

PHYSICAL LAYER FORMULAS:

frequency = 1/period

n periods in a sec

period = 1/n secs

Period		Frequency	
Unit	Equivalent	Unit	Equivalent
Seconds (s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (kHz)	10^3 Hz
Microseconds (μ s)	10^{-6} s	Megahertz (MHz)	10^6 Hz
Nanoseconds (ns)	10^{-9} s	Gigahertz (GHz)	10^9 Hz
Picoseconds (ps)	10^{-12} s	Terahertz (THz)	10^{12} Hz

phase shift:

offset of 1/n cycle

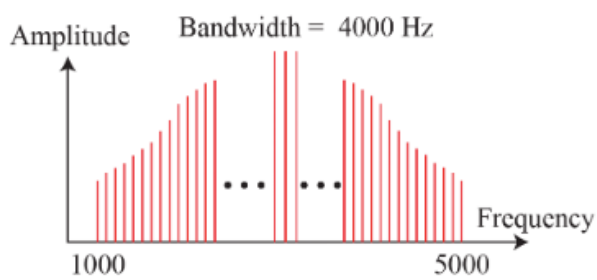
$1/n * 360$ degrees = answer in degrees = answer * $(2\pi/360)$ = answer in radians

wavelength = Propagation speed X period

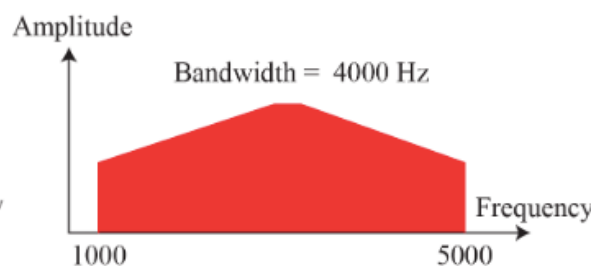
$$\lambda = \frac{c}{f}$$

bandwidth of composite signal = range of frequency

= largest freq – smallest freq

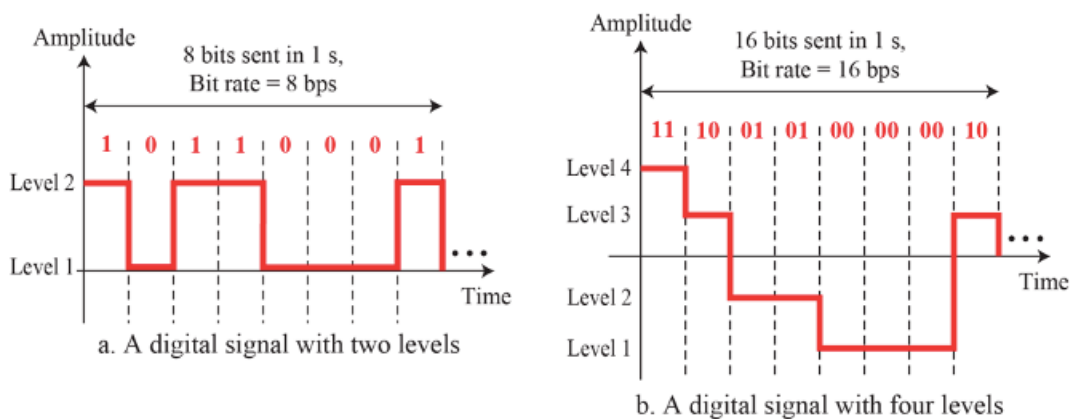


a. Bandwidth of a periodic signal



b. Bandwidth of a nonperiodic signal

If signal has N levels, each level needs $\log_2 L$ bits



L represents levels.

number of bits sent per level must always be power of two

To show signal has lost or gained the strength, **decibel (dB)** unit is used.

Signal attenuated \rightarrow -ve dB

Signal amplified \rightarrow +ve dB

$$dB = 10 \log_{10} \frac{P_2}{P_1}$$

Signal-to-noise Ratio (SNR) = $\frac{\text{average signal power}}{\text{average noise power}}$

SNR (High) \rightarrow signal is less corrupted

SNR (low) \rightarrow signal is more corrupted

SNR is ratio of two powers, it is often described in decibel units,

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

Noiseless Channel: Nyquist Rate

$$\text{BitRate} = 2 \times \text{bandwidth} \times \log_2 L$$

Noisy Channel: Shannon Capacity

$$\text{Capacity} = \text{bandwidth} \times \log_2(1 + SNR)$$

NETWORK LAYER FORMULAS:

Bellman-Ford equation

Let $D_x(y)$: cost of least-cost path from x to y .

Then:

$$D_x(y) = \min_v \{ c_{x,v} + D_v(y) \}$$

\min taken over all neighbors v of x

$c_{x,v}$ direct cost of link from x to v
 $D_v(y)$ v 's estimated least-cost-path cost to y

ICMP

Type	Code	description
0	0	echo reply (ping)
3	0	dest. network unreachable
3	1	dest host unreachable
3	2	dest protocol unreachable
3	3	dest port unreachable
3	6	dest network unknown
3	7	dest host unknown
4	0	source quench (congestion control - not used)
8	0	echo request (ping)
9	0	route advertisement
10	0	router discovery
11	0	TTL expired
12	0	bad IP header

Formula:

$$\text{The required number of fragments} = \left\lceil \frac{\text{Datagram} - \text{IP header}}{\text{MTU} - \text{IP header}} \right\rceil$$

LINK LAYER FORMULAS:

Cyclic Redundancy Check (CRC): example

We want:

$$D \cdot 2^r \text{ XOR } R = nG$$

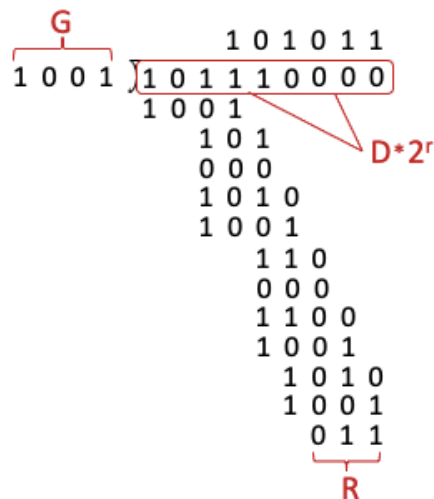
or equivalently:

$$D \cdot 2^r = nG \text{ XOR } R$$

or equivalently:

if we divide $D \cdot 2^r$ by G , want remainder R to satisfy:

$$R = \text{remainder} \left[\frac{D \cdot 2^r}{G} \right]$$



CSMA/CD:

delay after n number of collision

k chosen from $\{0, 1, 2, \dots, 2^n - 1\}$

delay = $k * 512$ bit times