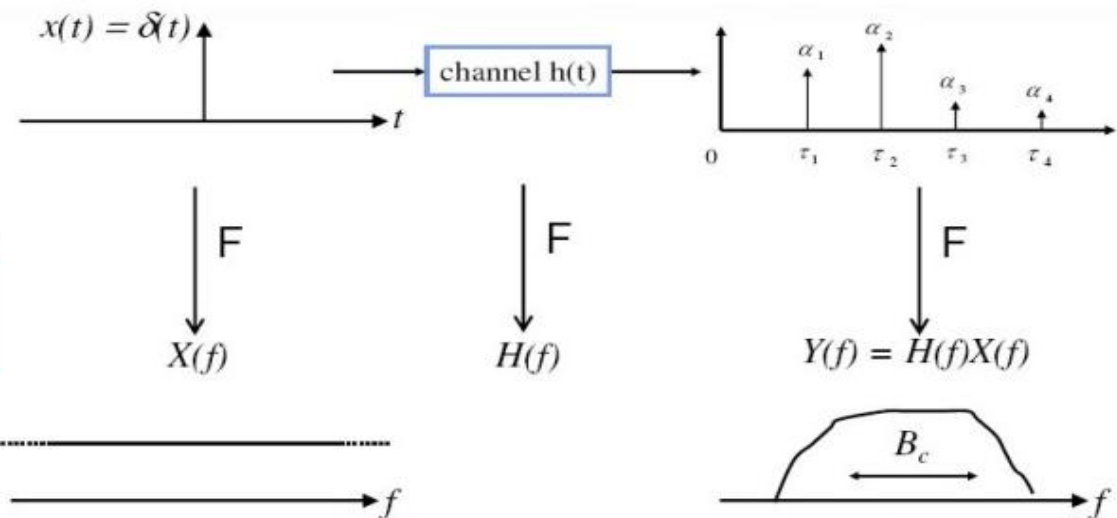
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# Rayleigh Fading Channel(1/4)

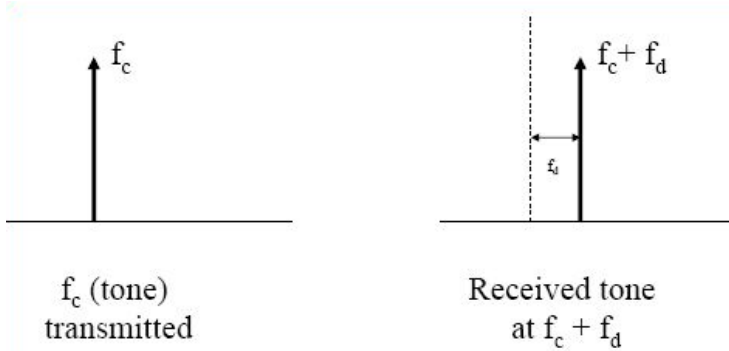
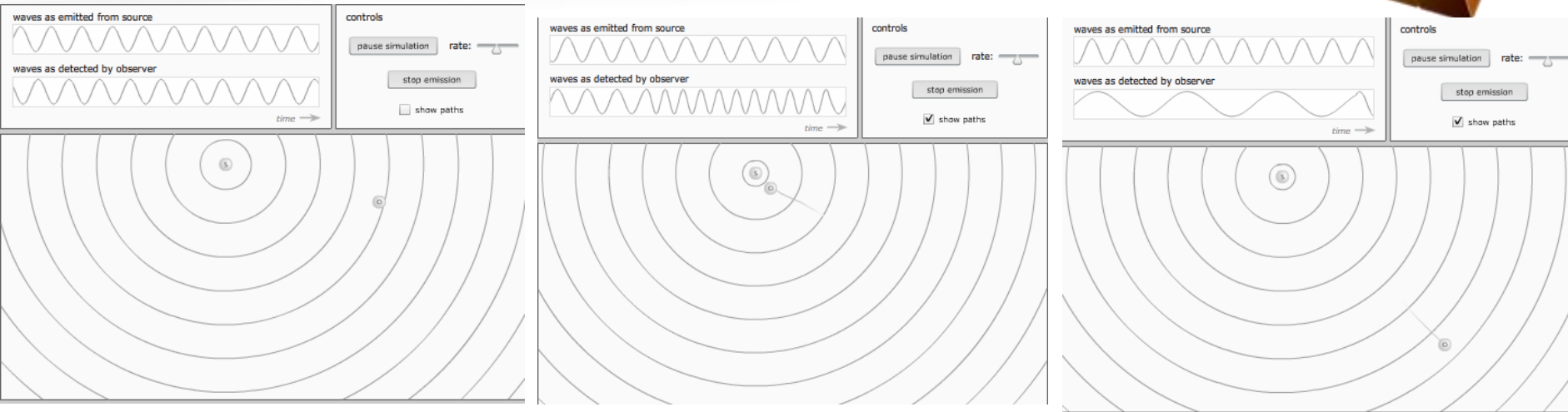


The multipath challenge



$$h(t, \tau) = \sum_{k=0}^{N(\tau)-1} \alpha_k(t) \delta[\tau - \tau_k(t)] e^{j\theta_k(t)}$$

# Rayleigh Fading Channel(2/4)



## Doppler Shift

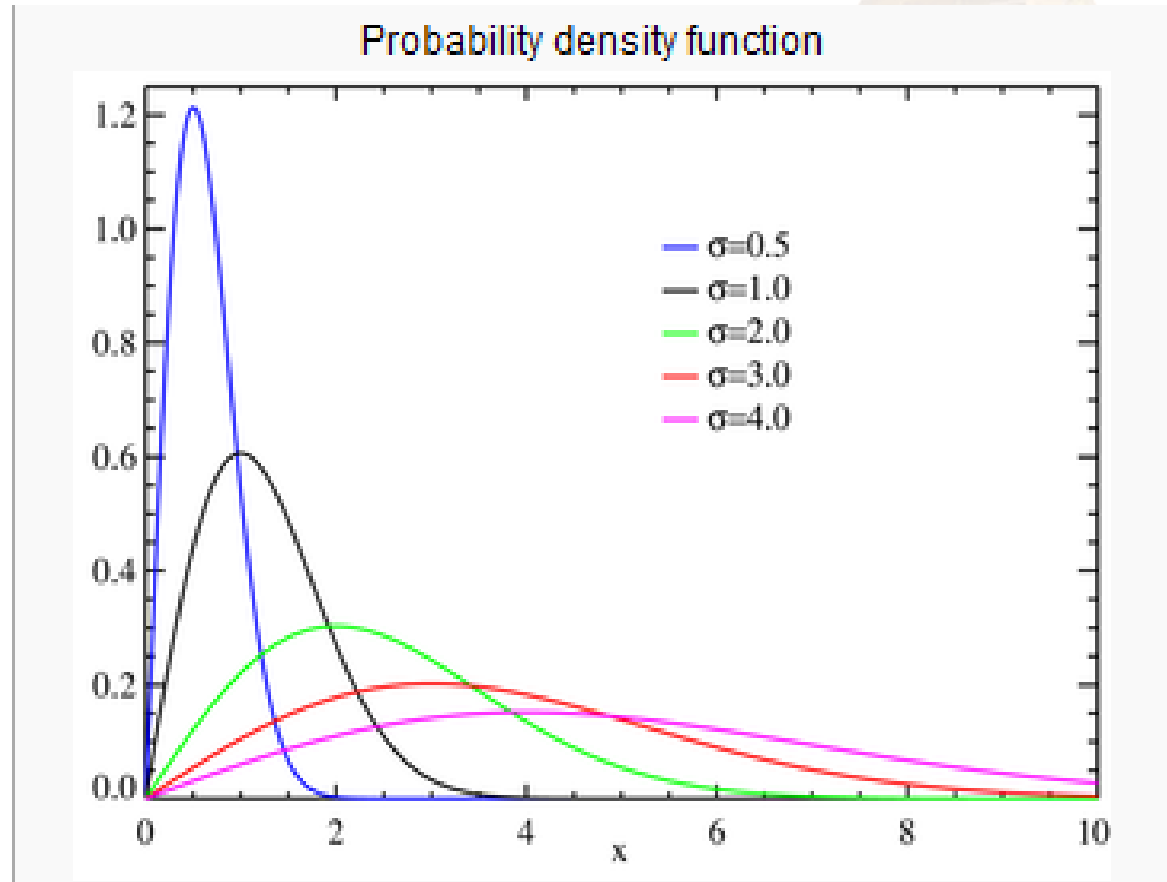
$$f_d = \frac{v}{c} \cdot f_c$$

# Rayleigh Fading Channel(3/4)

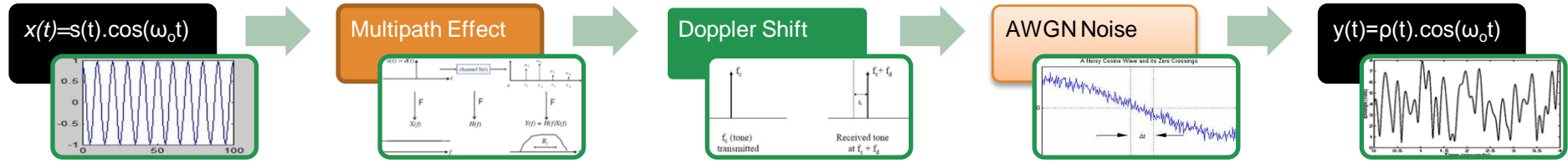


## Rayleigh Distribution

$$\Pr(r) = \frac{r}{\sigma^2} \exp\left\{-\frac{r^2}{2\sigma^2}\right\}, \quad r \geq 0$$



# Rayleigh Fading Channel(4/4)



## Channel Response

$$\rho(t) = \sum_{k=0}^{N-1} a_k s(t - t_k) e^{j\theta_k} + n(t).$$

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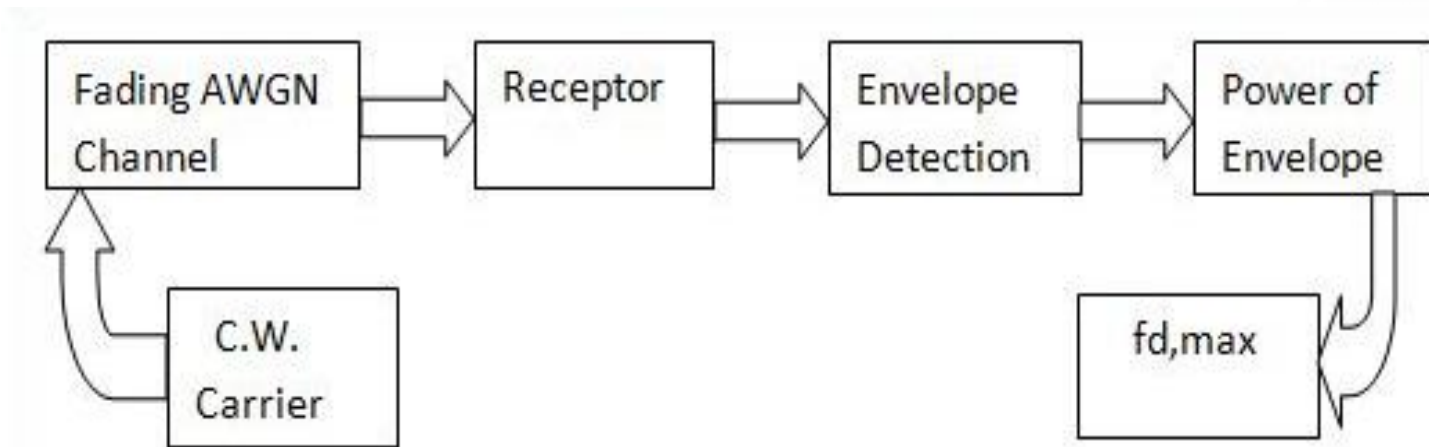
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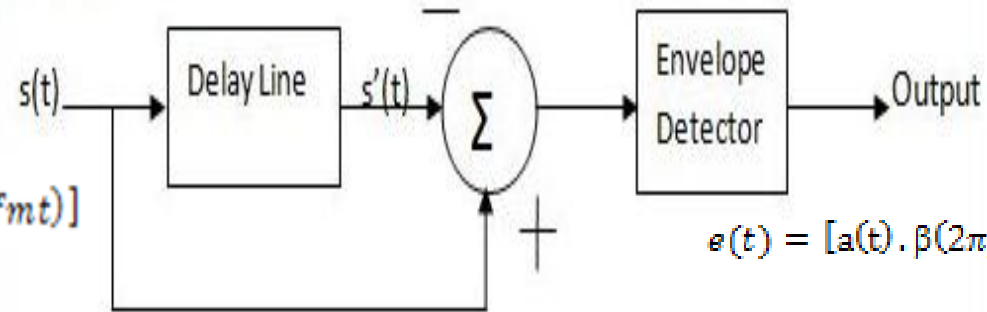
# Doppler Estimation Procedure



# Receiver



FM Wave



$$s(t) = a(t) \cdot A \cos [2\pi f_c t + \beta \sin(2\pi f_m t)]$$

$$e(t) = [a(t) \cdot \beta(2\pi f_m T) \cos(2\pi f_m t)] \cdot A$$

Delay line: Produces a phase shift of  $\pi/2$  radians

# Mathematical Equations Involved



$$s(t) = A \cos(2\pi fct) \cos[\beta \sin(2\pi fmt)] \\ - A \sin(2\pi fct) \sin[\beta \sin(2\pi fmt)]$$

$$\cos[\beta \sin(2\pi fmt)] \approx 1 \\ \sin[\beta \sin(2\pi fmt)] \approx \beta \sin(2\pi fmt)$$

$$s(t) = A[\cos(2\pi fct) - \beta \sin(2\pi fct) \sin(2\pi fmt)]$$

Passing through the delay line we get-

$$s'(t) = A[\cos(2\pi fc(t - T)) \\ - \beta \sin(2\pi fc(t - T)) \sin(2\pi fm(t - T))]$$

$$s'(t) = A[\sin(2\pi fct) - \beta \cos(2\pi fct) \sin(2\pi fmt - 2\pi fmT)]$$

$$r(t) = s'(t) - s(t) = [\beta(2\pi fmT) \cos(2\pi fct)]. A \cos(2\pi fct)$$

Considering the effect  $a(t)$  of multipath Fading-

$$r(t) = [a(t) \cdot \beta(2\pi fmT) \cos(2\pi fct)]. A \cos(2\pi fct)$$

$$r(t) = h(t) \cdot A \cos(2\pi fct)$$

Where

$$h(t) = a(t) \cdot \beta(2\pi fmT) \cos(2\pi fct)$$

Also there would be a carrier involved so,

$$r(t) = [b + h(t)] \cdot A \cos(2\pi fct)$$

Where  $bA$  is the amplitude of the carrier involved.

This  $r(t)$  is an AM wave now and we use an envelope detector to extract the envelope. The output of envelope detector would be-

$$e(t) = [b + a(t) \cdot \beta(2\pi fmT) \cos(2\pi fct)]. A$$

Filtering out the carrier gives:

$$e(t) = [a(t) \cdot \beta(2\pi fmT) \cos(2\pi fct)]. A$$

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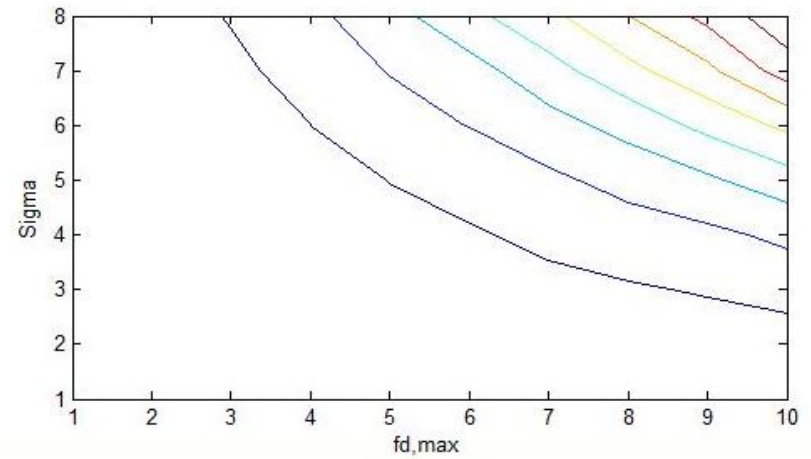
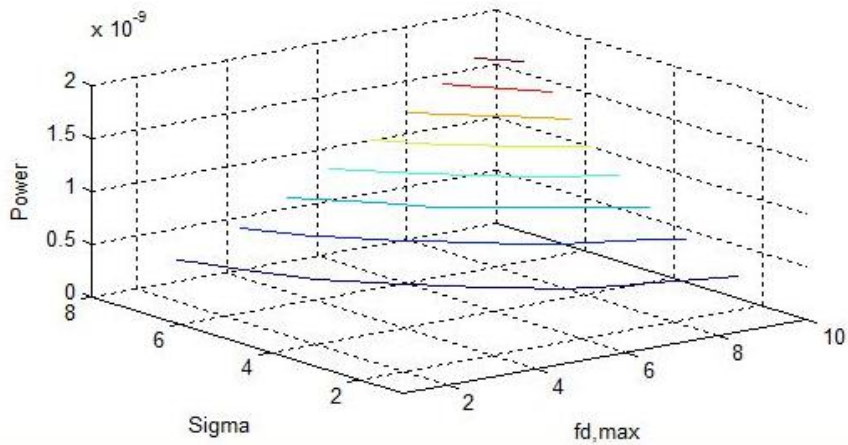
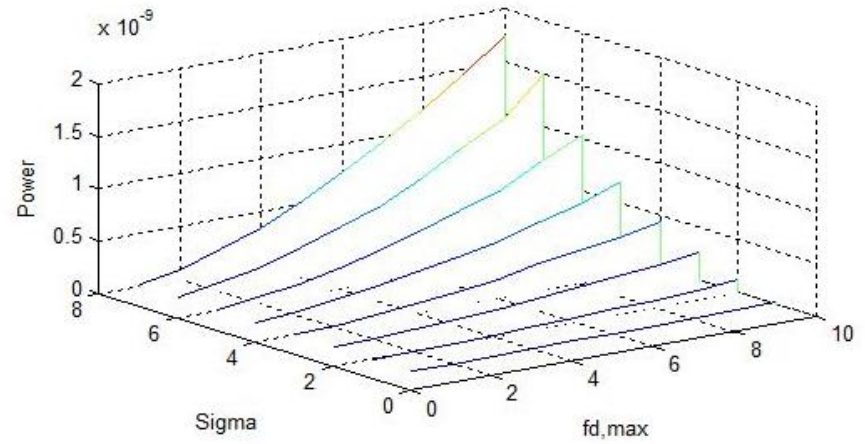
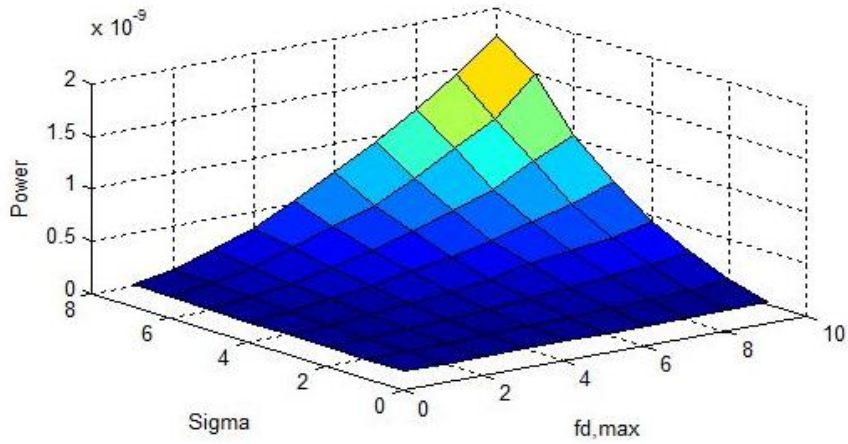
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# Simulation Results (1/2)



# Simulation Results (2/2)



Table: Power level with respect to Doppler spread for variations in Sigma.

$P = 1.0e-008$  \*

$\sigma \backslash f_d$	1	2	3	4	5	6	7	8	9	10
1	0.0000	0.0002	0.0003	0.0005	0.0008	0.0011	0.0015	0.0019	0.0024	0.0029
2	0.0002	0.0006	0.0014	0.0022	0.0032	0.0044	0.0058	0.0073	0.0094	0.0119
3	0.0004	0.0013	0.0030	0.0047	0.0075	0.0105	0.0143	0.0181	0.0217	0.0265
4	0.0007	0.0025	0.0051	0.0094	0.0131	0.0178	0.0252	0.0307	0.0355	0.0445
5	0.0011	0.0040	0.0083	0.0140	0.0203	0.0283	0.0358	0.0468	0.0571	0.0713
6	0.0015	0.0058	0.0118	0.0199	0.0289	0.0406	0.0531	0.0664	0.0855	0.1043
7	0.0021	0.0078	0.0158	0.0272	0.0411	0.0527	0.0721	0.0944	0.1145	0.1503
8	0.0027	0.0098	0.0213	0.0346	0.0534	0.0739	0.0952	0.1193	0.1454	0.1746

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“The received power level is observed to vary significantly with respect to the Doppler shift. This variation is unique for different values of  $\sigma$  in the fading channel model. The results are useful in direct estimation of Doppler shift from the received power level under known value of  $\sigma$ , that subsequently has been measured priory by some suitable technique.”



**Thank You !**

**Queries!**

