Data Communication:

Thermal Noise: "white noise"

The amount of thermal noise to be found in bandwidth of 1 HZ in any device: $N_o = K \cdot T$ (W/HZ)

where:

N_o: noise power density in watts per 1 of bw

k: Bolzmann's constant $= 1.38 \times 10^{-23}$ J/K

T: Temperature in Kelvins

Thermal noise in watts persent in a bw of B HZ

$$N = K \cdot T \cdot B$$

Ex.: Room temperature is 17c°

$N_o = K \cdot T = 1.38 \times 10^{-23} \times 290$

$= 4 \times 10^{-21}$ W/HZ

$= -204$ dBW/HZ

decible Notation:

$N = 10 \log k + 10 \log T + 10 \log B$

$= -228.6\,dBW + 10 \log T + 10 \log B$

Ex.: Given a receiver with an effective noise temperature of 294K and a 10 MHZ bw, the thermal noise at receiver output?

Sol: $N = 10 \log k + 10 \log T + 10 \log B$

$= -228.6\,dBW + 10 \log(294) + 10 \log(10^7)$

$= -228.6\,dBW + 24.7 + 70 = -133.9\,dBW$

* Nyquist Bandwith:

* Data rate is simply limited by bw
* if the rate of signal transmission is 2B, then a signal with frequency no greater than B is sufficient to carry the signal rate

or Given a bw of B, the highest signal rate that can be carried is 2B

Note: channel is error Free

if the signals are exprenices in two no huge levels the rate can be supported by BHZ is 2B bps

Nyquist to Multilevel signaling:

$C = 2B \log_2 M$

where

M: the number of discrete signal or voltage leveles

Ex: Consider a voice channel used via modem to transmit digital data. Assume a bw of 3100 HZ

Nyq. $C = 2B \log_2 M$ $(M = 8)$ örnek

$= 2 \cdot 3100 \log_2 8 = 18600$ bps

SHANNON CAPACITY:

Channel is not error free

For a given level of noise, we would expect that a precents signal strength would improve the ability to receive data correctly in present of signal-to-noise

Signal-to-noise Ratio (SNR) (S/R)

* The ratio of power in a signal to the power contained in the noise in any particuler point of transmission

Type measured at receives;

$SNR_{dB} = 10 \log_{10} \frac{\text{Signal power}}{\text{Noise power}}$ Ratio

Note: A high SNR will mean high-quality signal and a low number of required intermediate repeaters

Shannon's Maximum channel capacity:

$C = B \cdot \log_2 (1 + SNR)$

C: bps

B: HZ

Ex: Suppose that the spectrum of a channel is between 3MHZ and 4MHZ, SNR = 24dB

Sol: $B = 4 - 3 = 1$ MHZ

$SNR_{dB} = 24$ dB

we have:

$SNR_{dB} = 10 \log_{10} (SNR)$

$24 = 10 \log_{10} (SNR)$

$SNR = 251$

$C = B \log_2 (1 + SNR)$

$= 1 \times \log_2 (1 + 251)$

$= 1 \times \log_2 (252)$

$\simeq 8$ Mbps

Ödev1:

Consider a channel with a 1MHZ capacity and SNR of 63, what is the upper limit of the data rate of this channel?

Sol:

$C = B \times \log_2(1 + SNR)$

$= 1 \times \log_2(1 + 63)$

$= 1 \times \log_2(64) = 6$ Mbps

Ödev3:

A digital signaling system is required to operate at 9600 bps if a signal element is encoding a 4-bit word. What is the maximum required bw of the channel?

Sol:

$M = 4$-bit, $C = 9600$ bps

$C = 2B \log_2 M$

$9600 = 2B \cdot \log_2 4$

$4 \times B = 9600$

$B = 2400$ HZ

Ödev2:

Given a channel with intended capacity of 20Mbps, the bw of the channel is 3MHZ. what signal to noise ratio is required to achieve this capacity?

Sol: $C = 20$ Mbps

$B = 3$ MHZ

we have: $C = B \times \log_2(1 + SNR)$

$20 = 3 \times \log_2(1 + SNR)$

$1 + SNR = 101 \Rightarrow SNR = 100$

Kişisel Çözümdür!

hocanın Çözümü değildir

Data Communication:

Gain and Loss:

Signal streangth fall of exponentially
Loss is expressed in terms of DECIBEL (logartmic unit).
The decible is a measure of the ratio between two signal level

Decible Gain:

$$G_{dB} = 10 \log \frac{P_{out}}{P_{in}}$$

where:

P_{out}: output power level

P_{in}: input power level

~~G_{dB}~~ G_{dB}: gain in decible

Decible Loss:

$$L_{dB} = -10 \log \frac{P_{out}}{P_{in}} = 10 \log \frac{P_{in}}{P_{out}}$$

Ex: $P_{in} = 10mw$, $P_{out} = 5mw$

$$L_{dB} = 10 \log \frac{P_{in}}{P_{out}} = 10 \log 2 = 3.01 dB$$

Decible-Watts dBW:

The absolute decible level of power in dBW is:

$$Power_{dBW} = 10 \log \frac{Power\,w}{1w} = 10 \log (power\,w)$$

Ex: 1000 w → 30dBW

1mw → -30dBW

Antenna-Gain:

$$G_{dB} = 10 \log \frac{P_2}{P_1}$$ where:

G_{dB}: antenne gain

P_1: radited power from reference antenne

P_2: radited 〃 〃 directional 〃

Ex: Consider a directional antenna that has gain of 6dB over a referance antenna that radiates 700w. How much power must referance antenna radiate to provide same signal power in ...?

Sol: we have:

$$G_{dB} = 10 . \log \frac{P_2}{P_1} \Rightarrow 6 = 10 \log \frac{P_2}{700}$$

$$\frac{P_2}{700} = 10^{0.6} = 3.98 \Rightarrow$$

$$P_2 = 2788 w$$

Effective Area of an Antenna (Ae):

Ae: of an antenna is related to its physical size on a its shape,

$$G = \frac{4\pi Ae}{\lambda^2} = \frac{4\pi f^2 Ae}{c^2}$$

where:

Ae: effective area (m^2)

G: antenna gain (ratio)

f: carries frequency (HZ)

c: speed of light ($\simeq 3 \times 10^8$ m/s)

λ: carries wave length (m)

« $G_{dB} = 10 \log G$ »

Effective Area of an isotropic Antenna:

$Ae = \frac{\lambda^2}{4\pi}$ with a power gain of 1

Effective Area of an parabolic reflective with face area of A

$Ae = 0.5\,A$

power gain is $\frac{7A}{\lambda^2}$

Ex/ For a parabolic reflective antenna with a diameter of 2m operating at 12GHz. What are Ae and G?

Sol/: $2r = 2m \Rightarrow r = 1m$

$f = 12\,GHz = 12\times10^9\,Hz$

$\lambda = c/f = \frac{3\times10^8}{12\times10^9} = 0.025\ m$

$A = \pi r^2 = \pi(1)^2 = \pi$

$Ae = 0.5A$

$= 0.5(\pi) = 0.5\pi$

$G = \frac{7A}{\lambda^2} = \frac{7\pi}{(0.025)^2} = 35.186$

$G_{dB} = 10\log G = 10\log(35.186)$

$= 45.46\ dB$

Summary

Type	Ae	Power gain
Isotropic	$\lambda^2/4\pi$	1
Parabolic faces area A	$0.56\,A$	$7A/\lambda^2$
Infinitesmal	$1.5\,\lambda^2/4\pi$	1.5
Half wave dispole	$1.64\,\lambda^2/4\pi$	1.64
Horn / Mouth area of A	$0.81\,A$	$10A/\lambda^2$
Turnstile	$1.15\,\lambda^2/4\pi$	1.15

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Data Communication:

Optical Los:

The term optical line of sight refers to the straight line propogation of light waves

$$d = 3.57\sqrt{h}$$

d ↓ Km, h ↓ m

Radio los:

The term radio line of sight or effective los, refers to propogation of radio waves bent by curvers of earth

$$d = 3.57\sqrt{k.h}$$

where:

k: is an adjustment factor to account

$k = 4/3$

★ Maximum distance btw two antenna for los propogation:

$$d = 3.57(\sqrt{k.h_1} + \sqrt{k.h_2})$$

where:

h_1, h_2 are the hieghest of two antenna

Ex): a): What is the maximum distance btw two antenna, if one antenna is 100m high and the other is at ground level?

$h_1 = 100\ m$

ground level $(h_2) = 0\ m$

$$d = 3.57(\sqrt{k.h_1} + \sqrt{k.h_2})$$

$$= 3.57(\sqrt{\tfrac{4}{3}.100} + \sqrt{\tfrac{4}{3}\times 0})$$

$$= 41\ Km$$

b): Now suppose that the receiving antenna is 10m high. To achieve the same distance, how high must the transmitting antenna be?

sol//

We have $d = 41\ Km$

$$d = 3.57(\sqrt{k.h_1} + \sqrt{k.h_2})$$

$$41 = 3.57(\sqrt{\tfrac{4}{3}.h_1} + \sqrt{\tfrac{4}{3}.10})$$

$$41 = 3.57(\sqrt{\tfrac{4}{3}h_1} + \sqrt{13.3}) \Rightarrow$$

$$\boxed{h_1 = 46.2m}$$

Free Space: is same attonuation in guided and unguided madia

Free space Loss: for other types of antennas

$$\frac{P_t}{P_r} = \frac{(4\pi)^2.d^2}{G_t.G_r.\lambda^2} = \frac{(\lambda d)^2}{A_t.A_r} = \frac{(c.d)^2}{f^2.A_t.A_r}$$

where:

G_t: gain of transsion antenna

λ: carrier wavelength

d: propogation distance btw antennas

C: speed of light $(3\times10^8\ m/s)$

A_r: Ae of recieving antenna

$$L_{dB} = 20\log(f) + 20\log(d) - 169.54dB$$

$$L_{dB} = 20\log(\lambda) + 20\log(d) - 10\log(A_t A_r)$$

$$= -20\log(f) + 20\log(d) - 10\log(A_t A_r) + \cancel{20\log}\ 169.54dB$$

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