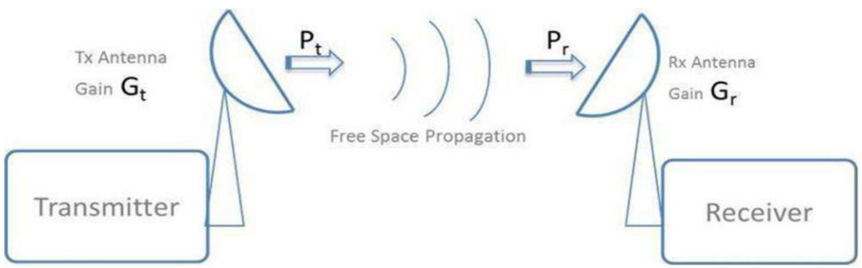
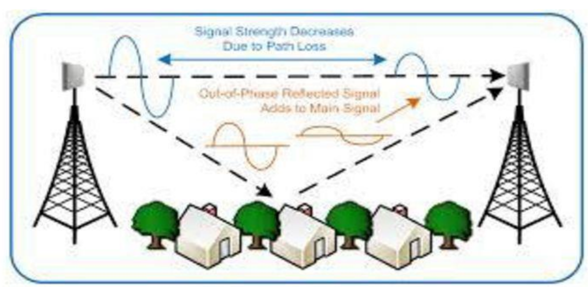
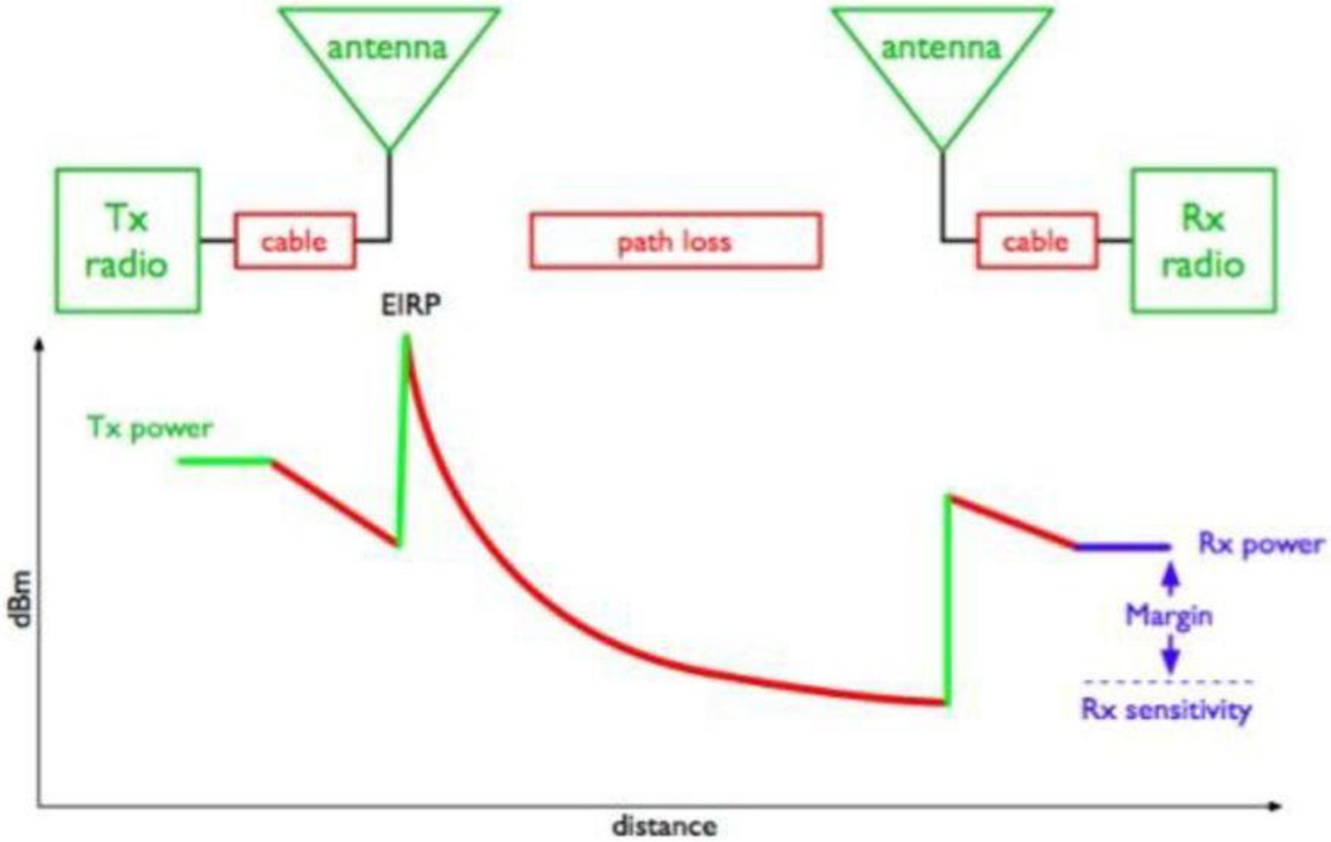
19EC601 – Wireless Communication

Unit -2
Mobile Radio Propagation
Link Budget Design





Power in a wireless system



- In a wireless communication system, the **link margin**, measured in dB, is the difference between the receiver's sensitivity (i.e., the received power at which the receiver will stop working) and the actual received power.
- A 15 dB link margin means that the system could tolerate an additional 15 dB of attenuation between the transmitter and the receiver, and it would still just barely work.
- It is typical to design a system with at least a few dB of link margin, to allow for attenuation that is not modelled elsewhere.

- A system with a negative link margin would mean the system is insufficient to transfer data, usually this means a better receiver is needed, with improved sensitivity.
- When designing a complete, i.e. end to end radio communications system, it is necessary to calculate what is termed the link budget.
- The link budget enables factors such as the required antennas gain levels, radio transmitter power levels, and receiver sensitivity figures to be determined.
- By assessing the link budget, it is possible to design the system so that it meets its requirements and performs correctly without being over designed at extra cost.

What is link budget?

- As the name implies, a link budget is an accounting of all the gains and losses in a transmission system.
- In essence the link budget will take the form of the equation below:

Received power (dBm) = Transmitted power (dBm) + gains (db) - losses (dB)

- Where the losses may vary with time, e.g. fading, and allowance must be made within the link budget for this - often the worst case may be taken, or alternatively an acceptance of periods of increased bit error rate (for digital signals) or degraded signal to noise ratio for analogue systems.

Link budget equation

- In order to devise a link budget equation, it is necessary to investigate all the areas where gains and losses may occur between the transmitter and the receiver.
- Although guidelines and suggestions can be made regarding the possible areas for losses and gains, each link has to be analysed on its own merits.

A typical link budget equation for a radio communications system may look like the following:

$$P_{RX} = P_{TX} + G_{TX} + G_{RX} - L_{TX} - L_{FS} - L_{P} - L_{RX}$$

Link budget equation

- Where:

  P_{RX} = received power (dBm)
  P_{TX} = transmitter output power (dBm)
  G_{TX} = transmitter antenna gain (dBi)
  G_{RX} = receiver antenna gain (dBi)
  L_{TX} = transmit feeder and associated losses (feeder, connectors, etc.)(dB)
  L_{FS} = free space loss or path loss (dB)
  L_{P} = miscellaneous signal propagation losses (these include fading margin, polarization mismatch, losses associated with medium through which signal is travelling, other losses...) (dB)
  L_{RX} = receiver feeder and associated losses (feeder, connectors, etc.) (d)B

- For the sake of showing losses in the link budget equation is "minus" actual loss figures, e.g. L_{TX} or L_{FS}, etc should be taken as the modulus of the loss.

RF Link Budget

$$P_{RX}(dBm) = P_{TX}(dBm) + G(dB) - L(dB) \qquad (1)$$

$$L = \frac{P_T}{P_R} = \frac{(4\pi)^2 d^N}{G_R G_T \lambda^2} = \frac{(4\pi)^2 d^N f^2}{c^2 G_R G_T} \qquad (2)$$

$$\lambda = \frac{c}{f} \qquad (3)$$

- *(1)The link budget equation*
- *(2)The path loss is proportional to the operation frequency f squared ; N=2 is free space path loss exponent, vary from 1~6 depends on environment*
- *(3) The antenna's length is inversely proportional to its operation frequency*

Effect of multipath propagation

- For true free space propagation such as that encountered for satellites there will be no noticeable reflections and there will only be one major path.
- However for terrestrial systems, the signal may reach the receiver via a number of different paths as a result of reflections, etc that will occur as a result of the objects around the path.
- Buildings, trees, objects around the office and home can all cause reflections that will result in the signal variations.

- The multipath propagation will cause variations of the signal strength when compared to that calculated from the free space path loss.
- If the signals arrive in phase with the direct signal, then the reflected signals will tend to reinforce the direct signal.
- If they are out of phase, then they will tend to cancel the signal.
- If either the transmitter or receiver moves, then the signal strength will be seen to vary as the relative strengths and phases of the different signals change.
- In order to allow for this in a link budget, a link margin is added into the equation to allow for this.

- Link budget calculations are an essential step in the design of a radio communications system.
- The link budget calculation enables the losses and gains to be seen, and devising a link budget enables the apportionment of losses, gains and power levels to be made if changes need to be made to enable the radio communications system to meet its operational requirements.
- Only by performing a link budget analysis is this possible. ....


Thank you