6)

Timing offset

Frequency distance = $\frac{\Delta l}{T_{sym}}$

phase rotation between two pilots = $2\pi \frac{\Delta l}{T_{sym}} \tau_0$

$$-\pi < 2\pi \frac{\Delta l}{T_{sym}} \tau_0 < \pi$$

$\Delta l = 1$

$$-\pi < 6 \frac{\tau_0}{T_{sym}} < 1$$

$$-\frac{1}{6} T_{sym} < \tau_0 < \frac{1}{6} T_{sym}$$

Frequency offset

Δm: distance of the closest same subcarrier

Time distance = $\Delta m \underbrace{(T_{sym} + T_{cp})}_{T_{overall}} = \Delta m \, T_{overall}$

Phase rotation between 2 pilots = $2\pi \Delta m \, T_{overall} \, F_{CFO}$

$$-\pi < 2\pi \Delta m T_{overall} F_{CFO} < \pi$$

$\Delta m = 4$

$$\frac{-1}{\gamma T_{overall}} < F_{CFO} < \frac{1}{\gamma T_{overall}}$$

7) If OFDM symbol are Tx in 1ms

a) I) For each subcarrier

total bits in 1ms for 1 subcarrier = 14+2
= 28 bits

$$\text{overhead} = \frac{2}{28} = \frac{1}{14}$$

II) Total bits in 1ms subcarrier = 14 × 8
= 112 bits

$$\text{overhead} = \frac{1}{56}$$

b) subcarrier symbols = 14×12
= 168

I) $\text{over head} = \frac{1}{168}$

II) $\text{over head} = \frac{2}{168 \times 8} = \frac{1}{672}$

8) $P_{tot} = 10mW$

Fr. response = [0.25, 0.5, 1, 1]

$$\mu = \frac{1}{N_{act}} \left[P_{tot} + \sum_{k \in N_{act}} \frac{1}{\gamma_k} \right] \quad \begin{cases} \gamma_k = \dfrac{|H_k|^2}{\text{DFN}_0} \\ \uparrow \text{channel SNR} \end{cases}$$

$N_{act} = 4$

$$\mu = \frac{1}{4} \left[50 + \frac{1}{(0.25)^2} + \frac{1}{(0.5)^2} + \frac{1}{1^2} + \frac{1}{12} \right]$$

$= 8$

$$P_{opt} = \max \left[\mu - \frac{1}{\gamma_k}, 0 \right]$$

$= \max(-7, 0)$ $\max(4, 0)$ $\max(7, 0)$ $\max(7,$

$= [0, 4, 7, 7]$

remove 0.25 subcarrier

$N_{act} = 3.6$

$P_{tot} = 10mW$

$$\mu = \frac{1}{3}\left[10 + \frac{1}{(0.5)^2} + \frac{1}{1^2} + \frac{1}{1^2}\right]$$

$$= 5.33$$

$$P_{opt} = \max\left(\mu - \frac{1}{\partial_k}, 0\right)$$

$$= \left[\max(5.33, 0), \max(4.33, 0), \max(4.33, 0)\right]$$

$$= \left[1.33 \quad 4.33 \quad 4.33\right]$$

$$C_k = \Delta f \log_2\left[1 + \frac{P_k |H_k|^2}{\Delta f N_0}\right] = \int_W \log_2\left(1 + \frac{P_{(f)} |H_{(f)}|^2}{N_0}\right) df$$

$$= \int_W \log_2\left[1 + \frac{10 |H_f|^2}{N_{act}}\right]$$

$$C_{opt} = \int_W \log_2\left[1 + \frac{10 (0.5^2)^2}{3}\right]$$

$$= 5.11$$

SNR even power alloc. $= 10 \log_{10}\left(\frac{|H_{ii}|^2 P_t}{N_{act}}\right)$

$= 5.74$ dB

SNR optimized power alloc. $= 10 \log_{10}\left(P_{opt} |H_i|^2\right)$

$= 10$