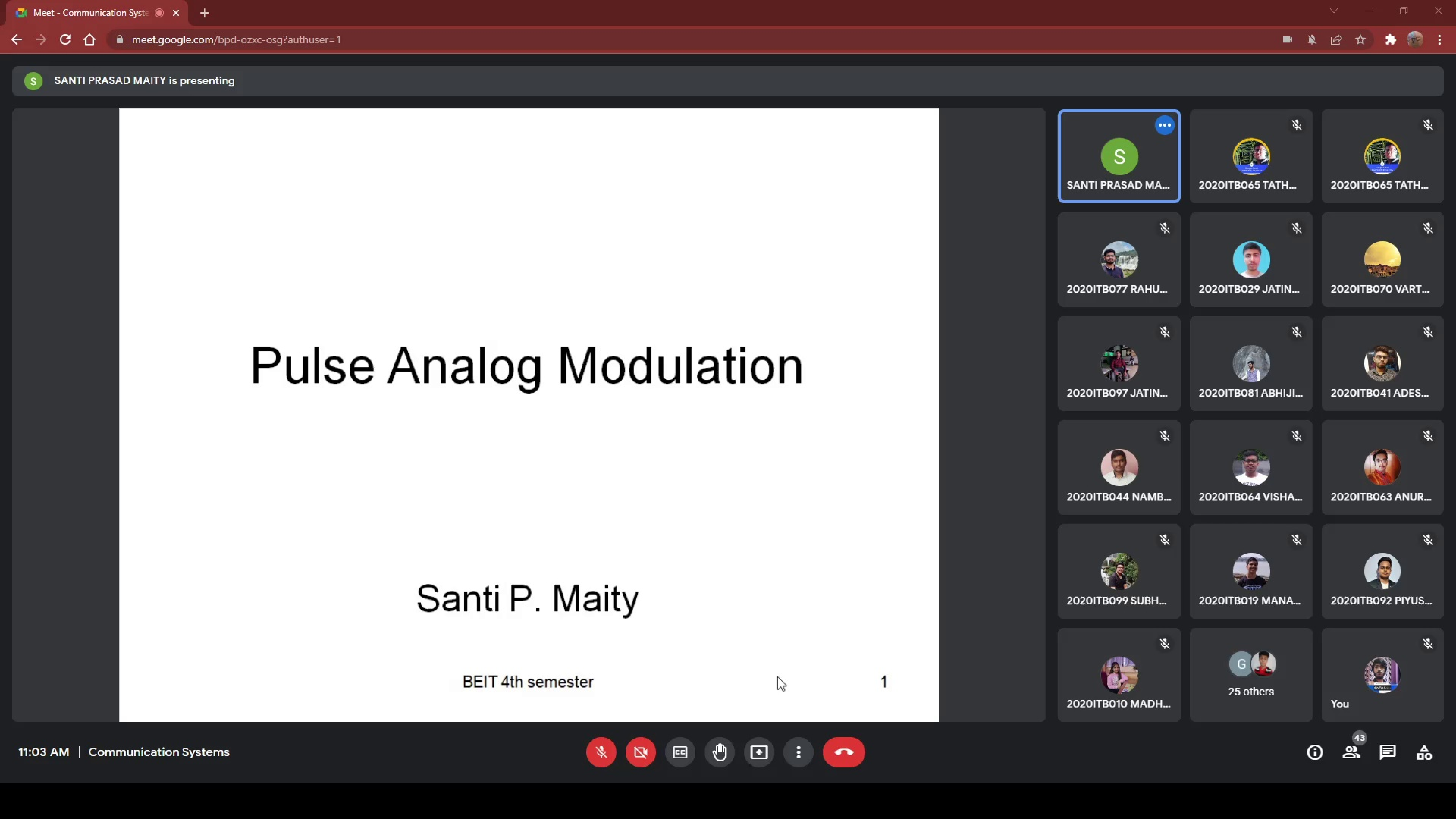
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Pulse Analog Modulation
Santi P. Maity
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1
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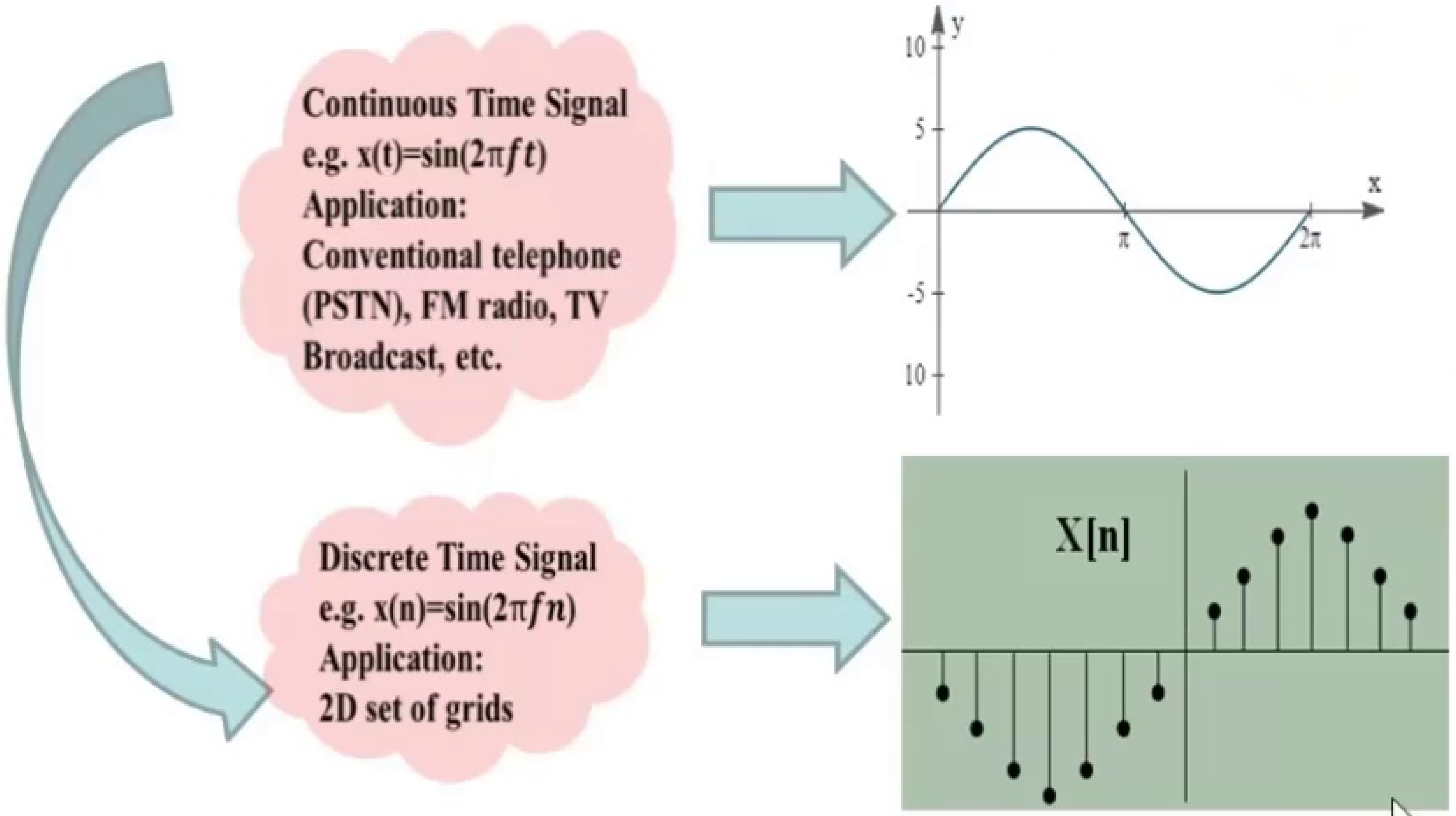
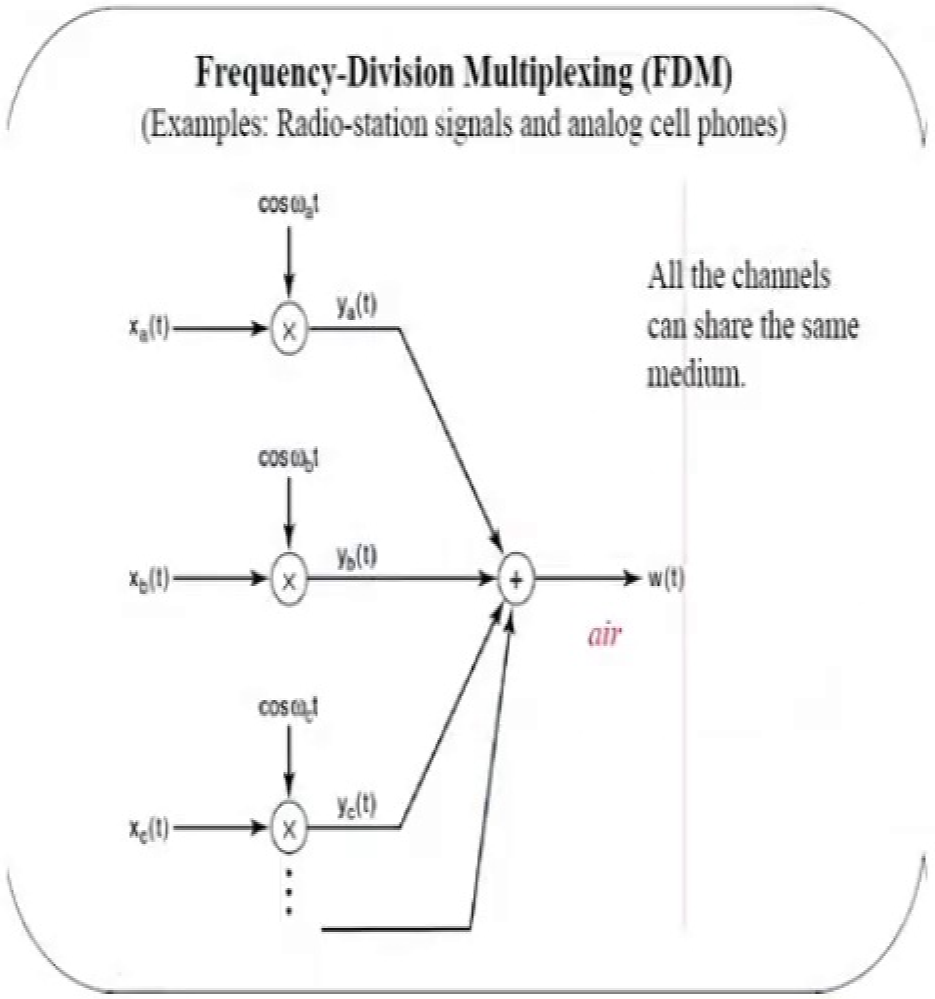
Communication Systems

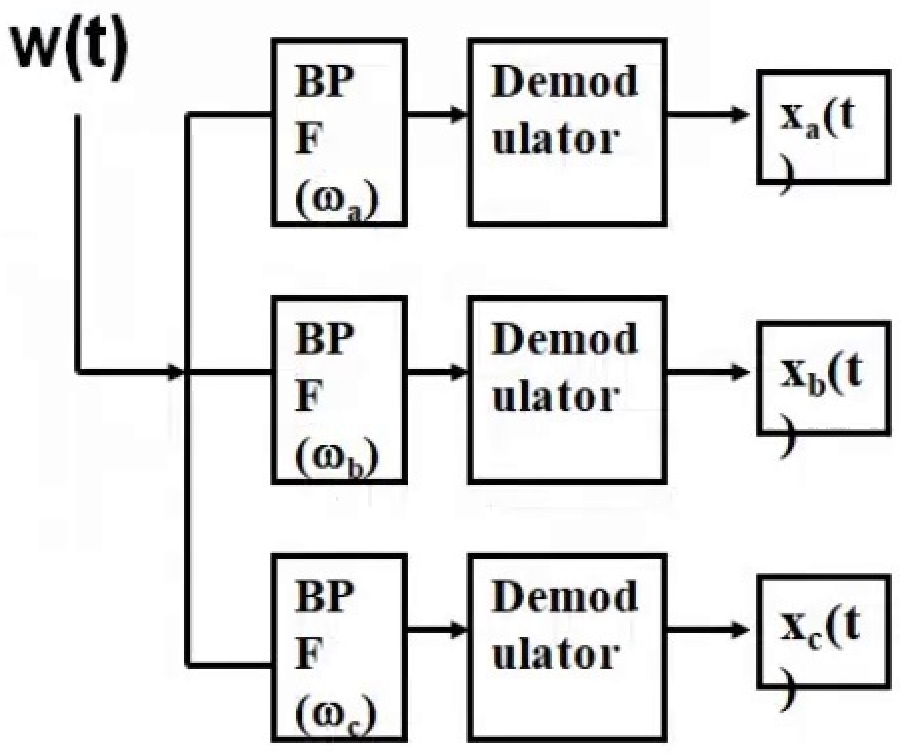
Continuous and Discrete Time Signal

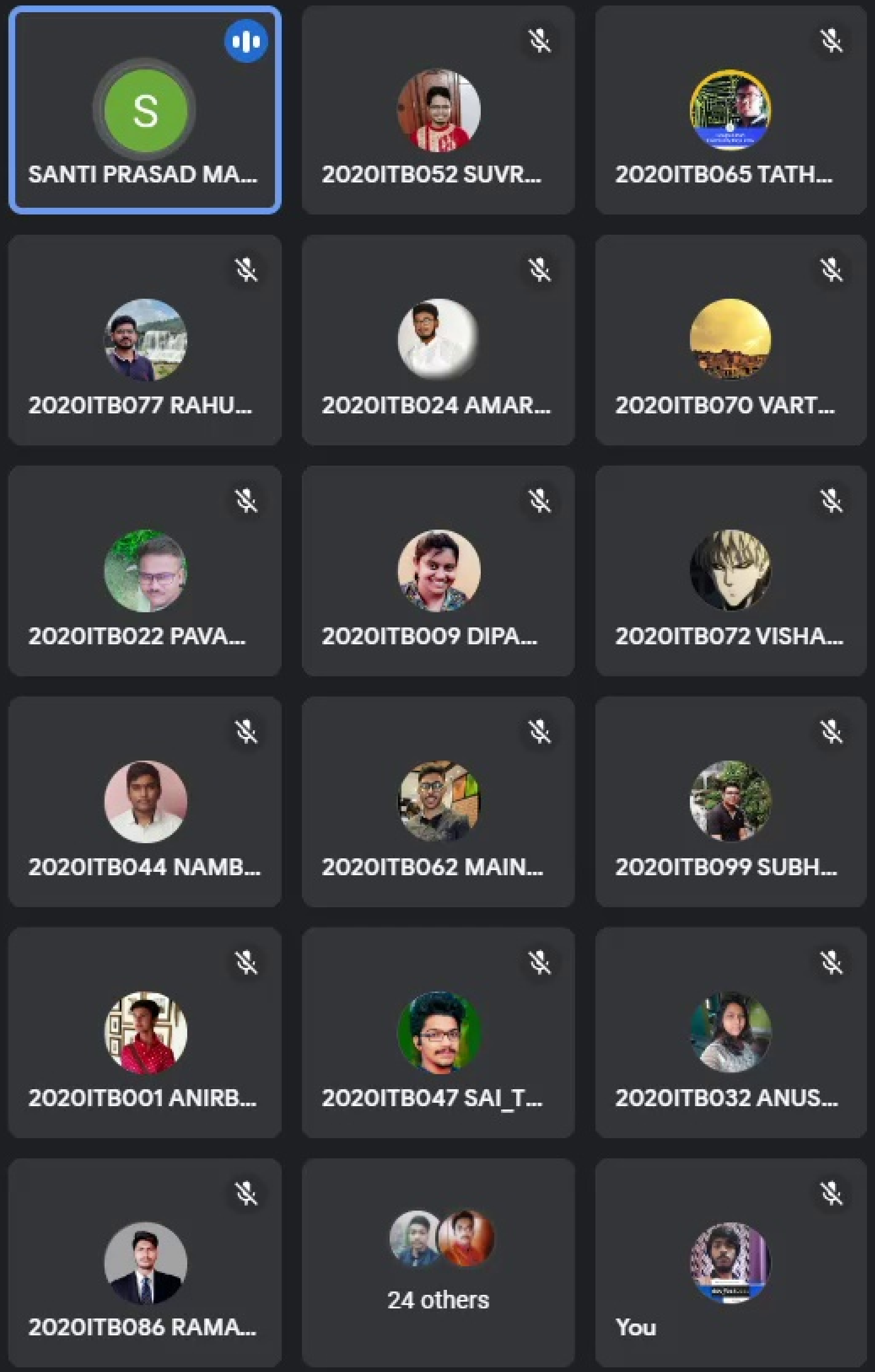
Sampling---A Continuous curve can be represented as discrete set of points



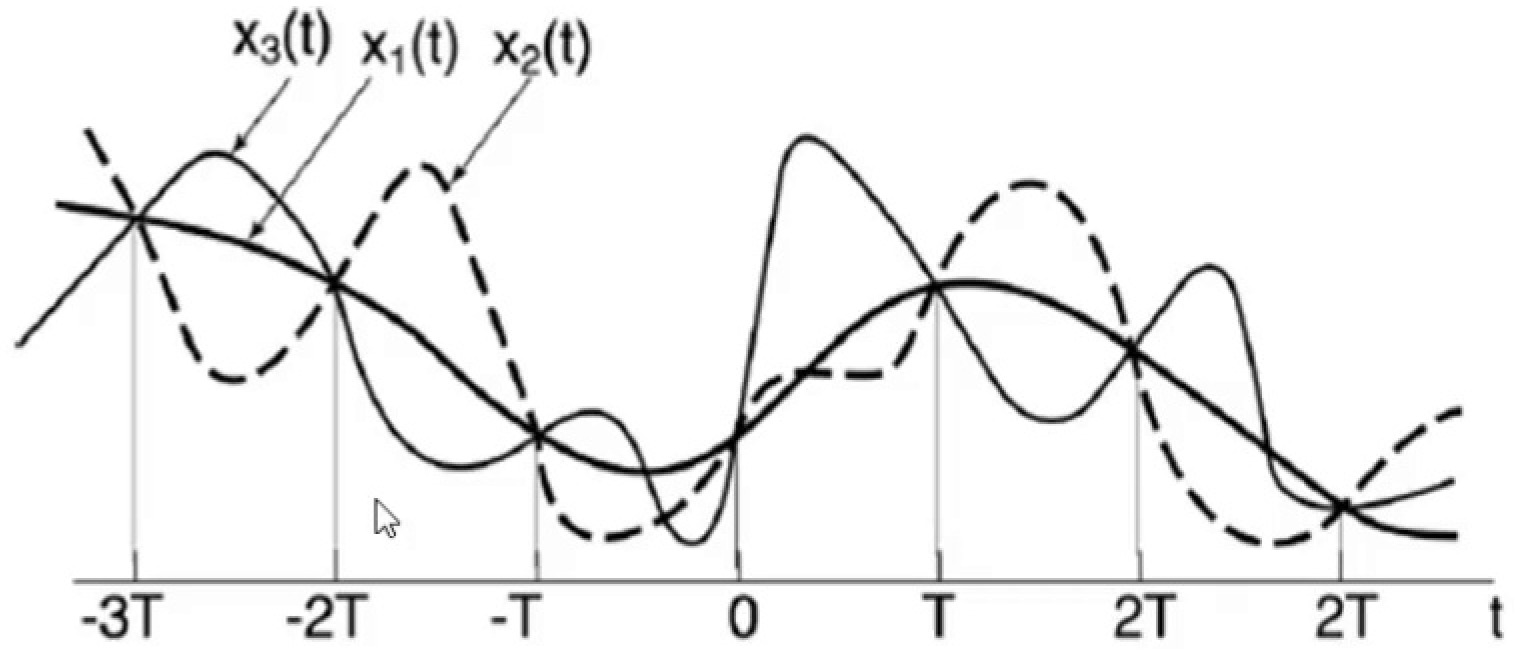
Reconstruction of original signals



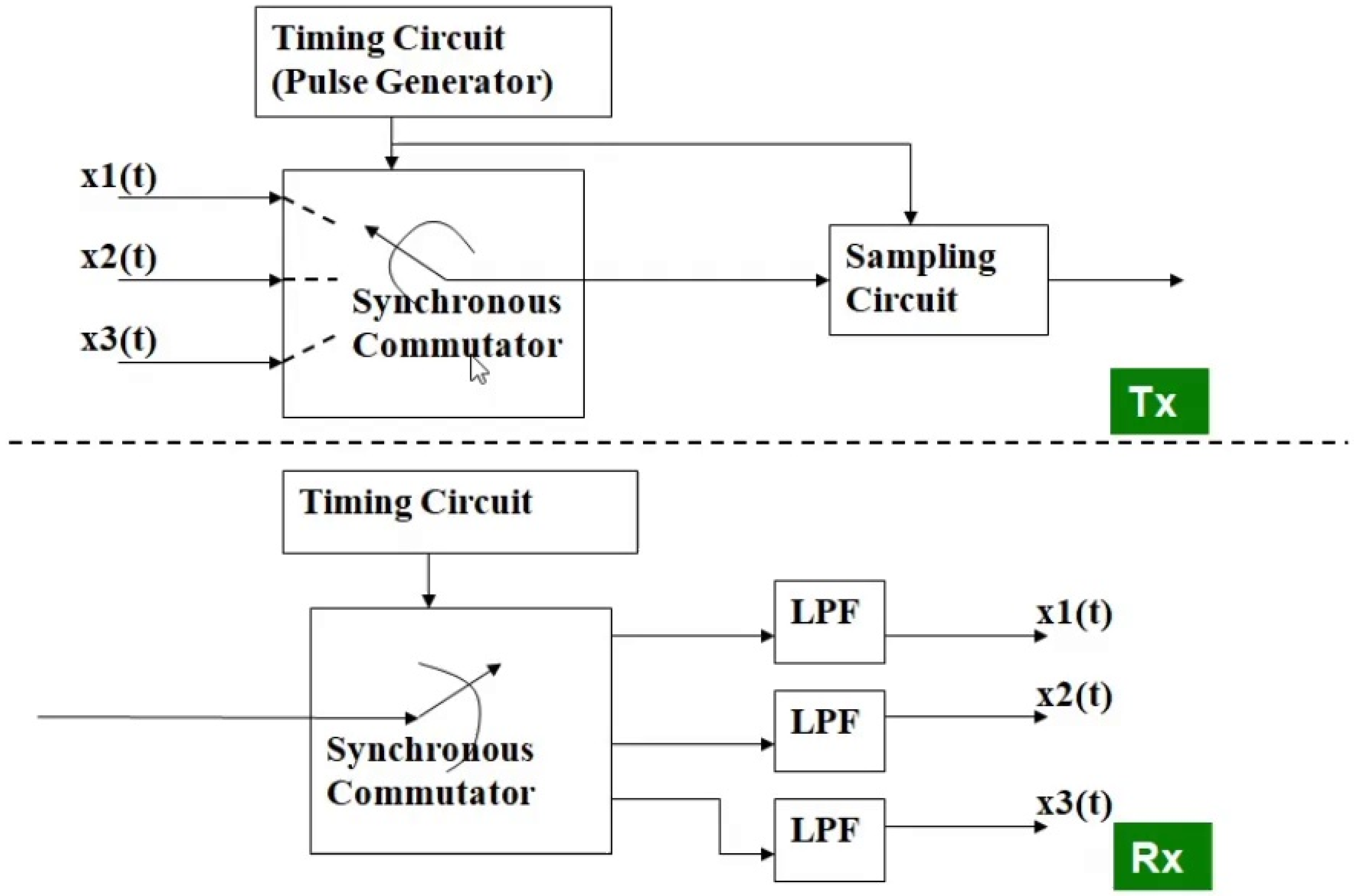




Time Division Multiplexing (TDM)



- By sampling we throw out lots of information
  – all values of $x(t)$ between sampling points are lost.


Timing Circuit
(Pulse Generator)
x1(t)
x2(t)
x3(t)
Synchronous
Commutator
Sampling
Circuit
Tx
Timing Circuit
Synchronous
Commutator
LPF
LPF
LPF
x1(t)
x2(t)
x3(t)
Rx

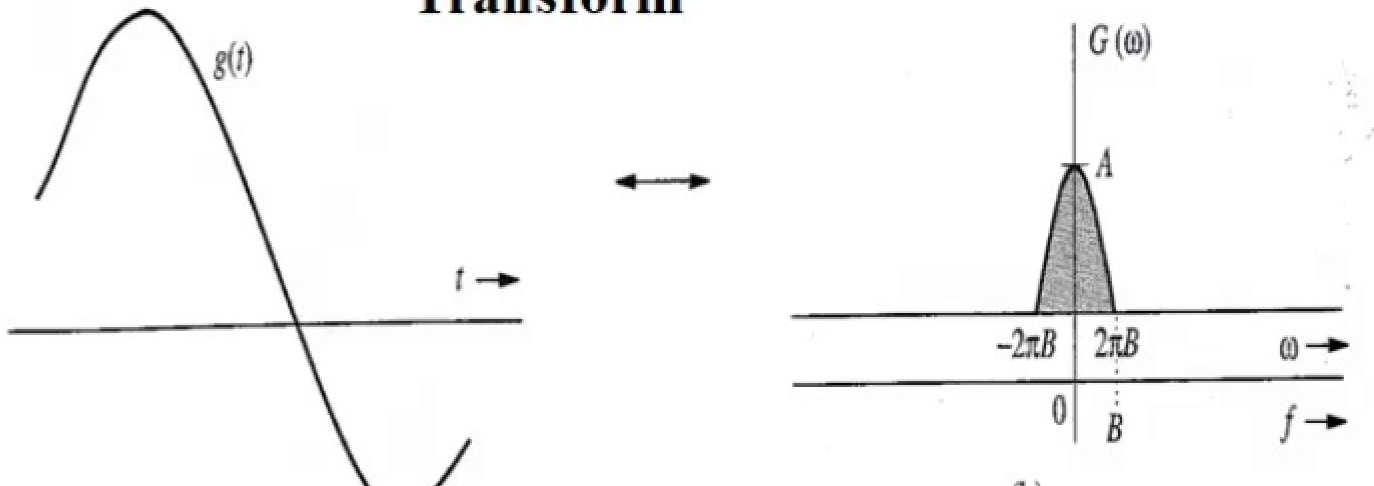
Sampling Theorem

- The signal whose spectrum is band limited to B Hz ($G(\omega)=0$ for $|\omega|>B$) can be reconstructed exactly (without any error) from its samples taken uniformly at a rate $R>2B$ Hz (samples per second).

$$\boxed{f_s = 2B \text{ Hz}}$$

Minimum sampling frequency

Fourier Transform



(a) (b)

Advantage and Disadvantage of Pulse modulation over CW

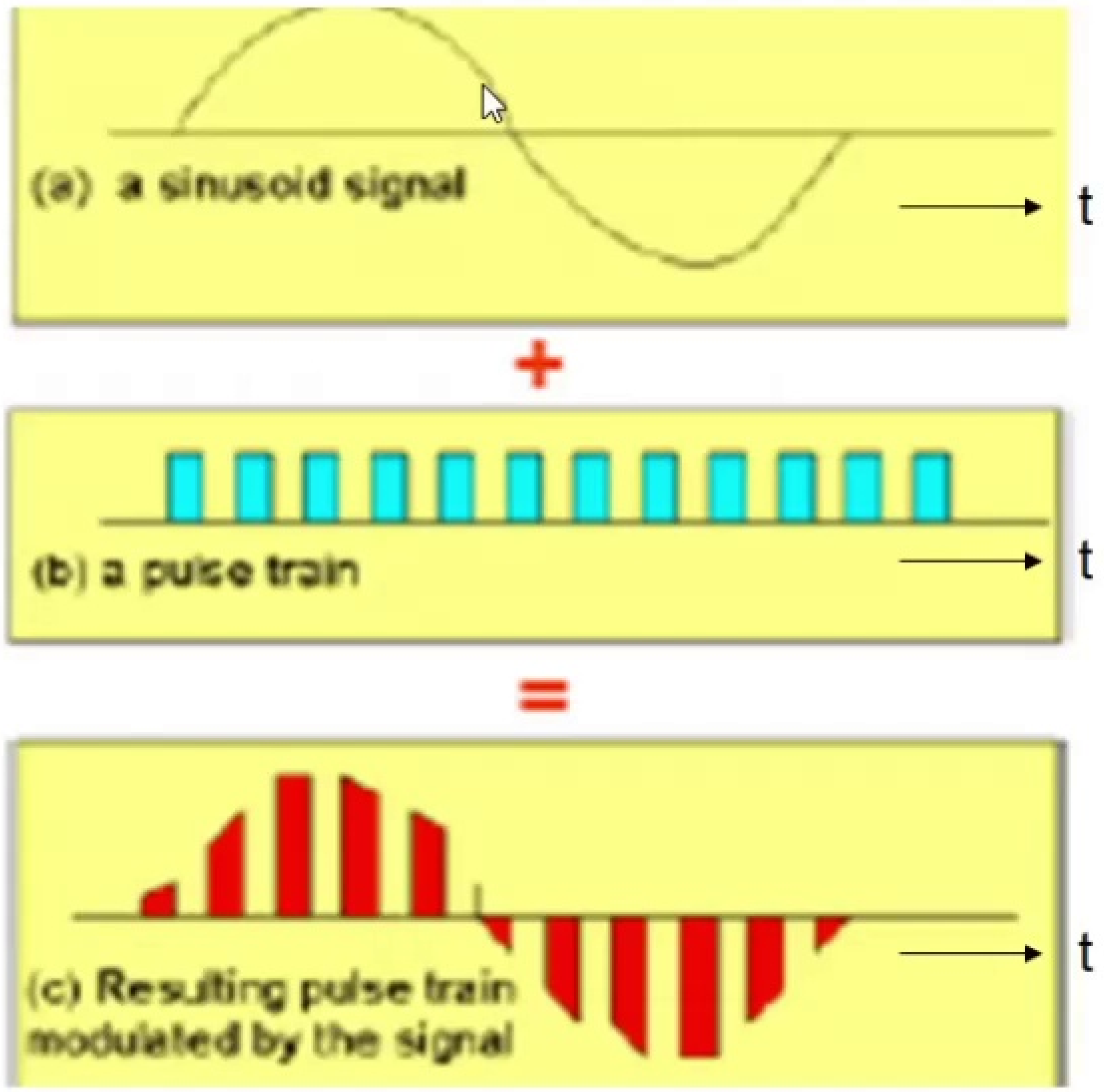
- Pulse modulation advantages over CW modulation

i) Transmitted power –concentrated on short duration

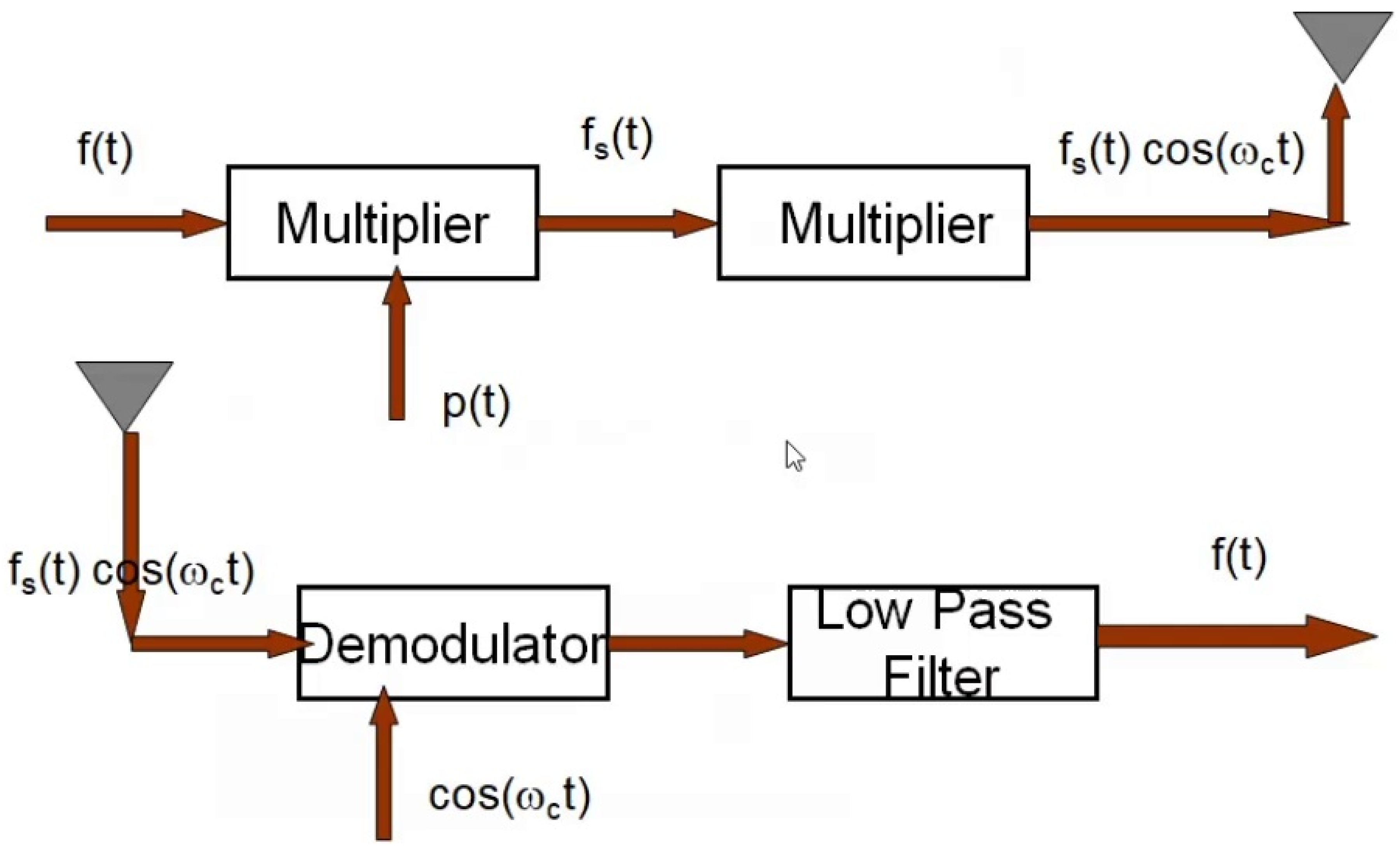
ii) Time-division multiplexing

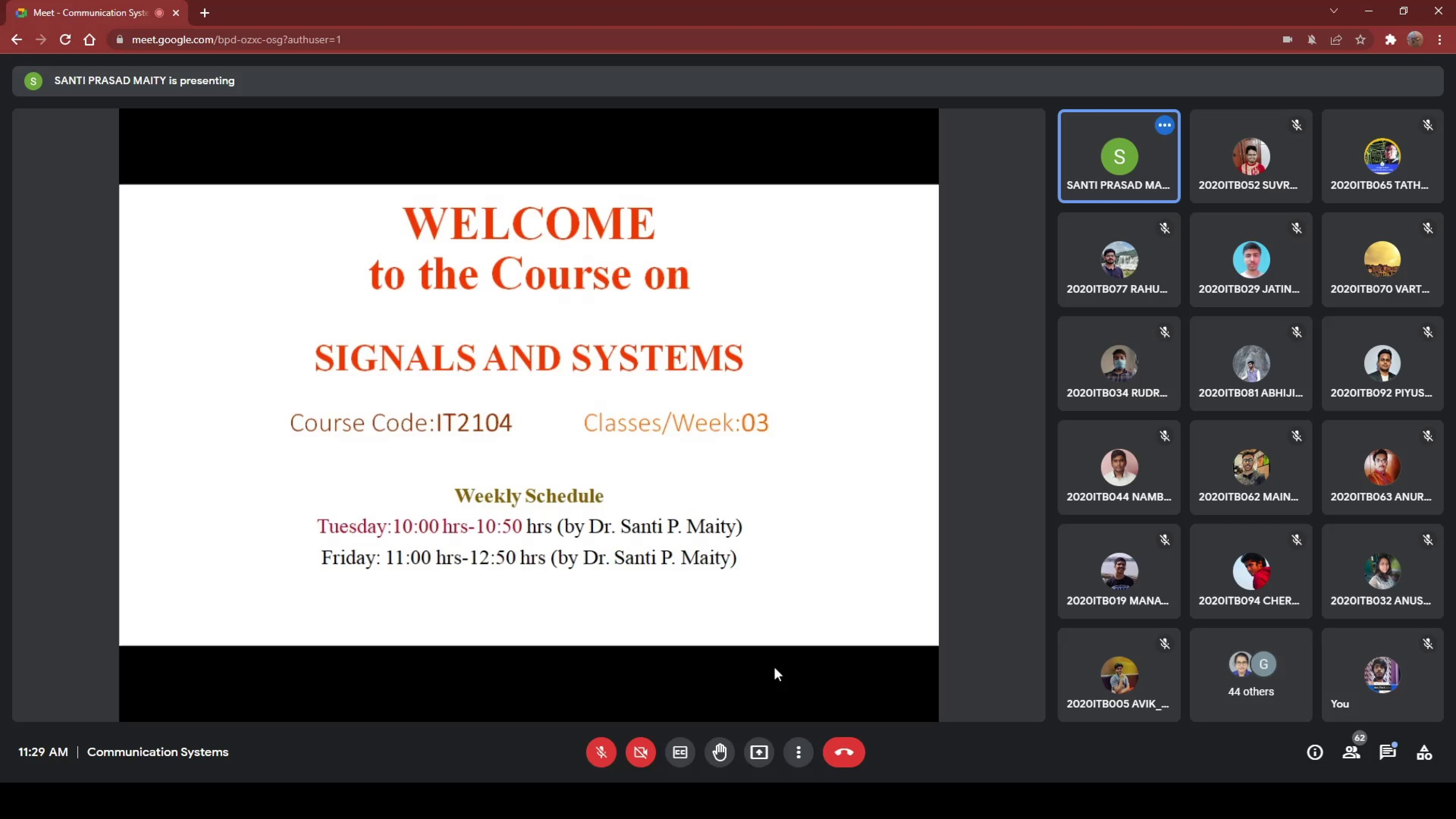
Pulse amplitude modulation
Pulse position modulation
Pulse width modulation

Pulse Amplitude Modulation



PAM/AM Transmission and Reception

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WELCOME
to the Course on
SIGNALS AND SYSTEMS
Course Code:IT2104
Classes/Week:03
Weekly Schedule
Tuesday:10:00 hrs-10:50 hrs (by Dr. Santi P. Maity)
Friday: 11:00 hrs-12:50 hrs (by Dr. Santi P. Maity)
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2020ITB063 ANUR...
2020ITB019 MANA...
2020ITB094 CHER...
2020ITB032 ANUS...
2020ITB005 AVIK_...
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Properties of Signals

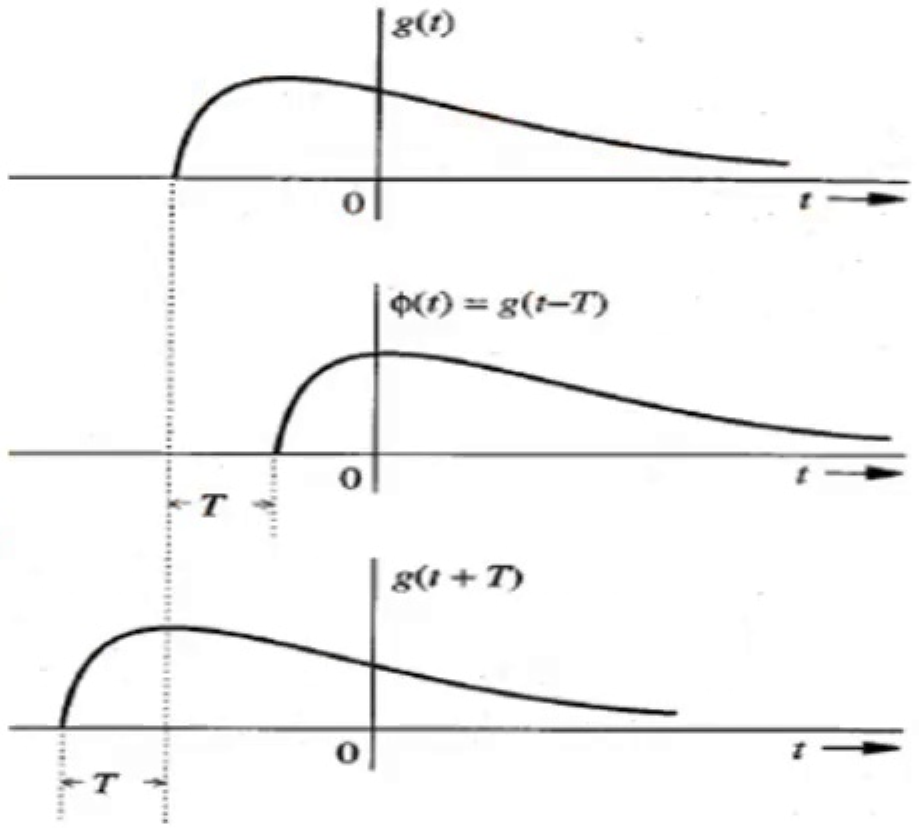
- 1. Time Shifting

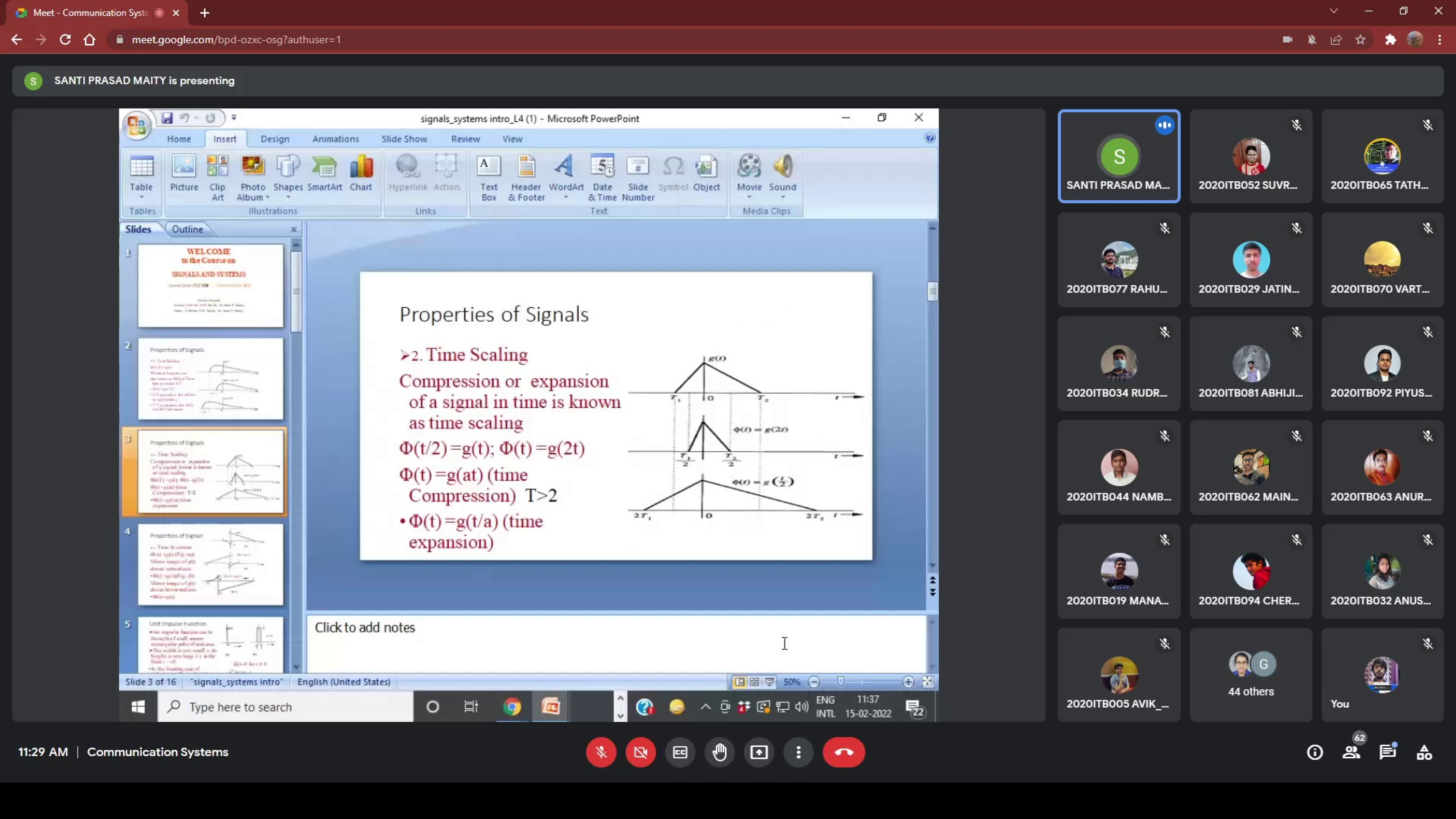
$\Phi(t+T) = g(t)$

Whatever happens at t,

also occurs in $\Phi(t)$ at T time later at instant t+T

- $\Phi(t) = g(t-T)$
- If T is positive , the shift is to right (delay).
- If T is negative , the shift is to left (advance).

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signals_systems intro_L4 (1) - Microsoft PowerPoint
Properties of Signals
➢2. Time Scaling
Compression or expansion of a signal in time is known as time scaling
Φ(t/2) =g(t); Φ(t) =g(2t)
Φ(t) =g(at) (time Compression) T>2
• Φ(t) =g(t/a) (time expansion)
g(t)
φ(t) = g(2t)
φ(t) = g(t/2)
Click to add notes
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Sampling and Reconstruction
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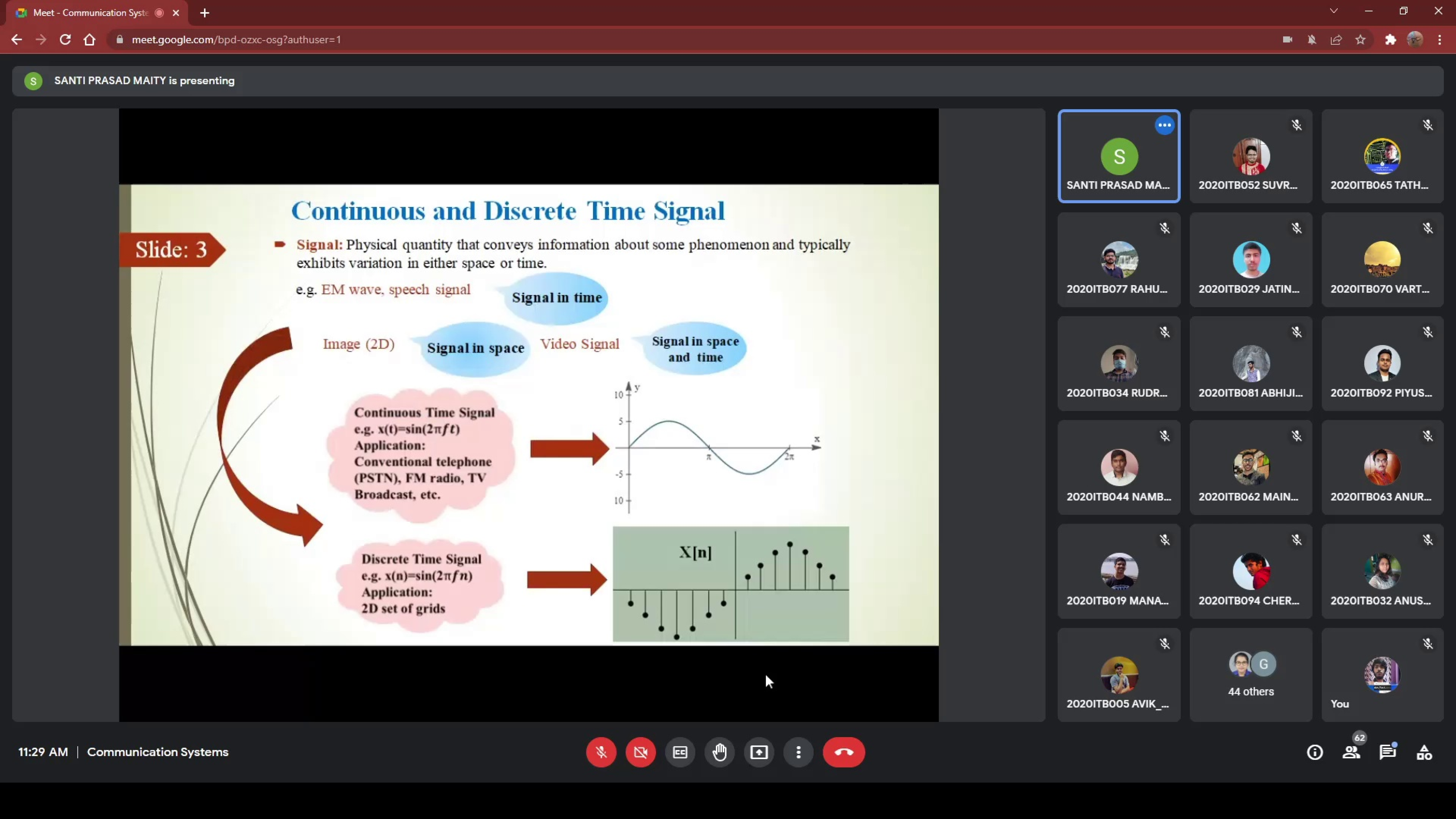
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Continuous and Discrete Time Signal
Slide: 3
Signal: Physical quantity that conveys information about some phenomenon and typically exhibits variation in either space or time.
e.g. EM wave, speech signal
Signal in time
Image (2D)
Signal in space
Video Signal
Signal in space and time
Continuous Time Signal
e.g. x(t)=sin(2πft)
Application:
Conventional telephone (PSTN), FM radio, TV Broadcast, etc.
10
y
5
x
π
2π
-5
10
Discrete Time Signal
e.g. x(n)=sin(2πfn)
Application:
2D set of grids
X[n]
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Slide: 4

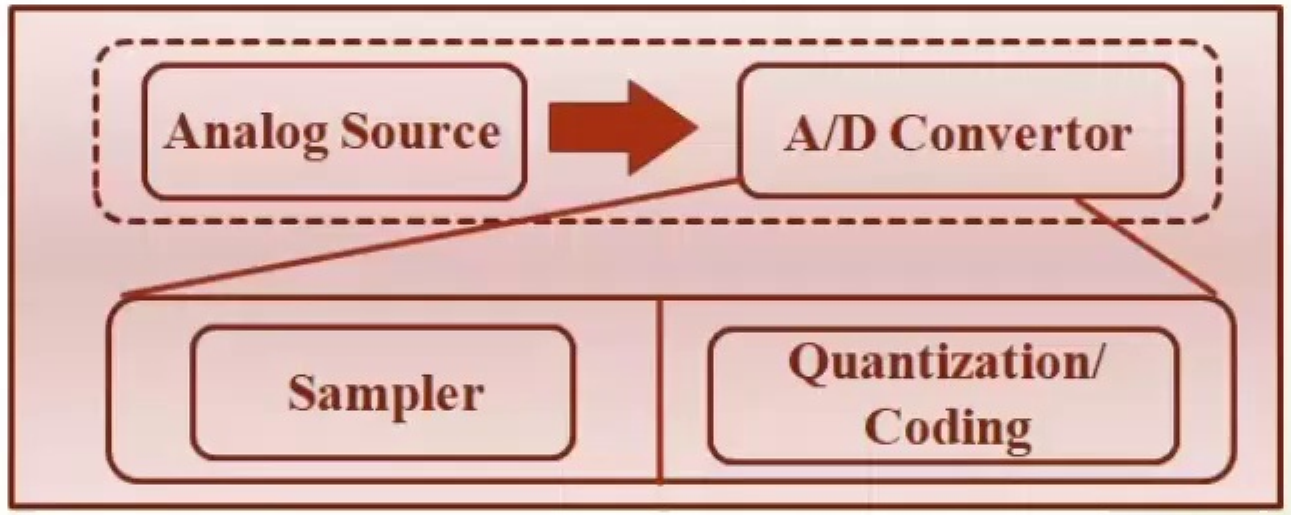
Types of Sources

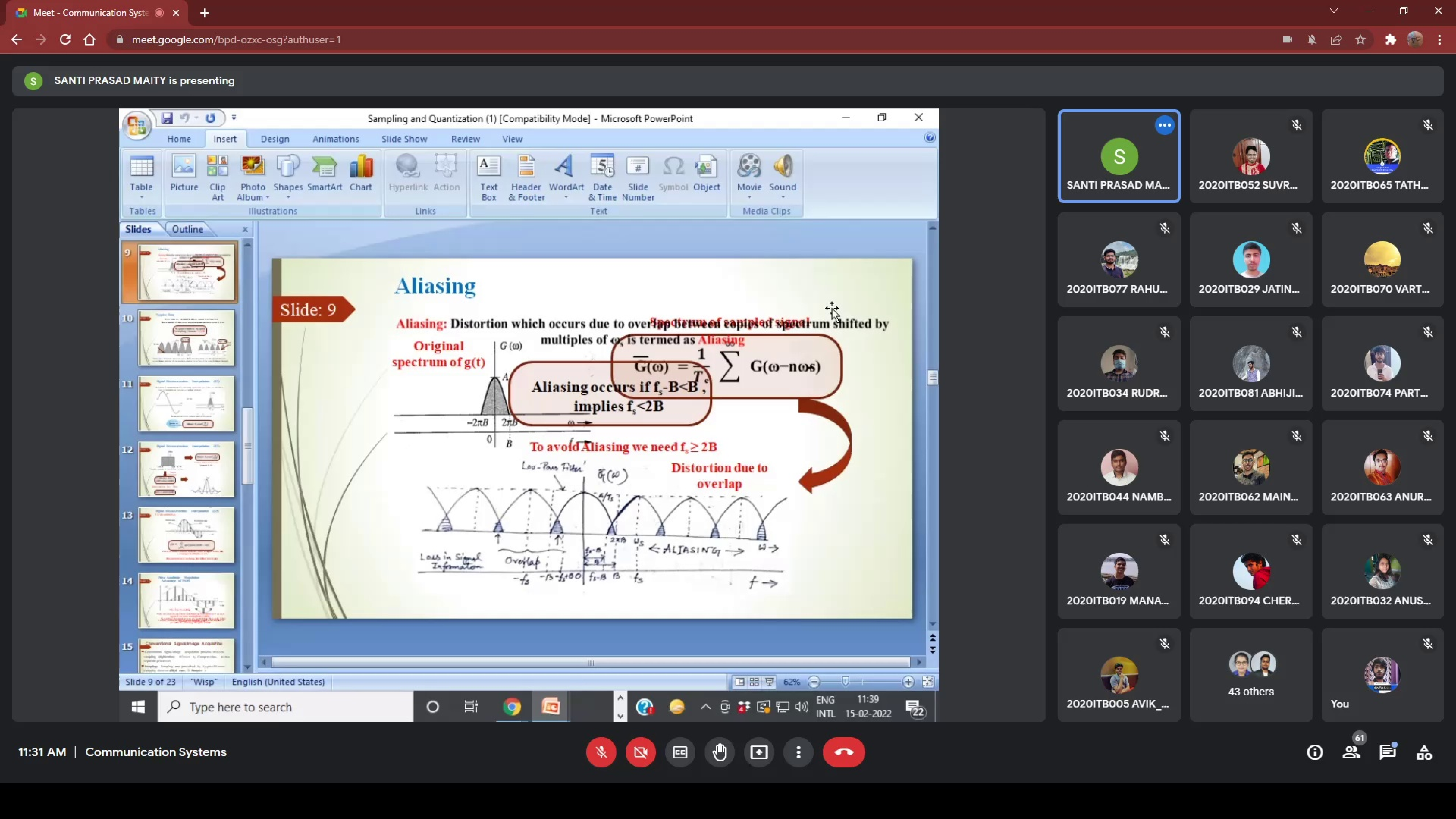
- **A) Analog Source: Continuous time** and **continuous valued signal** where every point/sample can take any one of **infinite** number of values

  Example: Audio Signal captured in a microphone, video signal captured in a video camera.

- **B) Digital Source:** Energy sample can take **finite** number of values

  Example: Binary source, binary file in bits, typing English text.

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Sampling and Quantization (1) [Compatibility Mode] - Microsoft PowerPoint
Aliasing
Slide: 9
Aliasing: Distortion which occurs due to overlap between copies of spectrum shifted by multiples of ωs is termed as Aliasing
Spectrum of sampled signal
Original spectrum of g(t)
Aliasing occurs if fs-B<B , implies fs<2B
To avoid Aliasing we need fs ≥ 2B
Distortion due to overlap
Low-Pass Filter
Loss in Signal Information
Overlap
ALIASING
Slide 9 of 23
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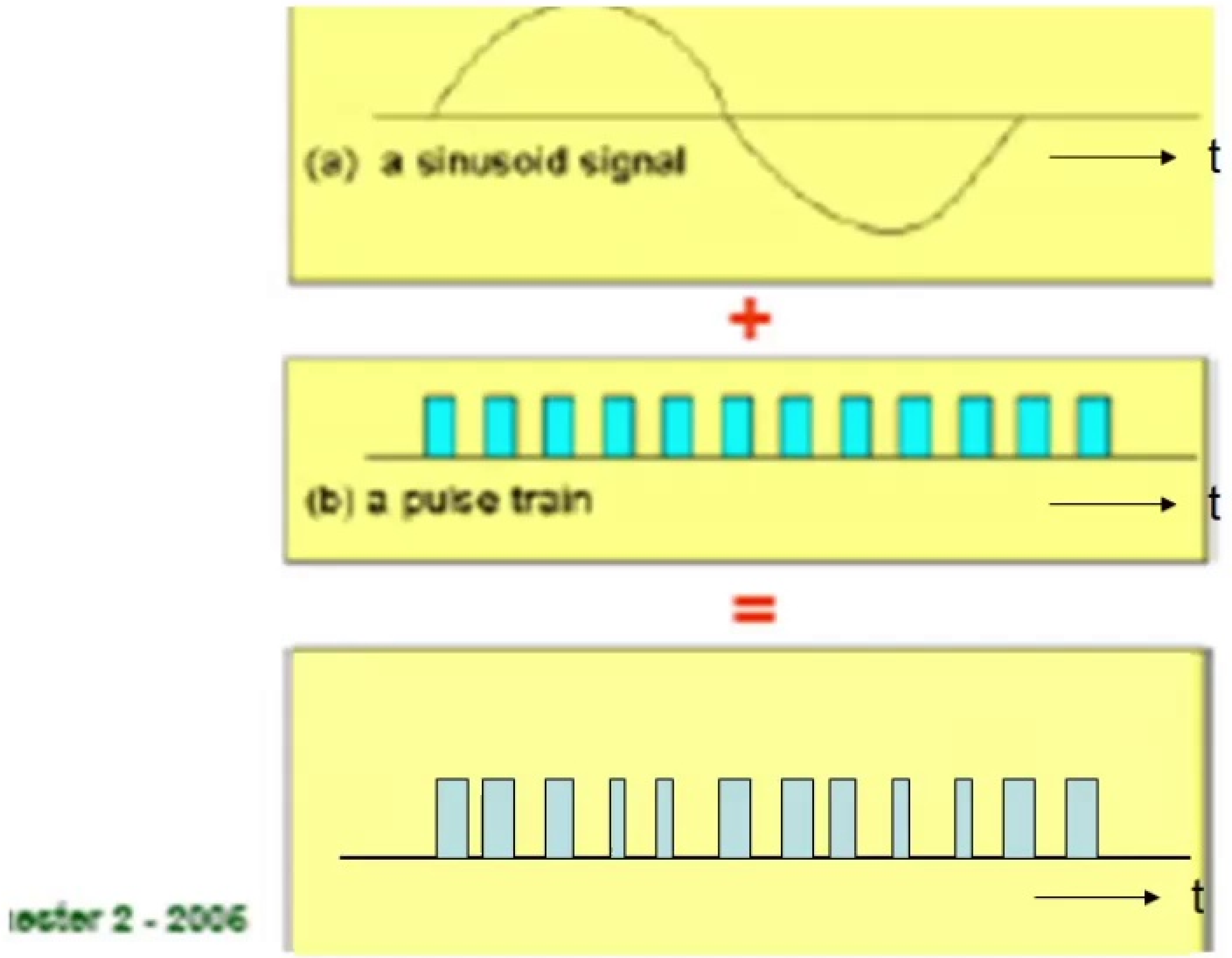
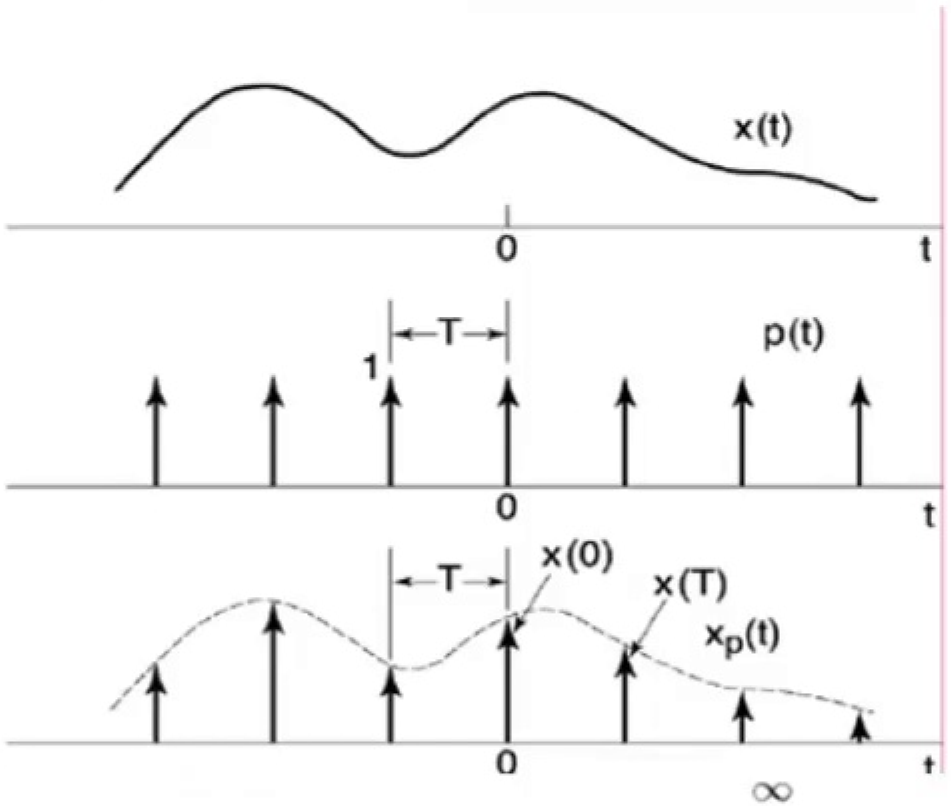
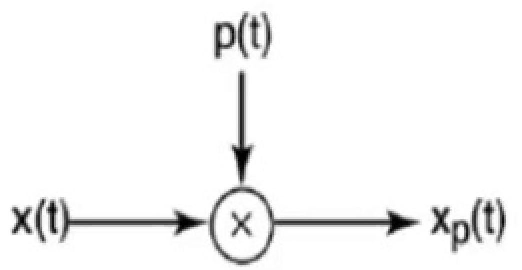
Pulse Width Modulation



Instantaneous Sampling





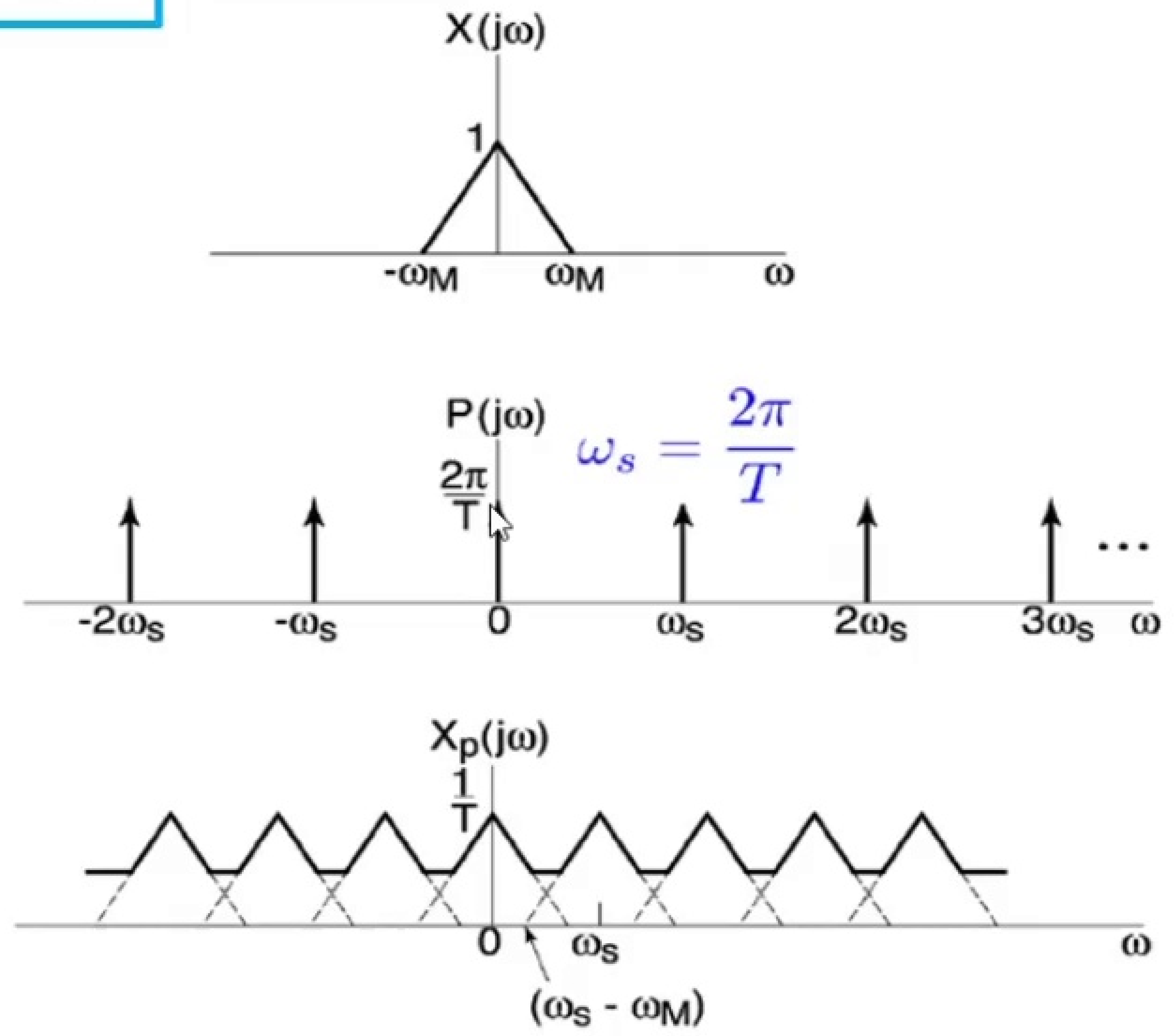
$$\boxed{\begin{aligned} &\omega_s - \omega_M > \omega_M \\ &\omega_s > 2\omega_M \end{aligned}}$$

$$p(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT)$$

$$x_p(t) = x(t)p(t) = \sum_{n=-\infty}^{\infty} x(t)\delta(t - nT) = \sum_{n=-\infty}^{\infty} x(nT)\delta(t - nT)$$

Undersampling and Aliasing

When $\boxed{\omega_s \le 2\,\omega_M \Rightarrow}$ Undersampling



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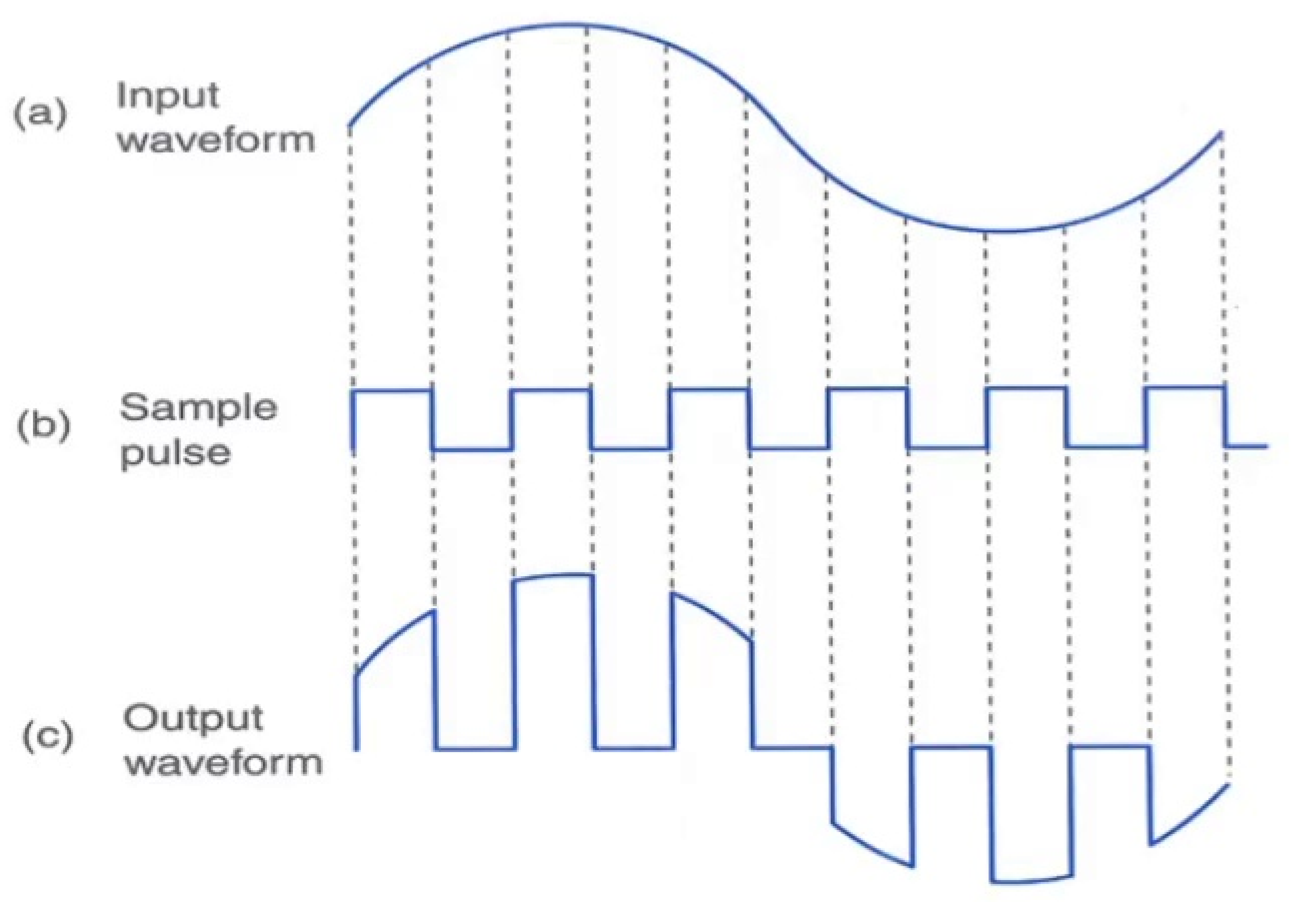
Natural Sampling



Natural sampling: (a) input analog signal; (b) sample pulse; (c) sampled output

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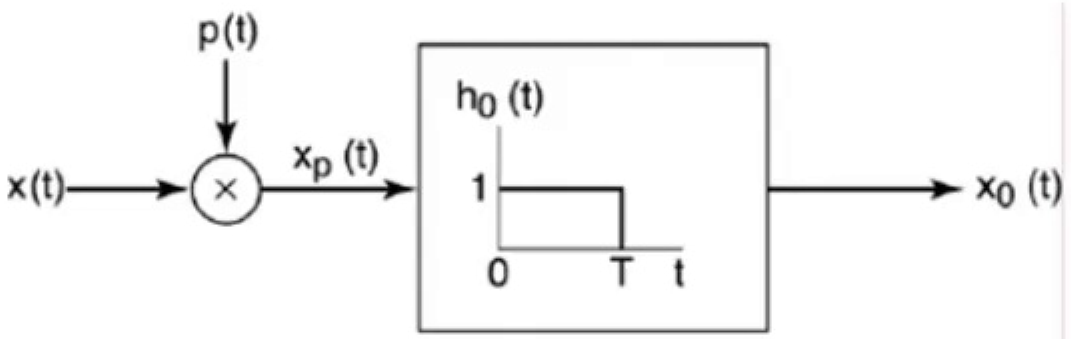
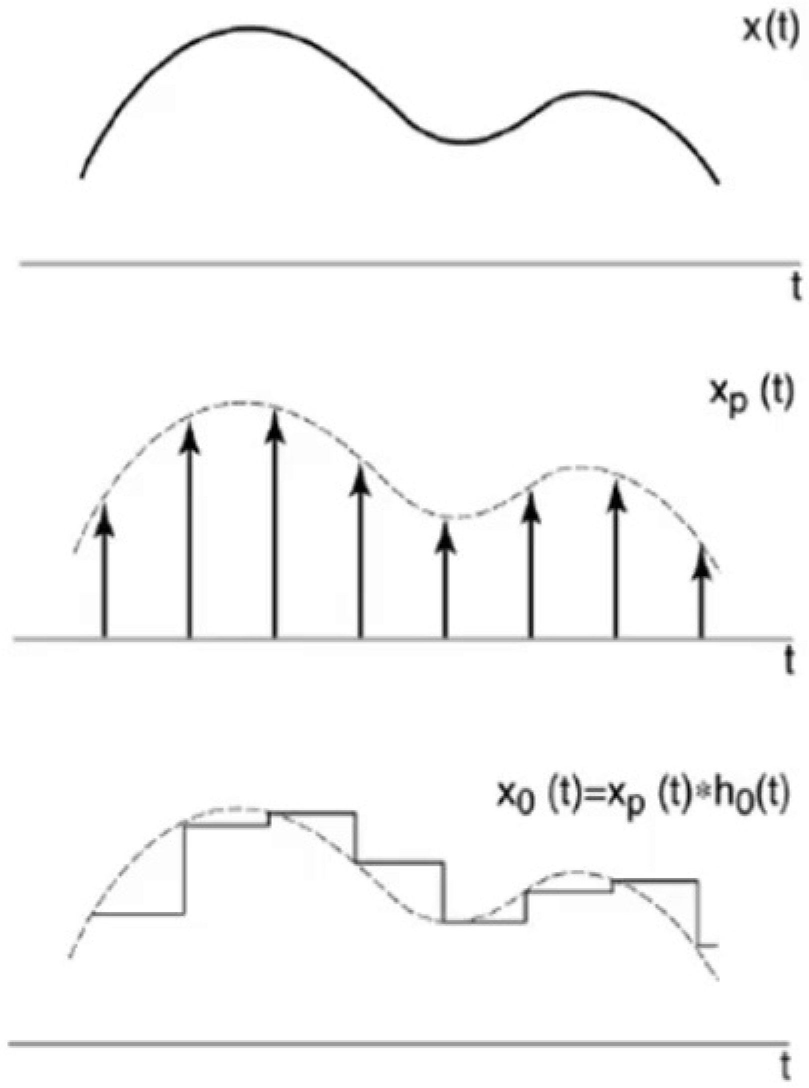
- **Sample and hold**
  - In its simplest form the sample is held until the next sample is taken, so it is of maximum width.
- **Practical example:**
  - **Zero-Order Hold**,
  - **First-Order Hold** —Linear interpolation





Flat-Top Sampling

- Let, p(t) → flat topped pulse of duration τ
- Sampled signal,

$$x_s(t) = \sum_{k=-\infty}^{\infty} x(kT_s)\,p(t-kT_s)$$
$$= p(t) * \sum_{k=-\infty}^{\infty} x(kT_s)\,\delta(t-kT_s)$$

- This type of sampling is called ***flat topped sampling***
- The spectrum is, [Taking Fourier Transform]

$$X_s(f) = P(f)X_\delta(f)$$
$$= P(f)[f_s \textstyle\sum_{n=-\alpha}^{\alpha} X(f - nf_s)]$$

Flat-Top Sampling

- Primarily this sampling technique attenuates high frequencies
- Pulse width is chosen small, $\tau << 1/f_s$
- Effect of pulse shape is unimportant and is a good approximation of ideal impulse sampling.

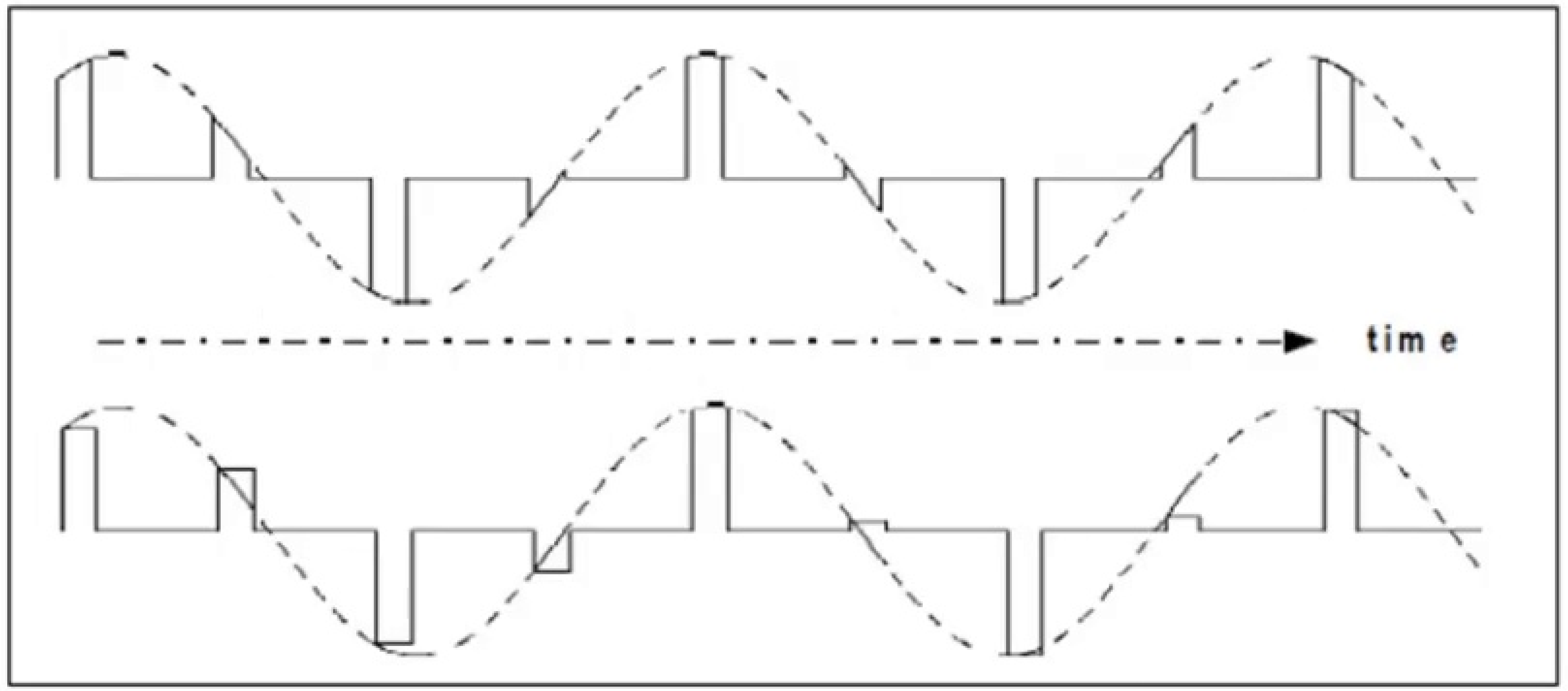


Figure 1: natural sampling (above) and flat top (below)

Nonideal reconstruction filter

Figure 1

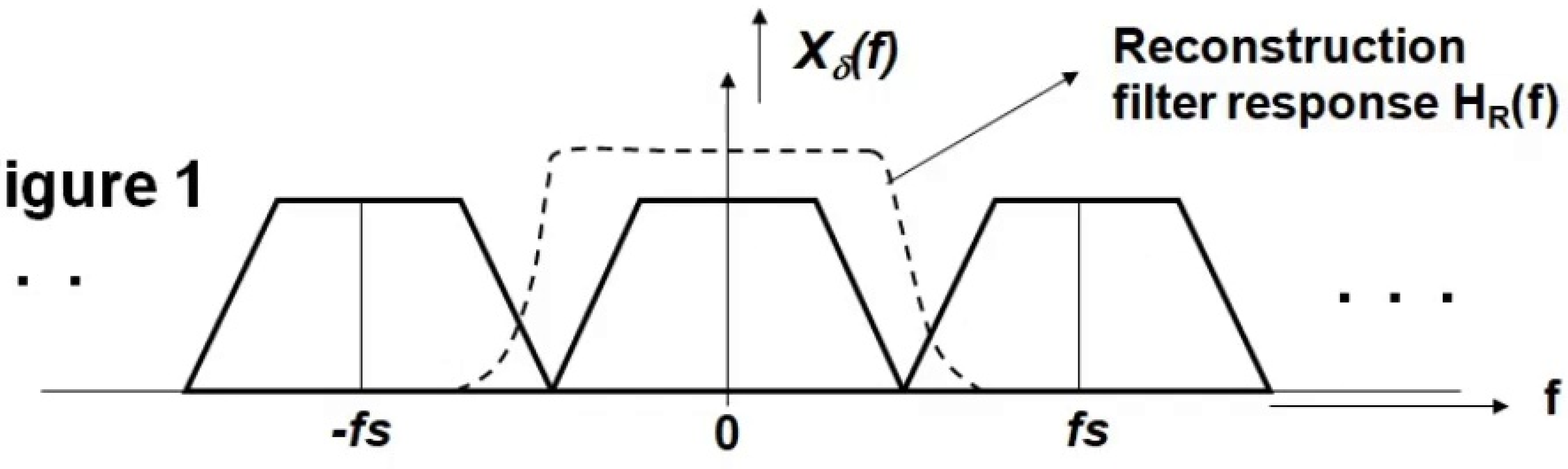
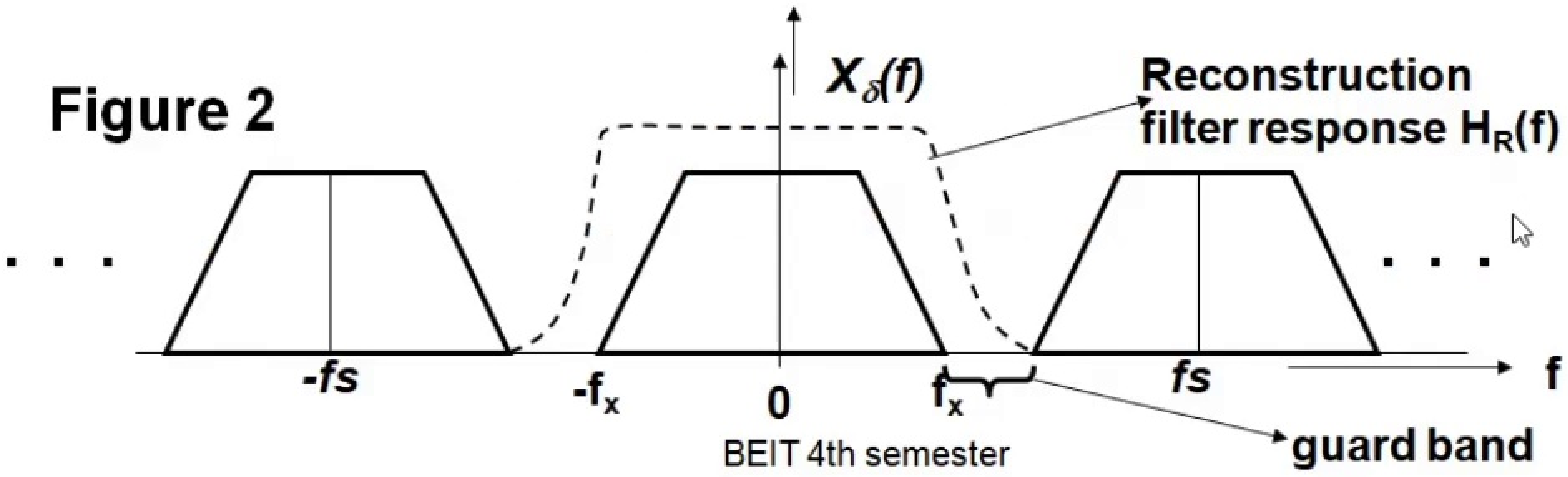


Figure 2



Nonideal reconstruction filter

- The filter response shown in first figure is not ideal and cannot suppress spurious components of x(t).
- In Figure 2, we design a filter with increased sampling frequency, with guard band $(f_s - 2f_x)$Hz.

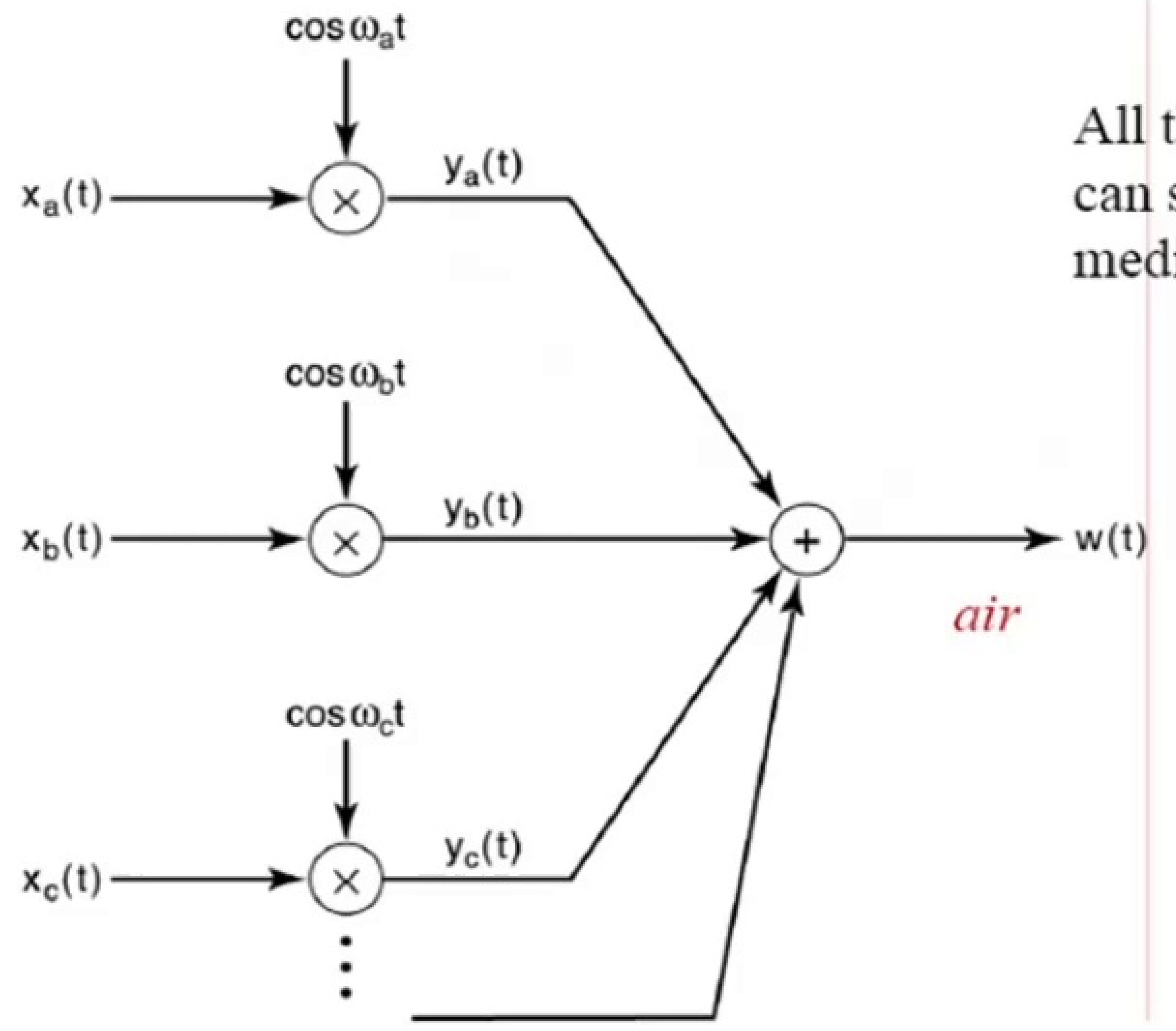
Multiplexing Techniques

- Frequency Division Multiplexing
- Time Division Multiplexing
- Multiplexing means simultaneous transmission of several message signals through a common channel or bearer

Transmitter end

Frequency-Division Multiplexing (FDM)

(Examples: Radio-station signals and analog cell phones)



All the channels can share the same medium.

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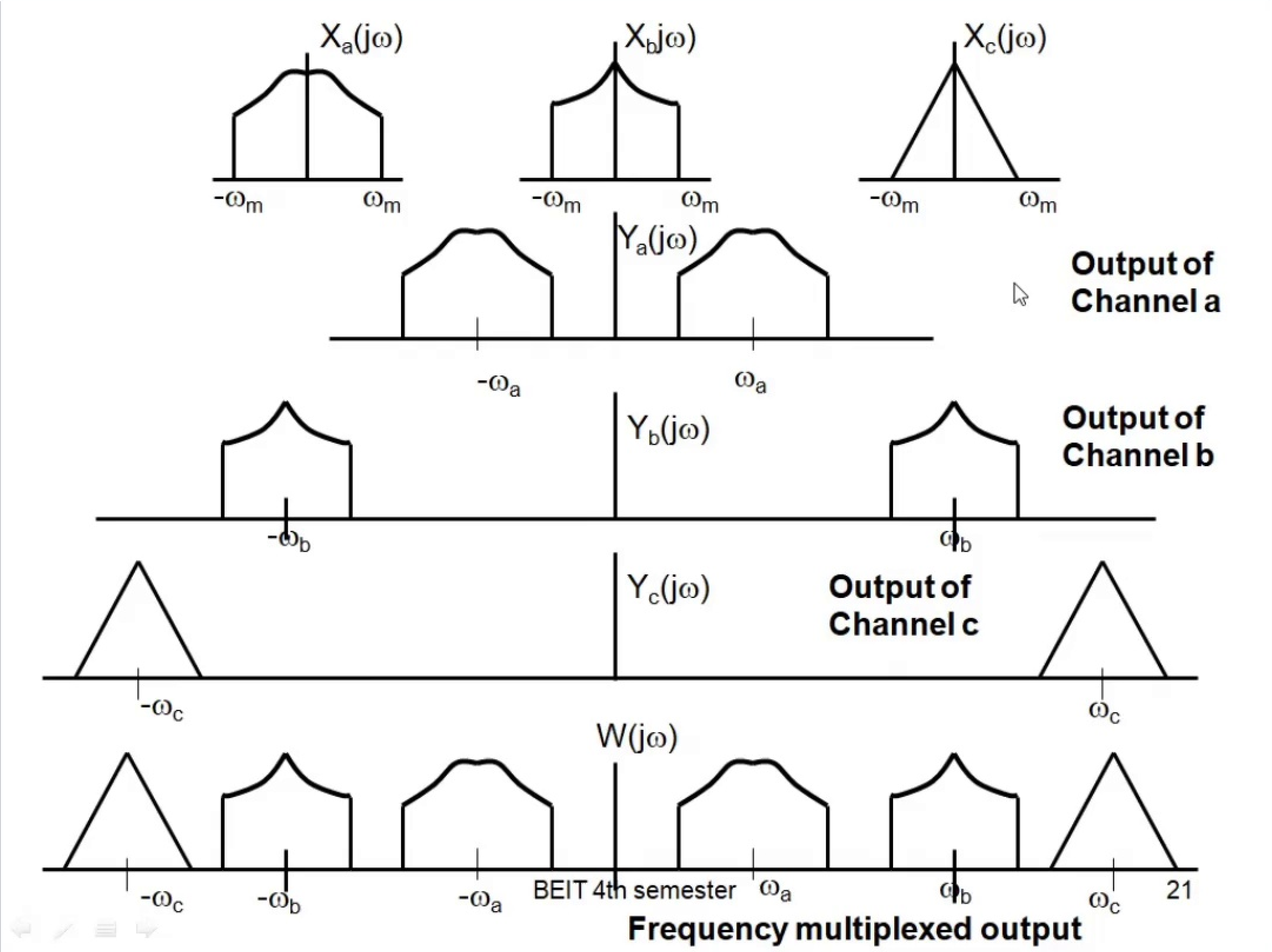

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Reconstruction of original signals