ELEC345

Lecture 2 dBs and Link Budgets

dB calculations
- Allows for dealing with large and small numbers easily
- dB = 10 lg (Distance)

Distance		dB
1mm	0.001m	-30dB
1m	-	0 dB
10m	-	10 dB
100m	-	20dB
1km	1000m	30 dB
10km	10 000m	40dB

Thermal Noise Power (N0) = kT
(measured in watts/Hz)
k : Boltzmann's constant = $1.380649 \times 10^{-23}\ m^2 kg s^{-2} K^{-1}$
T : Absolute temperature (room temp. 20°C = 293K)

Thermal Noise

$N = -204 + 10\log_{10}(B)$ — dBW $N_0 = -204$ — dBW/Hz

$N = -174 + 10\log_{10}(B)$ — dBm $N_0 = -174$ — dBm/Hz

-30dB

B: Bandwidth

Noise Factor

noise factor, $F = \dfrac{\left(\frac{S}{N}\right)_{in}}{\left(\frac{S}{N}\right)_{out}}$

Noise Figure

in dB, noise figure, $F = \left(\frac{S}{N}\right)_{in}(dB) - \left(\frac{S}{N}\right)_{out}(dB)$

Total Noise

$N = -204 + F(dB) + 10\log_{10}(B)$ — dBW

Path Loss

$$\boxed{L = 20\log_{10}\left(\frac{4\pi R}{\lambda}\right) dB}$$

R = distance from transmitter
λ = wavelength of signal from speed of light over frequency = c/f (3×10^8 m/s)

Example: WiFi @ 2.4GHz @ 100mW

GHz ⇒ 10^9
THz ⇒ 10^{12}

$\lambda = \dfrac{3\times10^8 m/s}{2.4\times10^9 Hz} = 0.125m$

$L = 20\log_{10}\left(\dfrac{4\pi(100)}{0.125}\right) = 80dB$

Communication System	Received Power	Transmit Power
GSM	-51dBm	Varies @ 900&1800MHz
GPS	-155dBW (-125dBm)	25.6W @ 1573MHz
WiFi	-75dBm or better	100mW @ 2.4GHz
Voyager Space Ships	-231dBm	18W @ 8GHz

Summary Question 1:
Calculate path loss given f = 800MHz and
Plympton 11 km & P_{TX}: 400W
Caradon 19 km & P_{TX}: 100kW
Then calculate the received power

⇒ Answer:
dB calculations: $10\log_{10}(400) = 26dBW$
$10\log_{10}(100\times10^3) = 50dBW$

$\lambda = \dfrac{3\times10^8}{800\times10^3} = 0.375m$

Path Loss: $20\log_{10}\left(\dfrac{4\pi(11000)}{0.375}\right) = 111dB$

$20\log_{10}\left(\dfrac{4\pi(19000)}{0.375}\right) = 116dB$

Received Power
$P_{TX} - P_L = P_{RX}$
26dB − 111dB = −85dBW → Plympton
50dB − 116dB = −66dBW → Caradon

Summary Question 2:
The WiFi in garage is 2.4GHz with bandwidth of 20MHz
P_{TX} = 100mW and distance = 25m. Find P_{RX} and SNR

⇒ $P_{RX} = P_{TX} - P_L$
P_{TX} = 100mW = 10log(100) = 20dBm
$P_L = 20\log\left(\dfrac{4\pi(25)}{\frac{3\times10^8}{2.4\times10^9}}\right) = 68dB$
Hence, P_{RX} = 20dBm − 68dB = −48dBm
SNR = P_{RX} − N
N = −174dBm + 10log(20×10⁶) = −100
SNR = −48dBm − 100 = 52dB