CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC 4700 Telecommunications Engineering Winter 2008

Assignment 2

Posting date: Thursday, February 7, 2008
Due date: 12:00 noon, Wednesday, February 13, 2008 (in box outside ME 4438)
Late submission: no late submissions are allowed
The assignment solutions will be posted at 1:00 pm on Feb 13

Question 1 [20 marks] Link Budget

You are supposed to find the minimum required transmit power, P_t (dBW), in a mobile communication system through link budget analysis.

The path-loss is worse than that in free-space propagation due to the attenuation caused by objects:

- Path-loss (in linear scale): $PL = (4\pi f/c)^2 d^{3.5}$, where c=3x10^8 m/sec.

From the temperature (T=290°K) and the noise figure (F=6 dB), the noise power can be calculated:

- Noise power (in dBW): $P_n = -228.6 + 10 \log_{10} T[^{\circ}\text{K}] + 10 \log_{10} B[\text{Hz}] + F$.

The total antenna gain of transmitter and receiver is 25 dB. For satisfactory performance, the minimum required signal-to-noise ratio at the receiver is 10 dB. The carrier frequency is f =2 GHz, and the transmission bandwidth is 5 MHz.

(a) Sketch a graph of the required transmitter power in dBW as a function of distance between the transmitter and receiver from 0.1 km. to 10 km. (Plot distance on a logarithmic scale; that is, put the ticks of your horizontal axis at 0.1 km, 1 km, and 10 km.)

(b) Discuss the advantages and disadvantages of using a carrier frequency of 700 MHz, instead of 2 GHz, for the radio transmission of this type of signal in the context of providing coverage.

Solution (a):

SNR = $P_{RX} - P_n > 10$ [dB]
$= (P_{TX} + G_{TX} - PL + G_{RX})$ [dBW] – P_n [dBW] > 10 [dB]. (1)

P_n [dBW] = $-228.6 + 10\log_{10}T$[^{o}K] + $10\log_{10}B$[Hz] + F
= $-228.6 + 10\log_{10}290$[^{o}K] + $10\log_{10}(5\text{x}10^6)$ [Hz] + F
= -130.99 [dBW]. (2)

$PL = (4\pi f/c)^2 d^{3.5}$
= $20\log_{10}(4\pi f/c) + 35\log_{10}d$ [dB]
= $38.46 + 35\log_{10}d$ [dB]. (3)

Substitute (2) & (3) in (1):

$P_{TX} + 25 - 38.46 - 35\log_{10}d + 130.99 > 10$

→ $P_{TX} > 35\log_{10}d - 107.53$ [dBW].

If you call $x = \log_{10}d$, then the required graph will be the line

$P_{TX} = 35\,x - 107.53$.

In order to meet the SNR requirement, the transmit power has to be above this line for any given d value.

Solution (b):

Note that the carrier frequency does have an important impact on the path loss. If $f = 700$ MHz, then $PL = 29.34 + 35\log_{10}d$ [dB] which is 9.11 dB less than the path loss incurred with a carrier frequency of 2 GHz [note that $9.11 = 20\log_{10}(2/0.7)$]. Consequently,

$P_{TX} > 35\log_{10}d - 116.64$ [dBW].

This means, for a given P_{TX}, the required SNR values can be maintained at further distances; that is, the coverage increases.