PAM = Pulse amplitude modulation
PPM = Pulse position modulation
PWM = Pulse width modulation

lec 8 (UNIT-4)

DIGITAL REPRESENTATION OF ANALOG SIGNAL

modulation

- Analog (continuous)
  - Amplitude modulation
    - AM
    - DSB-SC
    - SSB-SC
    - VSB
  - Angle modulation
    - FM
    - PM
- Digital
  - Baseband/Pulse modulation
    - Pulse Analog
      - PAM
      - PPM
      - PWM
    - Pulse digital modulation
      - PCM
      - DPCM
      - DM & ADM
  - Band Pass modulation
    - ASK
    - PSK
    - FSK

PCM : Pulse code modulation
DPCM : differential PCM
DM : Delta modulation
ADM : Adaptive DM

In Analog mod,

$\left.\begin{matrix} m(t) \\ c(t) \end{matrix}\right\} \rightarrow$ both Analog / continuous

In digital mod,

Pulse modulation

↳ $c(t)$ = pulse train
(pulse wave).

PULSE ANALOG MODULATION

* $c(t)$ = periodic pulse train

* Amp., position & width of the carrier pulse train is varid in accordance to samples of continuous $m(t)$.

PULSE DIGITAL MODULATION

$m(t)$ = discrete in both time & Amplitude

$c(t)$ = periodic pulse train
↳ sequence of coded pulses

* This type of modulation does not have any continuous wave counter part.

* PCM is most common.

4 predominat methods of pulse modulation

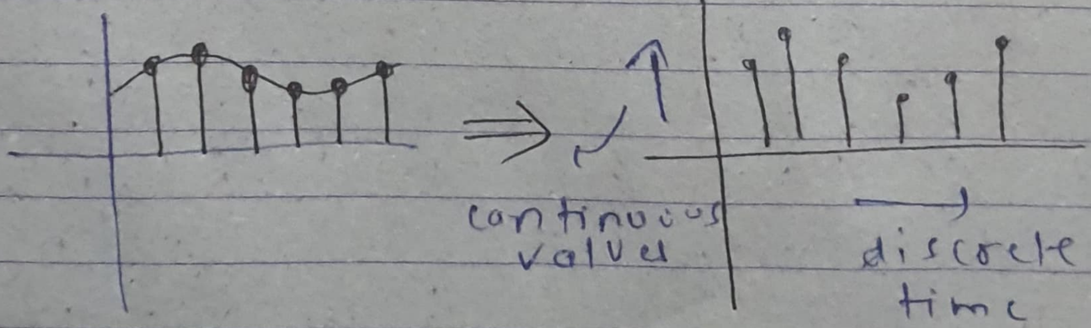
↳ PWM
↳ PPM
↳ PAM
↳ PCM

ANALOG TO DIGITAL SIGNAL

3 step process:

① Sampling ⟹ discrete time continuous valued signal

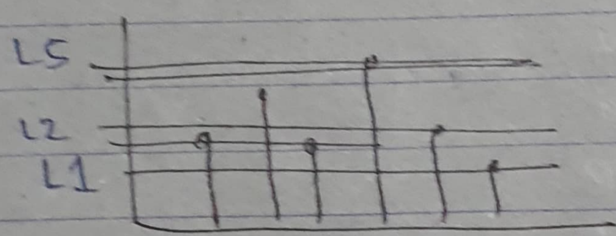
②



2 Quantization

(rounding of infinite sampled values to a finite no. of values)

→ Discrete time & discrete Amplitude



no. of levels fixed

3 Encoding

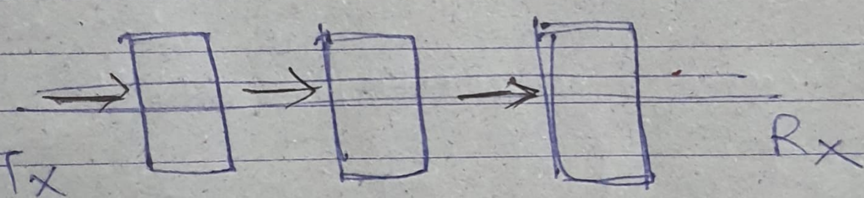
sequence (ones & zeros) ~~to diff~~ is assigned to different O/P values of quantizer

(CDC)

ADVANTAGES OF DIGITAL COMMUNIC-ATION

① Noise immunity => can withstand channel noise & distortion ~~th~~ much better than Analog ~~Communic~~ communication

② Regenerative repeaters in DC



* receive the signal
* regenerate digitial signal.
* retransmit

↳ advantage

noise overcome

③ Digital hardware implementation is flexible.

④ Coding can be done to reduce the error rate

(5) multiplexing of digital signals is easier

(6) Digital signal storage is relatively easy & inexpensive

(7) Reproduction of digital signal is reliable

(8) cost of digital hardware reduces to $\frac{1}{2}$th in every 2-3 years and performance is getting doubled

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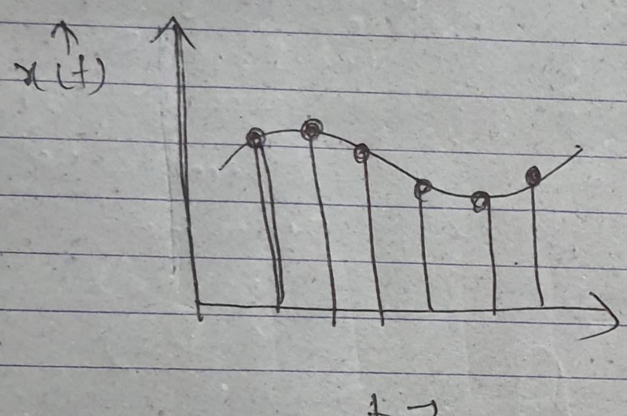
SAMPLING THEOREM

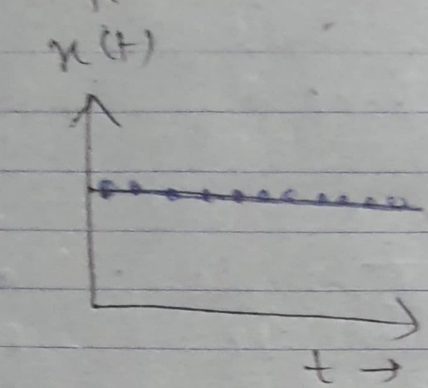
All the latest signal processing & digital comm. concepts are based on the validity of sampling theorem



→ A continuous time signal can be sampled & recovered back from the knowledge of the samples only if sampling frequency $\boxed{f_s \geq 2 f_m}$

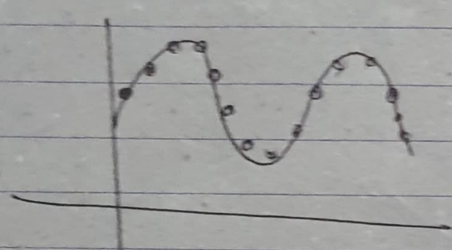
where f_m is max. frequency is present in the message signal

Ex1)



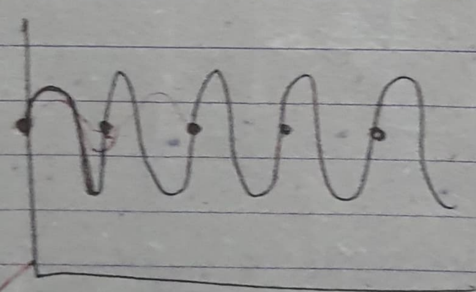
DC signal
"0 frequency"

Ex2)



max freq = f
let $f_s = 11f$
↓
11 samples in 1 time period (cycle)
↓
if $f = 1\,kHz$
$f_s = 11\,kHz$
↓
11000 samples/sec

Ex3)



↓
Let $f = 3\,kHz$
$f_s = f = 3\,kHz$
↓
1 sample per cycle

→ not desirable scenario, since hard to reconstruct back the message signal

Nyquist frequency $= 2 f_m$

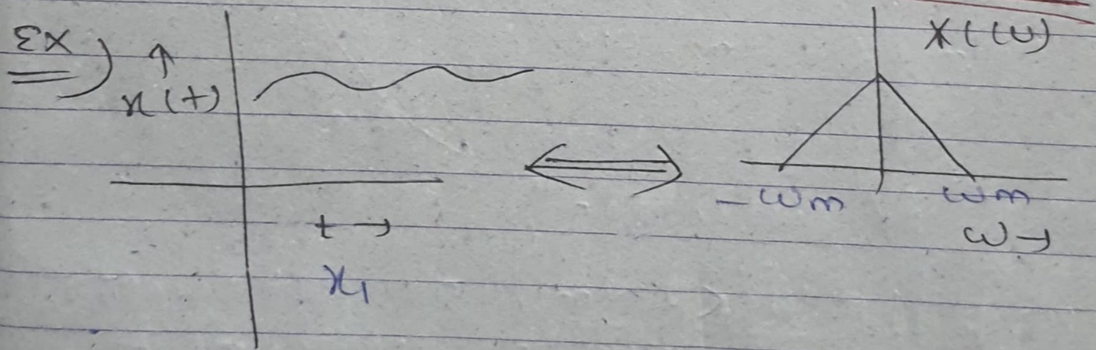
Nyquist rate $=$ minimum sampling rate

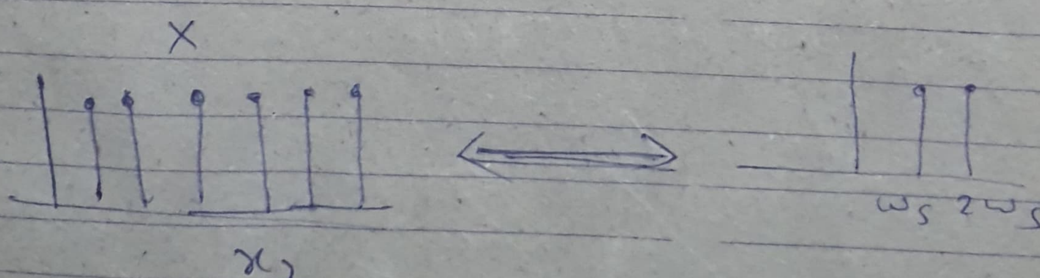
$= \frac{1}{2} \cdot$ (sampling rate)

Q) What happens when $f_s < 2 f_m$?

contributes to "Aliasing Error"

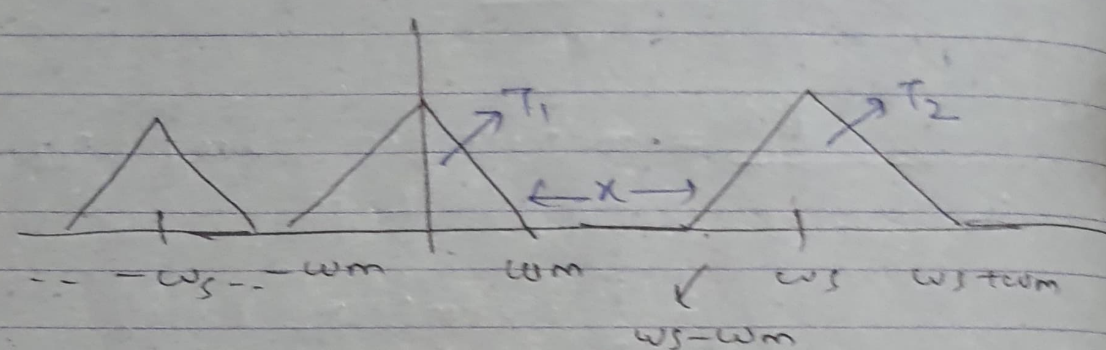
Ex)





convolution

$x_1 \cdot x_2 = X_1(w) * X_2(w)$



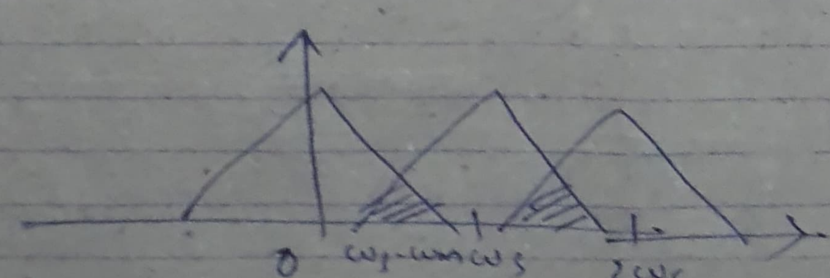
If $\omega_s \gg 2\omega_m$, sufficient guard band between T_1 & T_2

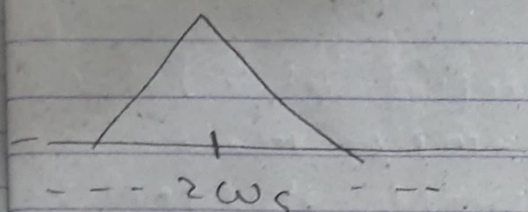
that is,

$\omega_m + x + \omega_m = \omega_s$

"no distortion"

Now if $\omega_s < 2\omega_m$, no sufficient guard band b/w the spectrums & they will overlap.





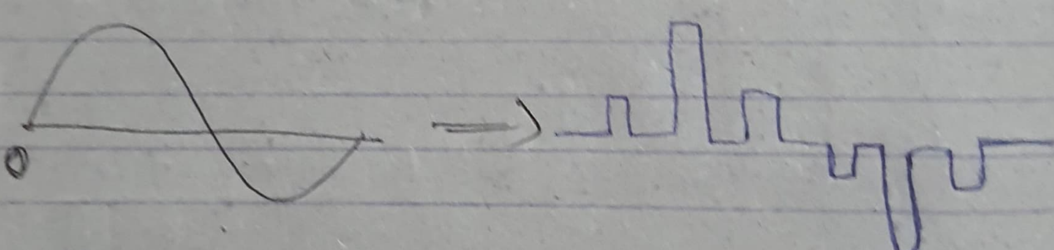
→ distortion, impossible to get back the m(t)

→ this type of signal is called aliasing error (if $f_s < 2f_m$)

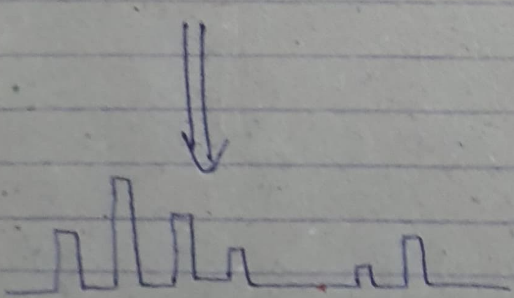
PULSE AMPLITUDE MODULATION (PAM)

* Simplest form of pulse modulation

* In PAM, signal sampled at regular intervals & each sample made proportional to amplitude of signal at the instant of sampling.



(Double polarity PAM signal)



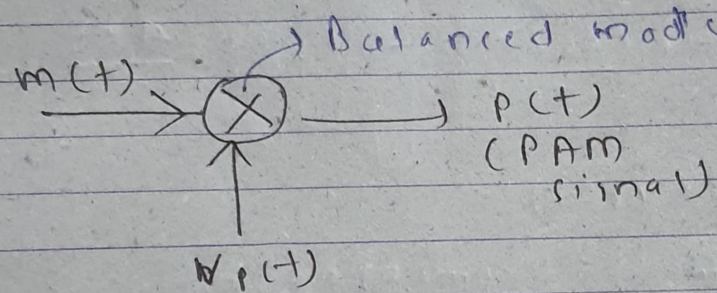
Single polarity PAM

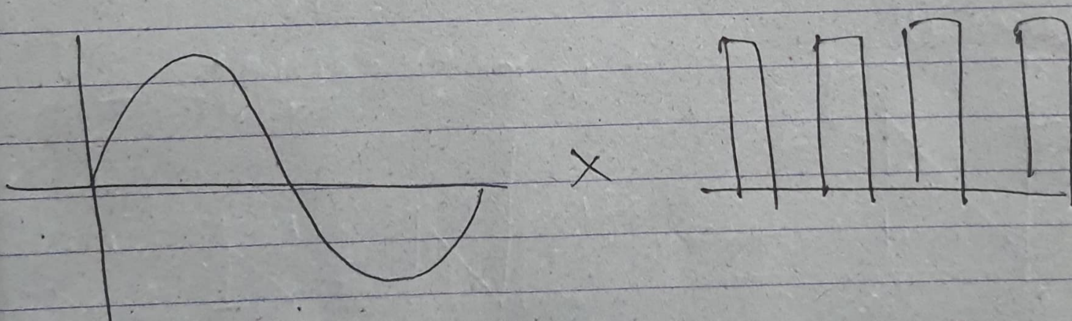
"A fixed DC ~~signal~~ signal given to Double polarity PAM to make negative pulses positive" modulating signal = message signal

NATURAL SAMPLING

m(t)

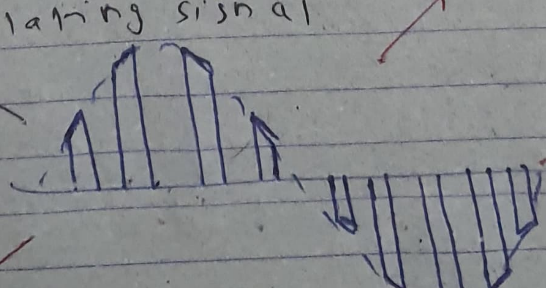
carrier pulse train $V_p(t)$ multiplied with m(t) to get PAM.





Top follows the shape of modulating signal

top part of pulses not flat



top part ~~not~~ same as natural m(t)

Also called "natural PAM"

Fourier series representation of pulse train

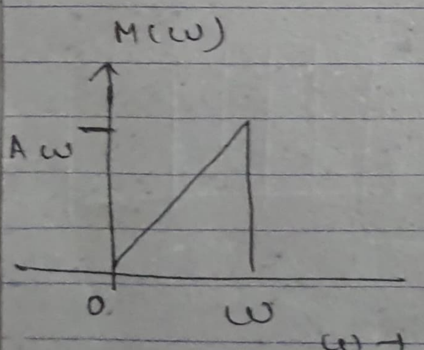
$$= a_0 + \sum_{n=1}^{\infty} a_n \cos\left(\frac{2\pi n t}{T_s}\right)$$

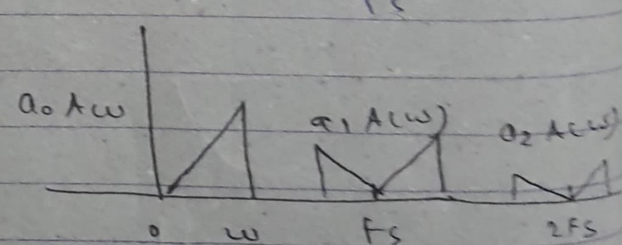
$$V_p(t) = a_0 + a_1 \cos\frac{2\pi t}{T_s} + a_2 \cos\frac{4\pi t}{T_s} + \dots$$

PAM

$$P(t) = m(t) \times v_p(t)$$

$$= a_0 m(t) + a_1 m(t) \cos\frac{\pi t}{T_s} + a_2 m(t) \cos\frac{4\pi t}{T_s} - -$$





✓ spectrum of m(t)

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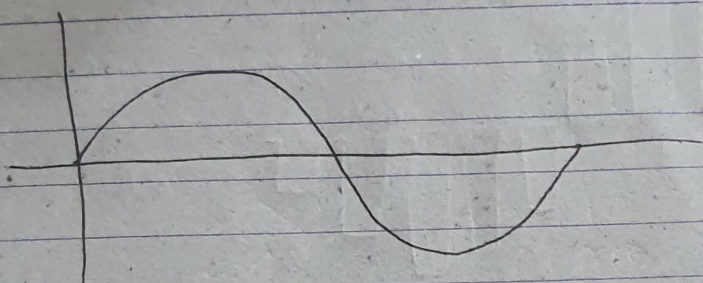
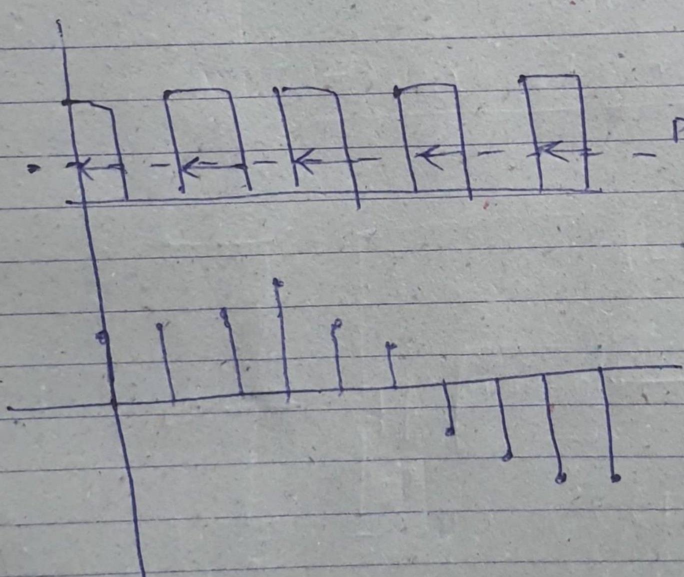
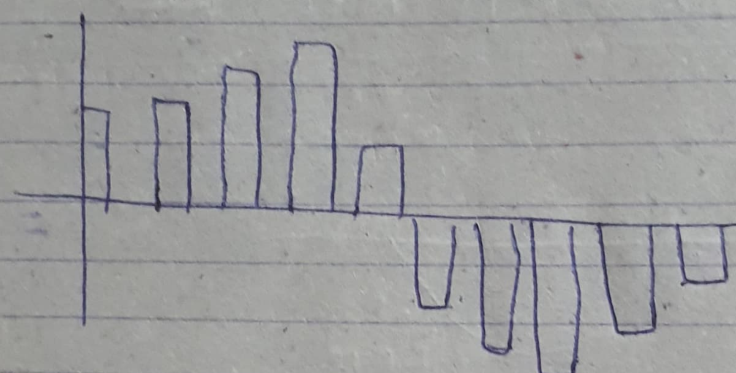
FLAT TOP ~~SIG~~ SAMPLING (~~FA~~ FLAT TOP PAM)



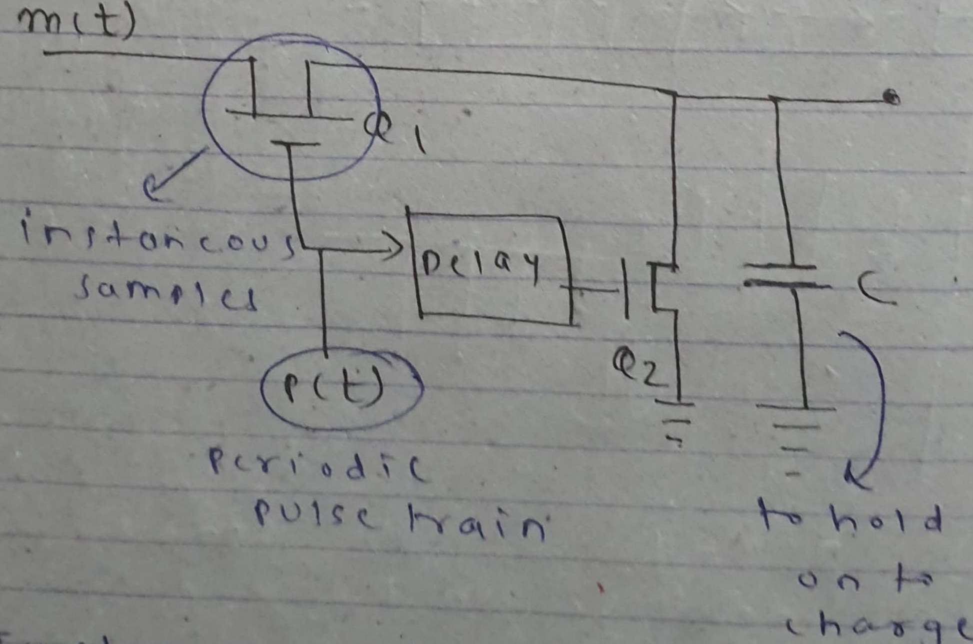


pulse width reduced to impulse, we get flat top

pulse energy will be small, hence cannot be used for communication first generate instantaneous sampling then hold it for certain time period to generate flat-top sampling

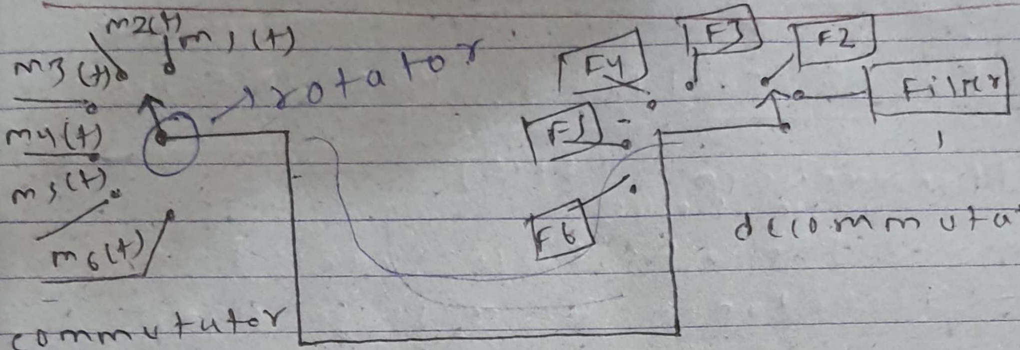


Sample & hold circuit

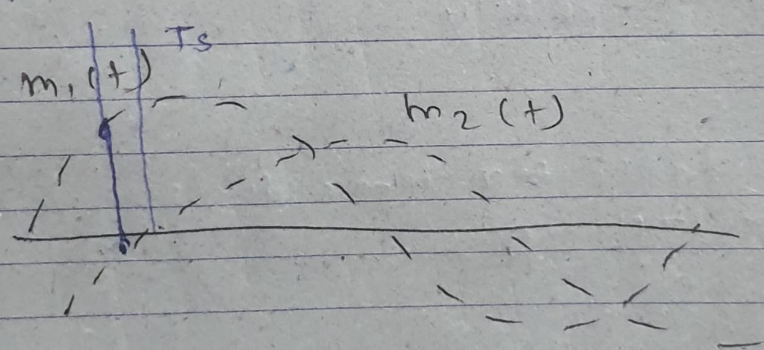


First sample, then hold charge for some instant

PAM & TIME DIVISION MULTIPLEXING



~~Sot~~ rotator 1 & rotator 2 ~~s~~ synchronized



First we sample $m_1(t)$, $m_2(t)$ at "T_s intervals"

PULSE WIDTH MODULATION (PWM) & PULSE POSITION MODULATION (PPM)

↳ Randomness in width of pulse

PWM = width of pulse varied in accordance to message signal

PPM = position of each fixed width pulse is varied in accordance to message signal

↳ randomness in position of pulse

↳ not suitable for time division multiplexing

Application:

① PWM finds in controlling speed of DC motor

PWM &
Pulse tim

PWM Gen

Input signal

Sawtooth signal

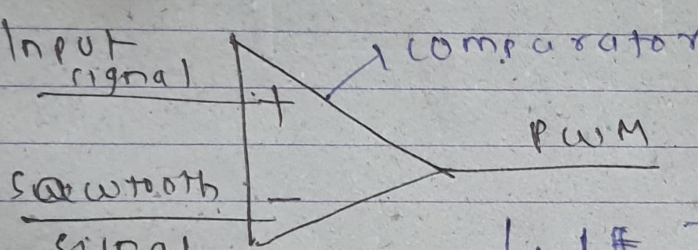
PPM Gener

PWM

Inverter

PWM & PPM together called
Pulse time modulation

PWM Generation



↳ If I/P signal more, O/P = +V
Sawtooth signal more, O/P = −V

PPM Generation