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ET3202 - Wireless Communication I

Practical 02 – Link Budget Simulation using Matlab

AIM- Matlab simulation for link budget analysis

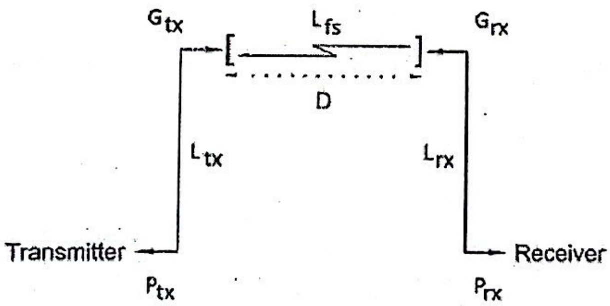
OBJECTIVES

- Design an App to analyze link budget

Software Requirements – Matlab App Designer

THEORY

To ensure a reliable link, the level of power available to the receiver should be in excess of that required for a minimum level of performance. An account of all the various gains and losses between the transmitter and the receiver is referred to as the link budget. The system factors involved in this accounting are illustrated in the figure.



Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) – Losses (dB)

Where:

P_{TX} = the transmit power in dBm.

L_{TX} = the total system loss in dB at the transmitter.

G_{TX} = the antenna gain in dBi at the transmitter.

LPATH = the total propagation losses in dB between the transmit and receive antennas.

G_{RX} = the antenna gain in dBi at the receiver.

L_{RX} = the total system loss in dB at the receiver.

P_{RX} = the receive power in dBm.

The level of received power in excess of that required for a specified minimum level of system performance is referred to as the fade margin. It provides a margin of safety in the event of a temporary attenuation or fading of the received signal power. The minimum required received power level used for the link budget can be totally arbitrary—owing to the designer's knowledge and experience—but is most often tied to the receiver's sensitivity. Simply put, the receiver's sensitivity specifies the minimum RF input power required to produce a useable output signal. Typical values for receiver sensitivity fall within the range of –90 to –120 dBm.

PROCEDURE

Given the following link description:

- RF output power (P_{TX}) = 5 watts; operating frequency = 170 MHz.
- Omnidirectional antenna (both ends) gain = 3 dBd;
- The elevation of the transmitting antenna is 30 meters.
- Transmission line at transmitter has a loss of L_{TX} = -3.2 dB
- The elevation of the receiving antenna is 10 meters.
- Transmission line at receiver has a loss of L_{RX} = -2.35 dB
- The path of propagation is an unobstructed line of sight (LOS) over a smooth earth.
- The distance between the transmitting and receiving antennas is 32.2 km.
- Rx Sensitivity = –119 dBm

Using Matlab app designer; design an app to derive the bellow link budget input parameters and output receiver power P_{RX} and fade margin. (A sample view of an app to calculate link budget is included at the end of the lab sheet for your reference)

1. To calculate transmitter power in dBm.
2. To calculate transmitter and reciever antenna gain in dBi.
3. Calculate maximum line of sight distance in kilometers

$$LOS_{MAX} = 4.124\sqrt{h_{TX}} + 4.124\sqrt{h_{RX}}$$

Where:

LOS_{MAX} = the maximum line-of-sight path distance in kilometers

h_{TX} = height of the transmitting antenna in meters above a smooth earth

h_{RX} = height of the receiving antenna in meters above a smooth earth

4. For a link to be considered as having a LOS path of propagation, the distance between the transmitter and receiver antennas must be equal to or less than the maximum line os sight distance. Does this link qualified as a LOS path propagation? Why?

5. To calculate the free space loss in dB.

$$FSL_{dB} = 32.45 + 20\log(d) + 20\log(f)$$

Where:

FSL_{dB} = free space loss in dB

d = distance in kilometers

f = frequency in megahertz

For distance in statute miles:

6. To calculate receiver power.

7. To calculate the fade margin

Fade Margin = PRX – Rx Sensitivity

DISCUSSION

A link budget provides a quick, simplistic assessment of a link's viability and should only be used as a design tool. The calculations herein provide only theoretical approximations and do not account for all of the myriad, real-world variables that can affect system performance. All link budgets should be verified via observed measurements before committing to an installation. Analysis is no substitute for empirical data. If a highly reliable, mission critical RF telemetry link is required, the design goal should be for a minimum fade margin of 20 to 30 dB. If the link budget calculations or on-site measurements indicate a fade margin of less than 10 dB, one should exercise all possible options to improve upon this figure.

Some possible options are:

• Use an antenna with a higher gain specification on one or both ends of the link. One should be cognizant of any FCC regulations that may put limits on the maximum radiated power for given transmitter site.

• Increase the antenna elevation at one or both ends of the link. If path obstructions or multipath interference is suspected, even a small increase (or decrease) of one-half wavelength could make a significant difference in received signal level. Any increase in system losses due to a longer transmission line are usually more than offset by the decrease in path loss.

• Add a repeater site to the path. By far, the largest factor in a link budget is path loss.

1. Briefly explain link budget, free space path loss
2. Analyze how power attenuated along with distance

Note - sample view of a designed app to calculate link budget using matlab app designer is shown below.