S-72.227 Digital Communication Systems (Spring 2005)

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Fiber Optic Communications

1.

The power budget for a system is given by the following expression

$P_i = P_o + C_L + M_a$ dB

where P_i is the mean input optical power launched into the fiber, P_o is the mean incident optical power required at the receiver, M_a is the safety margin, and C_L is the total channel loss. The total channel loss is given by,

$C_L = (\alpha_{fc} + \alpha_j)L + \alpha_{cr}$ dB

where L is the length in kilometers of the cable, α_{fc} is the fiber cable loss in decibels per kilometer, α_j is the loss due to joints (splices) in decibels per kilometers, and α_{cr} is the connector loss at the optical source and detector.

The following parameters are established for a long-haul single-mode optical fiber system operating at a wavelength of 1.3 um.

Mean power launched from the laser transmitter	-3 dBm
Cabled fiber loss	0.4 dB Km^{-1}
Splice loss	0.1 dB Km^{-1}
Connector loss at the transmitter and receiver	1 dB each
Mean power required at the APD receiver:	
When operating at 35 Mbit/s	-55 dBm
When operating at 400 Mbit/s	-44 dBm
Required safety margin	7 dB

Estimate:

(a) the maximum possible link length without repeaters when operating at 34 Mbit/s.

(b) the maximum possible link length without repeaters when operating at 400 Mbit/s.

2.

A silica fibre with has a core refractive index of 1.50 and a cladding refractive index of 1.47. Determine:

a) the critical angle at the core-cladding interface the NA for the fiber

b) the acceptance angle in air for the fiber.

Fading multipath radio channels

3.

The scattering function $S(\tau; v)$ for a fading multipath channel is nonzero for the range of values $0 \le \tau \le 1$ ms and $-0.1 \text{ Hz} \le v \le 0.1 \text{ Hz}$. Assume that the scattering function is approximately uniform in the two variables.

a. Give numerical values for the following parameters.
   1. The multipath spread of the channel
   2. The Doppler spread of the channel
   3. The coherence time of the channel
   4. The coherence bandwidth of the channel

b. Explain the meaning of the following taking into consideration the answers given in (a)
   1. The channel is frequency non-selective
   2. The channel is slowly fading
   3. The channel is frequency selective

4.

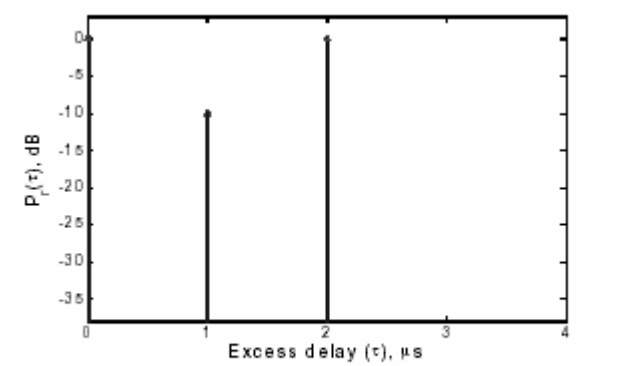
A Rayleigh fading radio channel has a delay spread of $T_m = 1$ ms and a Doppler spread $B_d = 10$ Hz. The signaling bandwidth is 25 KHz.

a. Estimate the coherence bandwidth and the coherence time of the channel
b. Is the channel frequency selective?
c. Are we dealing with slowly fading channel?

5.

A local spatial average of a power delay profile is shown below.

a. Determine the rms delay spread and mean excess delay for the channel
b. Determine the maximum excess delay (-20 dB).
c. Determine the maximum RF symbol rate if the symbol duration T is less than 10σ where σ is RMS delay spread, and ISI takes place.
d. If the mobile travelling at 30 Km/hr receives a signal through the channel, determine the time over which the channel appears stationary.



Power delay profile