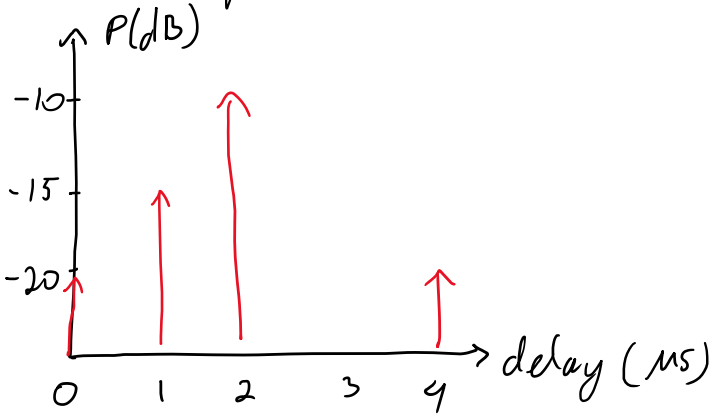
$v = 90\ km/jam = 25\ m/s$ $\quad f = 1800\ MHz$

$\theta = 0°$ $\quad BW = 200\ kHz$

$R_s = 120\ ksps$ $\quad$ faktor korelasi $> 0,5$



a. $T_s = \frac{1}{R_s} = \frac{1}{120.10^3} = 7,8125 \cdot 10^{-6}\ s = 7,8125\ \mu s$ Periode simbol

$\lambda = \frac{c}{f} = \frac{3.10^8}{1800.10^6} = \frac{1}{6}\ m$

$f_m = \frac{v}{\lambda} = \frac{25}{1/6} = 150\ Hz$ Doppler Spread

$T_c = \frac{0,423}{f_m} = \frac{0,423}{150} = 2,82 \cdot 10^{-3}\ s = 2,82\ ms$ Coherence Time

Syarat slow fading : $\boxed{T_s \leq T_c}$

$T_s\ max = T_c = 2,82\ ms$ Periode simbol max slow fading

b. $-20\ dB = \frac{1}{100} = 0,01$ $\quad -15\ dB = \frac{1}{30}$ $\quad -10\ dB = \frac{1}{10} = 0,1$

$\bar{\tau} = \frac{\sum P(\tau_k)\,\tau_k}{\sum P(\tau_k)} = \frac{0,01.0 + 1/30.1 + 0,1.2 + 0,01.4}{0,01 + 1/30 + 0,1 + 0,01} = \frac{0,273}{0,153} = 1,783\ ms$

$\bar{\tau^2} = \frac{\sum P(\tau_k)\tau_k^2}{\sum P(\tau_k)} = \frac{0,01.0^2 + 1/30.1^2 + 0,1.2^2 + 0,01.4^2}{0,01 + 1/30 + 0,1 + 0,01} = \frac{0,593}{0,153} = 3,87\ ms^2$

$$\sigma_\tau = \sqrt{\overline{\tau^2} - (\overline{\tau})^2} = \sqrt{3,07 - 1,703^2} = 0,031\ \mu s$$ Delay Spread

$$B_c \approx \frac{1}{5\,\sigma_\tau} = \frac{1}{5 \cdot 0,031 \cdot 10^{-6}} = 240,674\ kHz$$ Bw Coherence

Syarat flat fading : $BW_f \leq BW_c$

$BW_{max} = BW_c = 240,674\ kHz$ BW max flat fading

Karena BW sistem 200 kHz, maka yang terjadi adalah

Flat Fading

Mengatasi frecuency selective fading

- Equalizer
- Diversity
- channel coding

2. SIMO : 1×4 $\quad M = 4$

$\overline{SNR} = 13\ dB = 20\ x$

a. Selection Combining

$$\frac{\gamma}{\Gamma} = \sum_{k=1}^{M} \frac{1}{k} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} = \frac{25}{12} = 2,083$$

Max Ratio Combining

$$\frac{\gamma}{\Gamma} = M = 4$$

b. Selection Combining

$$R = \frac{\gamma}{\Gamma} \cdot \overline{SNR} = 2,083 \cdot 20 = 41,66$$

$$C = \log_2(1+R) = \log_2(1+41,66) = \log_2(42,66) = 5,415\ bps/Hz$$

Max Ratio Combining

$$R = \frac{\gamma}{\Gamma} \cdot \overline{SNR} = 4 \cdot 20 = 80$$

$$C = \log_2(1+R) = \log_2(1+80) = \log_2(81) = 6,34\ bps/Hz$$

c. $R = 10\ bps/Hz$ $\quad MIMO : 4 \times 4$ $\quad \overline{SNR} = 13\ dB = 20\ x$

multiplexing gain : $r \log_2(\overline{SNR}) = R$

$$r \log_2(20) = 10$$

$$r = \frac{10}{\log_2(20)}$$

$$r = 2,31378 \qquad \lceil r \rceil = 3$$

$N_T = N_R = 4$

$$d = (N_T - \lceil r \rceil)(N_R - \lceil r \rceil) = (4-3)(4-3) = 1$$

Manfaat MIMO :

- Meningkatkan kapasitas wireless channel tanpa melakukan penambahan bandwidth & power
- Pengurangan efek fading karena bertambahnya diversity
- Data rate dapat ditingkatkan dgn multiplexing spasial tanpa mengkonsumsi lebih banyak sumber daya frekuensi dan tanpa meningkatkan kekuatan total transmit