1. Delay distortion is one of the most significant impairments in transmission systems.

a) Present the reason of the occurrence of delay distortion. [50%]

b) Analysis the effects of delay distortion and the possible solutions to alleviate them, respectively. [50%]

1. a> Since ~~the~~ different components in the signal propagate at different speeds during transmission, it results in different arrival times at the receiver.

b> Effects: Some of the ~~signals~~ signal components of one bit position will spill over into other bit positions, causing intersymbol interference.

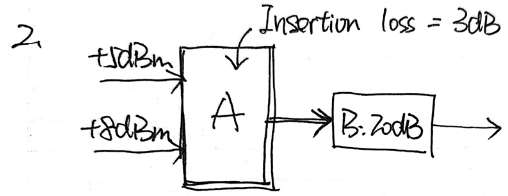
Equalizing techniques can alleviate them

2. Assume that a transmission system consists of two components A and B, A has two input ports with signal levels of 5 dBm and 8 dBm respectively, and the insertion loss of A is 3dB.

a) How many mW is the output signal of A? [50%]

b) If the output port of A is the input port of B, and the B has a gain of 20dB, how many W is the output signal of B? [50%]

2.



a> $P_1 = +5dBm = 10^{0.5}\ mW = \cancel{3.16mW}\ 3.162mW$

$P_2 = +8dBm = 10^{0.8}\ mW = 6.310\ mW$

Input power $P_i = P_1 + P_2 = 9.472mW = \cancel{9.764dBm}$

$10\log(9.472\ mW) = 9.764dBm.$

Out power $P_1 = P_i - 3dB = 6.764dBm$

b> $P_1 = 6.764\ dBm$

Output signal of B is: $P_2 = P_1 + 20dB = 26.764\ dBm$

3. Given that a company is deploying a metal cable as a transmission line, and the electrical properties are $58\Omega/km,\ 34\mu S/km,\ 48nF/km,\ 0.37mH/km$. If the signal frequency is 60MHz.

a) Calculate the characteristic impedance of this cable?

b) Calculate the propagation constant of this cable?

3. a) $R = 58\Omega/km \quad G = 34\mu S/km \quad L = 0.37mH/km$

$C = 48nF/km$

Since the frequency $f = 60MHz$ is very high, so $Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \approx \sqrt{\frac{L}{C}}$

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.37\times10^{-3}}{48\times10^{-9}}} = 87.81\Omega$$

b) Propagation constant: $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \alpha + j\beta$

Since $f = 60MHz > 30kHz$.

$$\alpha = \left(\frac{R}{2}\sqrt{\frac{C}{L}} + \frac{G}{2}\sqrt{\frac{L}{C}}\right) \ (Np/km)$$

$$\beta = \omega\sqrt{LC} \ (rad/km)$$

$\omega = 2\pi f = \cancel{377} \ 3.77\times10^{8}$ rad/s

$$\alpha = \left(\frac{58}{2}\cdot\sqrt{\frac{48\times10^{-9}}{0.37\times10^{-3}}} + \frac{34\times10^{-6}}{2}\sqrt{\frac{0.37\times10^{-3}}{48\times10^{-9}}}\right) = 0.33 \ (Np/km)$$

$$\beta = 3.77\times10^{8}\cdot\sqrt{0.37\times10^{-3}\times48\times10^{-9}} = 1587 \ (rad/km)$$

$\gamma = 0.33 + j1587$

4. A microwave transmission system employs parabolic antennas as transmitter and receiver. The diameters of the transmitting and receiving antennas are 2.2meters and 3.5 meters, respectively. Assume that the transmitter power is 100W at 3.5 GHz, the receiving antenna is located 50 KM away from the transmitting antenna.

a) What are the gains of the transmitting antenna and receiving antenna in decibels?

b) What is the available signal power out of the receiving antenna?

4. ~~a) ① Transmits~~

a) ~~Transmitter~~ Transmitting antenna: $r_1 = 1.1m$

Receiving antenna: $r_2 = 1.75m$

$A_1 = \pi r_1^2 = 3.8m^2$ $\quad A_2 = \pi r_2^2 = 9.62m^2$

$A_{e1} = 0.56A_1 = 2.128m^2$ $\quad A_{e2} = 0.56A_2 = 5.39m^2$

$\cancel{G_T = \frac{4\pi A_{e1}}{\lambda}}$ $\quad \lambda = \frac{c}{f} = \frac{3\times10^8 m/s}{3.5\times10^9 Hz} = 0.086m$

$G_T = \frac{4\pi A_{e1}}{\lambda^2} = 3615.6 \Rightarrow G_{T,dB} = 10lg(3615.6) = 35.58dB$

$G_R = \frac{4\pi A_{e2}}{\lambda^2} = 9158 \Rightarrow G_{R,dB} = 10lg(9158) = 39.62dB$

b) $L_{dB} = 32.45 + 20\,lg(d)(km) + 20lg(f)(MHz) - G_{T,dB} - G_{R,dB}$

$= 62.11dB$

$P_T = 100W$ ~~= 10lg(100)~~ $= P_{T,dB} = 10lg(100w) = 20dBW$

$P_R = P_{T,dB} - L_{dB} = 20dBW - 62.11dB = -42.11dB$

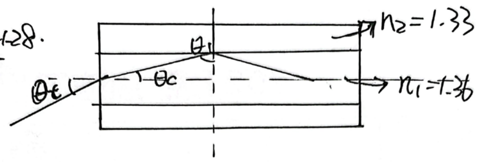
5. Assume a step-index optical fiber with core refractive index $n_1 = 1.36$ and cladding refractive index $n_2 = 1.33$. The acceptance angle, refraction angle, and reflection angle are denoted as $\theta_t,\ \theta_c,\ and\ \theta_1$, respectively.

a) If the interface of optical fiber is placed in vacuum with reflective index $n_0 = 1$, what is the numerical aperture?

b) If the interface of optical fiber is placed in liquid with reflective index $n_0 = 1.28$, what is the maximum acceptance angle?

5. $n_0 = 1.28$.

~~$n_0 = 1$~~



a) $NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.36^2 - 1.33^2} = 0.28$

b) $n_1 \sin\theta_1 = n_2 \sin 90^\circ \Rightarrow \sin\theta_1 = \frac{n_2}{n_1}$

~~$\theta_c = 90^\circ - \theta_1,\ \theta_1 = 90^\circ - \theta_c,\ so\ \sin\theta_1 = \sin(90^\circ - \theta_c) = \cos\theta_c$~~

$\theta_c = 90^\circ - \theta_1 \Rightarrow$ so $\sin\theta_c = \sin(90^\circ - \theta_1) = \cos\theta_1$

$n_0 \sin\theta_t = n_1 \sin\theta_c = n_1 \cos\theta_1 = n_1 \sqrt{1 - \sin^2\theta_1}$

$n_1\sqrt{1-\sin^2\theta_1} = n_1 \cdot \sqrt{1 - (\frac{n_2}{n_1})^2} = \sqrt{n_1^2 - n_2^2} = NA = 0.28$

so $\sin\theta_t = \frac{n_1\sqrt{1-\sin^2\theta_1}}{n_0} = \frac{0.28}{1.28} = \cancel{0.214}\ 0.219$

The maximum acceptance angle:

$\theta_t = \arcsin(0.219) = 12.65^\circ$