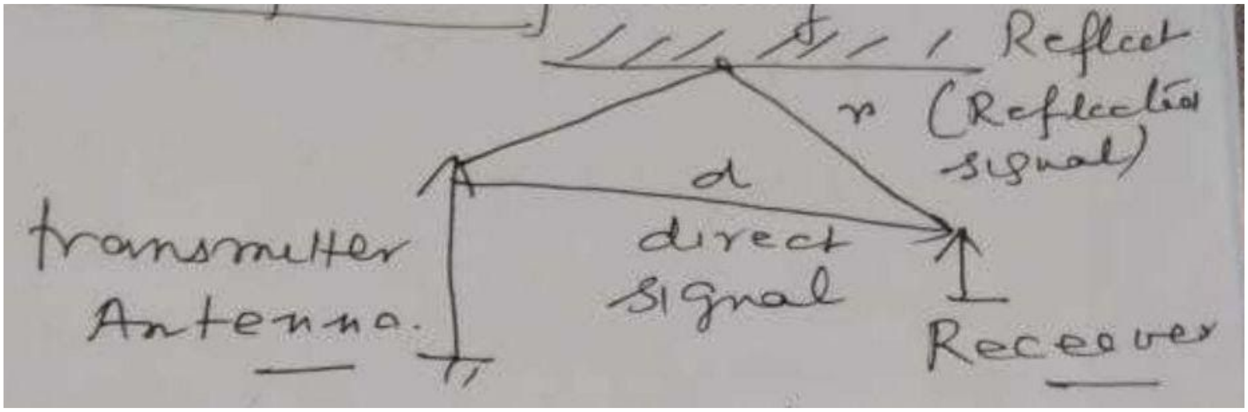
Satellite & Mobile Communication Network

25.08.2020

1. **Multiple Fading**



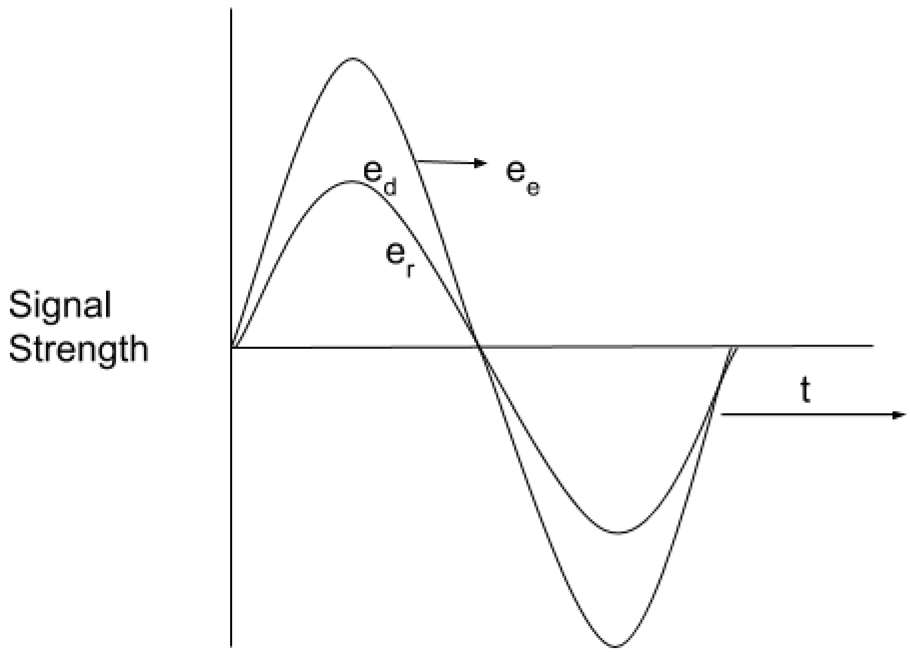
Distance travelled by direct signal = d
Distance travelled by reflected signal = r

a. $e(t, x) = E\,sin(2\pi ft + \frac{2\pi}{\lambda}x)$
b. $e_d(t, d) = E\,sin(2\pi ft + \frac{2\pi}{\lambda}d)$
c. $e_r(t, r) = E\,sin(2\pi ft + \frac{2\pi}{\lambda}r)$

Effective signal at the receiver

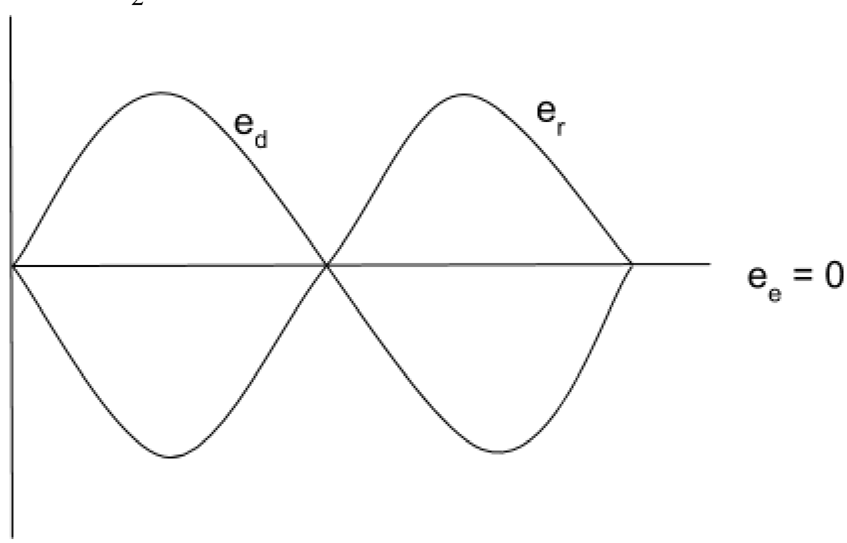
d. $e_e = e_d(t, d) + e_r(t, r)$
$= Esin(2\pi ft + \frac{2\pi}{\lambda}d) + Esin(2\pi ft + \frac{2\pi}{\lambda}r)$

e. Case 1:
Let $r = d + \lambda$
$e_e = Esin(2\pi ft + \frac{2\pi}{\lambda}d) + Esin(2\pi ft + \frac{2\pi}{\lambda}(d + \lambda))$
$= Esin(2\pi ft + \frac{2\pi}{\lambda} + 2\pi)$
$= Esin(2\pi ft + \frac{2\pi}{\lambda}d) + Esin(2\pi ft + \frac{2\pi}{\lambda}d + 2\pi)$
$= 2Esin(2\pi ft + \frac{2\pi}{\lambda}d)$
Signal strength doubles due to constructive interference → No multiple fading.



f. **Case 2:**

$$r = d + \frac{\lambda}{2}$$



Full Multipath Fading

$$e_d(t,\ d) = E\ sin(2\pi ft + \frac{2\pi}{\lambda}d)$$

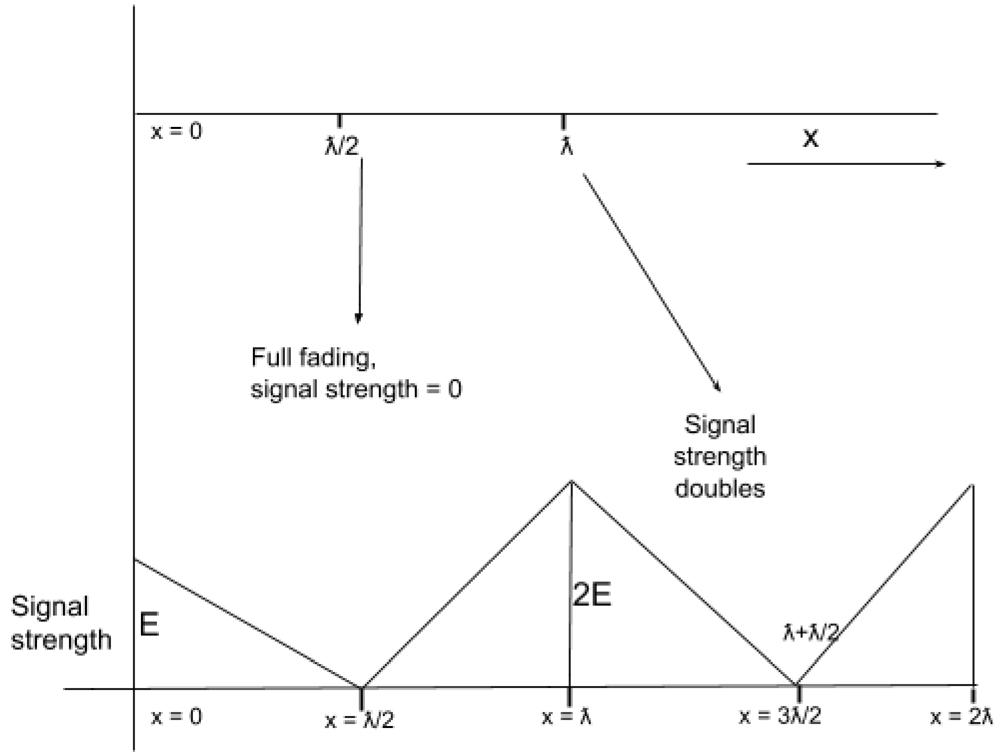
$$e_r(t,\ r) = E\ sin(2\pi ft + \frac{2\pi}{\lambda}d + \pi)$$

$$= -E\ sin(2\pi ft + \frac{2\pi}{\lambda}d)$$

$e_e = e_d(t, d) + e_r(t, r) = 0$

g. **Case 3:**

$$r = d + x$$



h. If a person talks while walking towards x direction:
   i. At $x = \frac{\lambda}{2}$, signal = 0 → call drop
   ii. At $\frac{\lambda}{2} < x <= \lambda$ → signal strength increasing → better conversation
   iii. At $\lambda < x <= \frac{3\lambda}{2}$ → again signal strength decrease

   Signal strength varies in congested areas (with building, mountains, while a person moves).

i. Signal strength in the basement of the house, here also the signal strength varies:
   i. At some points there is signal
   ii. At some other points there is no signal

Definition of Signal

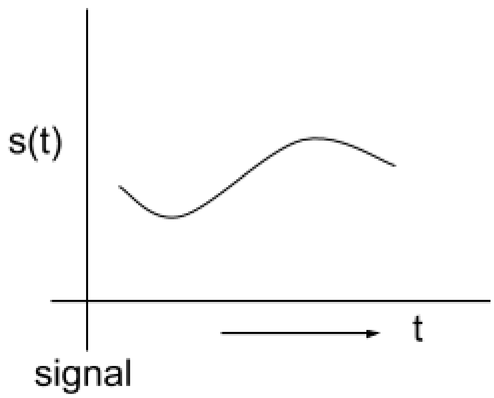
A time varying **physical quantity** using which data is transmitted from one computer to another computer using a communication **medium**.

1. Physical Quantity:
   a. Voltage/ current (electrical signal)
   b. Light intensity (optical signal)
   c. E and H field (electromagnetic signal)

2. Medium:
    a. Twisted pairs (signal is electric)
    b. Coaxial cable (signal is electric)
    c. Optical fibre (signal is light)
    d. Space (signal is electromagnetic)

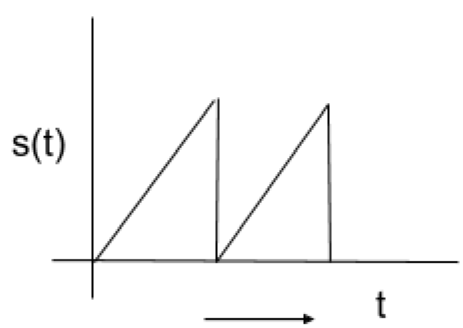
SIGNALS

1. **Analog:**
   Signal s(t) varies continuously

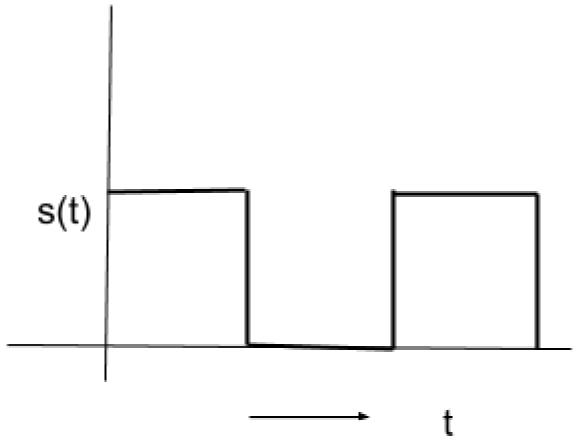


   If signal s(t) is continuous function with time → Analog signal
   Example: sine function

2. **Discrete:**
   If s(t) is a non-continuous function of time.
    i.



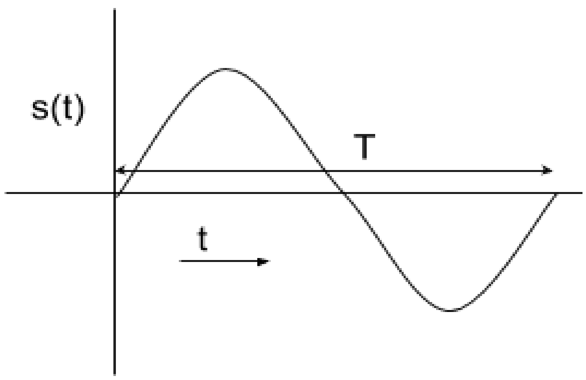
    ii.



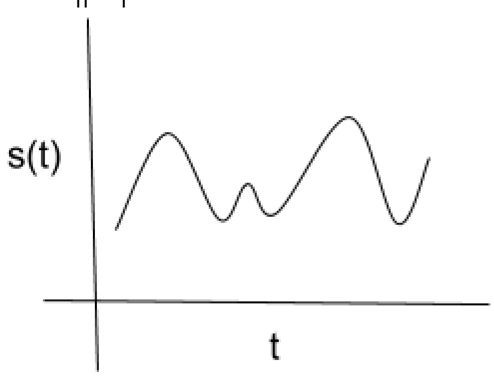
Square wave

Analog Signal

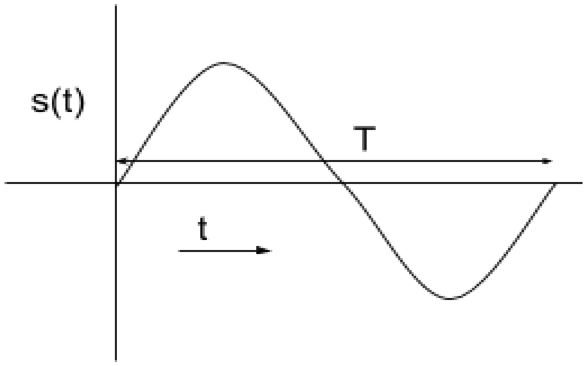
1. **Pure Analog Signal** with simple frequency.
   $f = \frac{1}{t}$



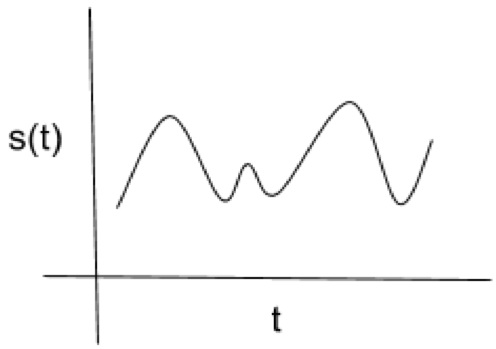
2. **Composite Analog Signal** with many frequencies consisting of many sine waves.
   f_h = highest frequency
   f_l = lowest frequency
   BW = $f_h - f_l$



1. **Periodic Analog Signal:**
   If there exists constant T such that s(t) - S(T + t) for all t.

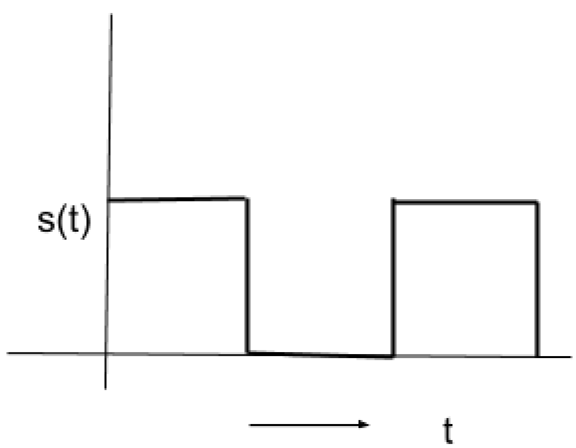


2. **Non Periodic Analog Signal:**
   If s(t) ≠ S(t + T)



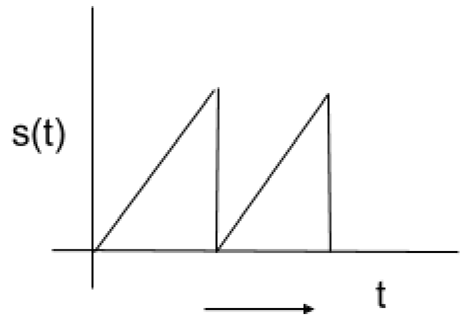
Digital Signal

1. **Digital Signal:**



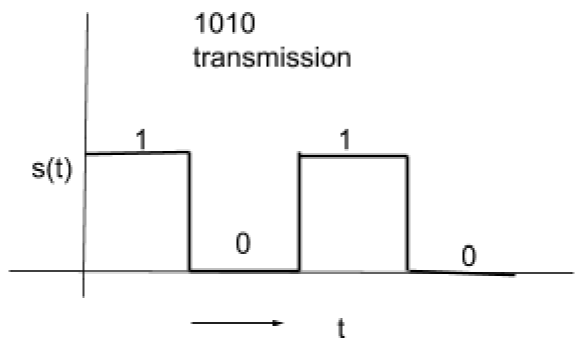
Square wave

2. **Saw Tooth:**



1. **Periodic Digital Signal:**

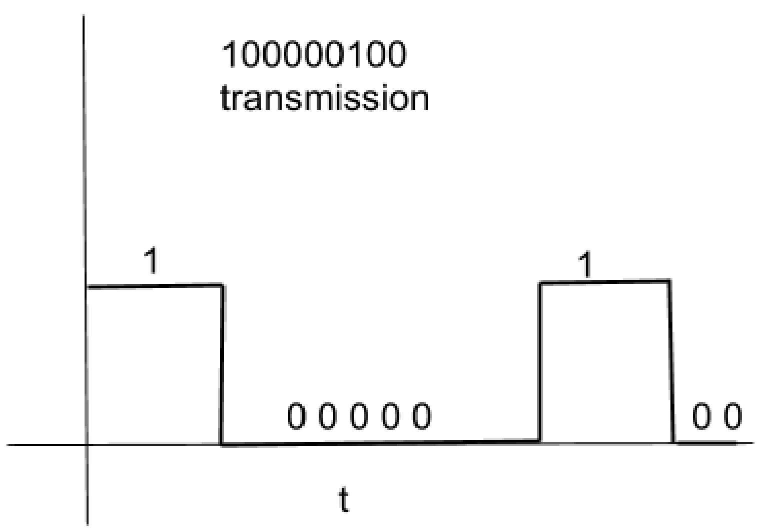
   s(t) = s(T + t)



Digital Periodic Signal

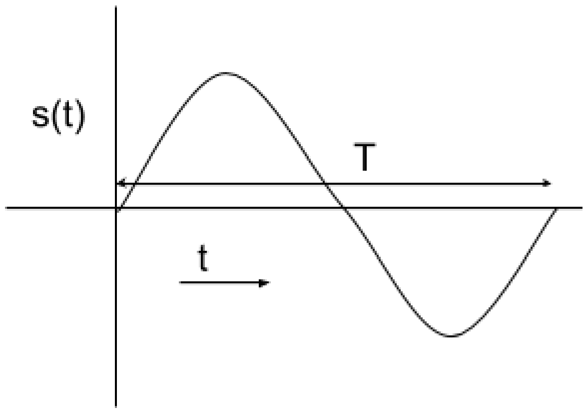
2. **Non-Periodic Digital Signal:**

   s(t) ≠ s(T + t)



Periodic Signal

1. Analog Signal

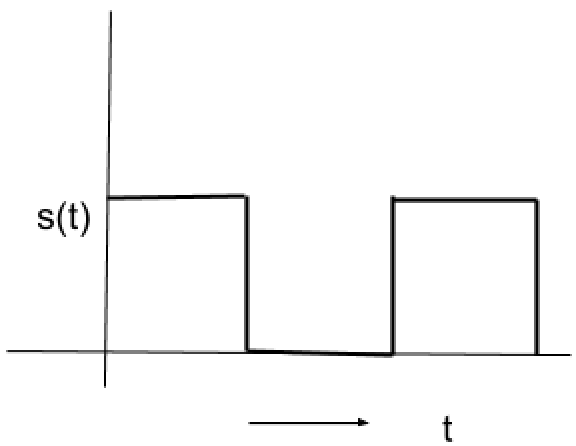


Pure analog signal: s(t) = s(t + T)

Only one frequency: $f = \frac{1}{T}$

Is it only one sine wave → NO

2. Square wave



Square wave

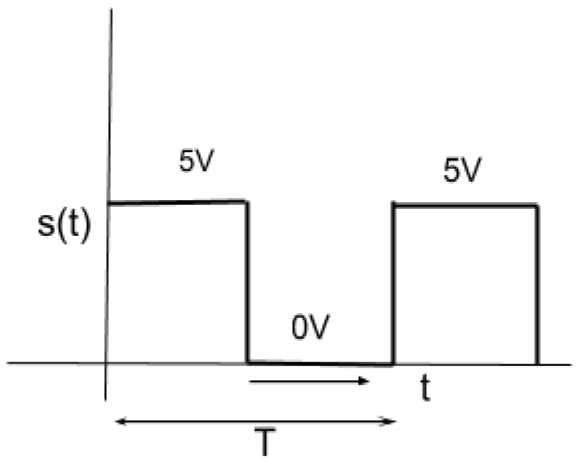
s(t) = s(t + T)

Fourier Analysis: If any function s(t) = s(t + T), then it can be analysed by Fourier series:

$$s(t) = \frac{c}{2} + \sum_{n=1}^{\infty} A_n sin(2\pi nft) + \sum_{n=1}^{\infty} B_n cos(2\pi nft)$$

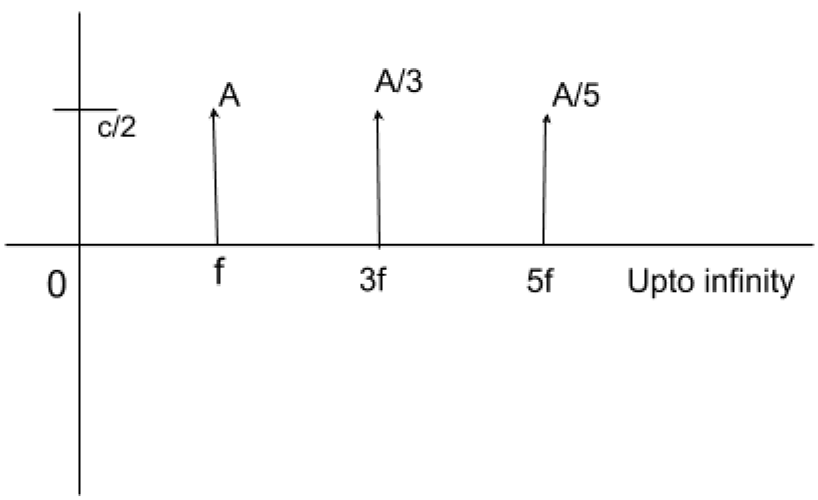
where, $f = \frac{1}{T}$

If c = 5V



After Fourier analysis,

$s(t) \ = \ \frac{5}{2} \ + \ Asin(2\pi ft) \ + \ \frac{4}{3}sin(3ft) \ + \ \frac{4}{5}sin(5ft)$



Signal Representation:

1. Time domain
2. Frequency domain

- Absolute

  $B_{W\ absolute} \ = \ \alpha \ - \ 0 \ = \ \alpha$
- Effective

  $B_{W\ effective} \ = f_c \ - \ 0$

  $= \ nf \ - \ 0$

  $= \ nf$

where,

value of n depends on the applications,

f_c = cutoff frequency

If we want n = 10 for cutoff frequency,

$A_n = \frac{1}{10}A$

$Amplitude\ of\ cutoff\ frequency = \frac{1}{10} of\ amplitude\ of\ fundamental\ frequency(f)$

Then,

$B_{W\ effective} = 10f$

$f = \frac{1}{T}$ → fundamental frequency