AKTU

B.Tech III-Sem

Digital System Design



Unit-5 Lecture-2

EC & EC Allied

Gateway classes

DIGITAL SYSTEM DESIGN

UNIT 5 : Digital-to-Analog converters (DAC)
Lec 2

Today's Target

- Analog-to-digital converter
- ADC Process
- Types of Analog to Digital Converter
- Application of ADC
- Single Slope ADC
- University Questions

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UNIVERSITY QUESTIONS

YEAR	QUESTIONS	MARKS
21-22	Explain single slope and dual slope ADC with a neat sketch.	10 Marks

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Analog-to-digital converter

- An analog-to-digital converter (ADC, A/D, or A-to-D) is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal.

- An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital number representing the magnitude of the voltage or current.

- A/D converter is a linkage between the analog (linear) world of transducers and discrete world of processing the signal and handling the data.

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ADC Process

- There are mainly two steps involves in the process of conversion. They are
- 1) Sampling and Holding
- 2) Quantizing and Encoding
- The whole ADC conversion process is shown in figure.

1·10 → 1
1·60 → 2

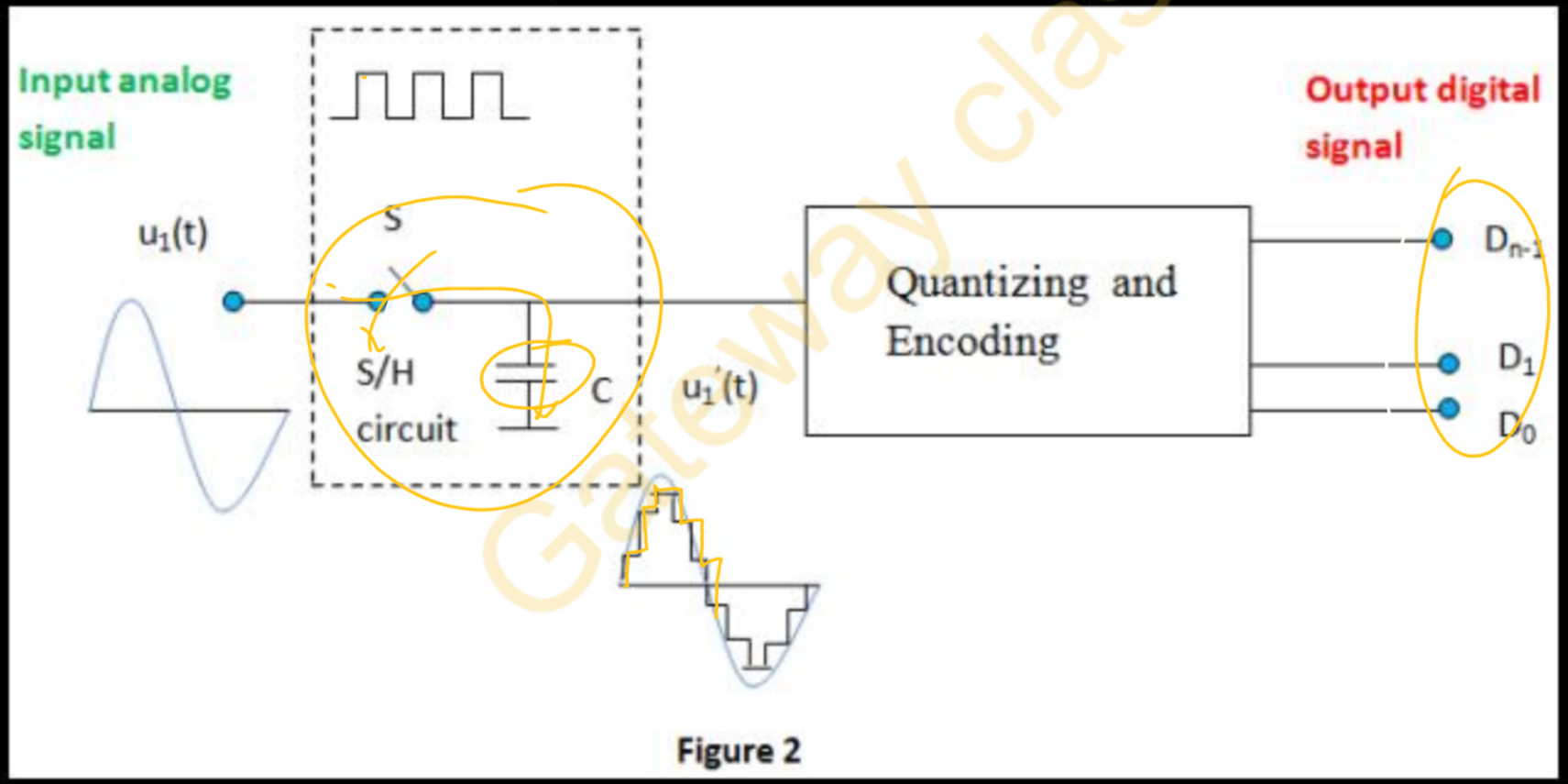
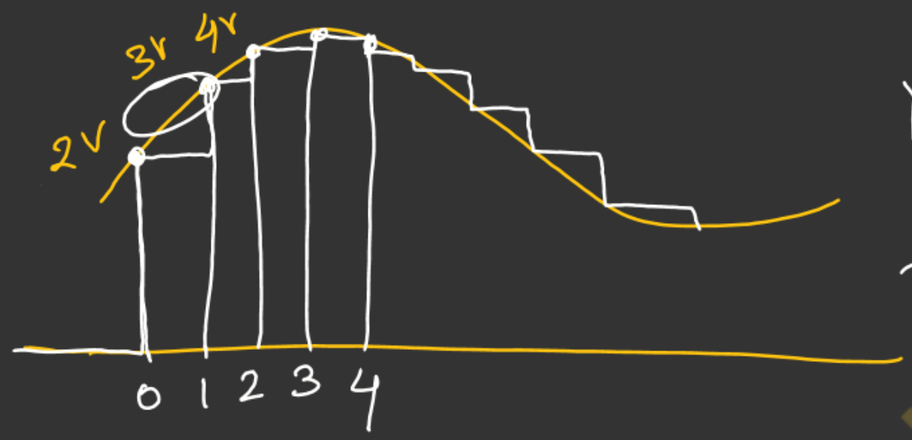


Figure 2

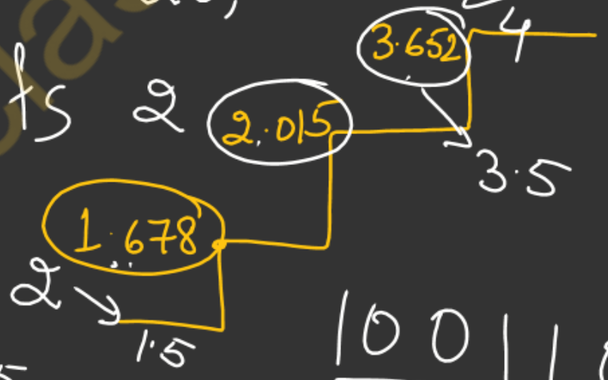
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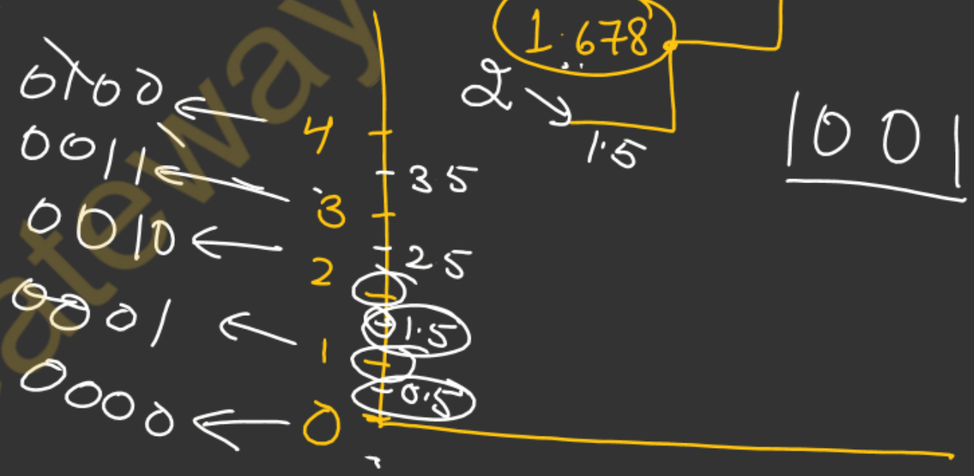
Nyquist Criteria

$f_s \geq 2f_m$

20,000 x 2







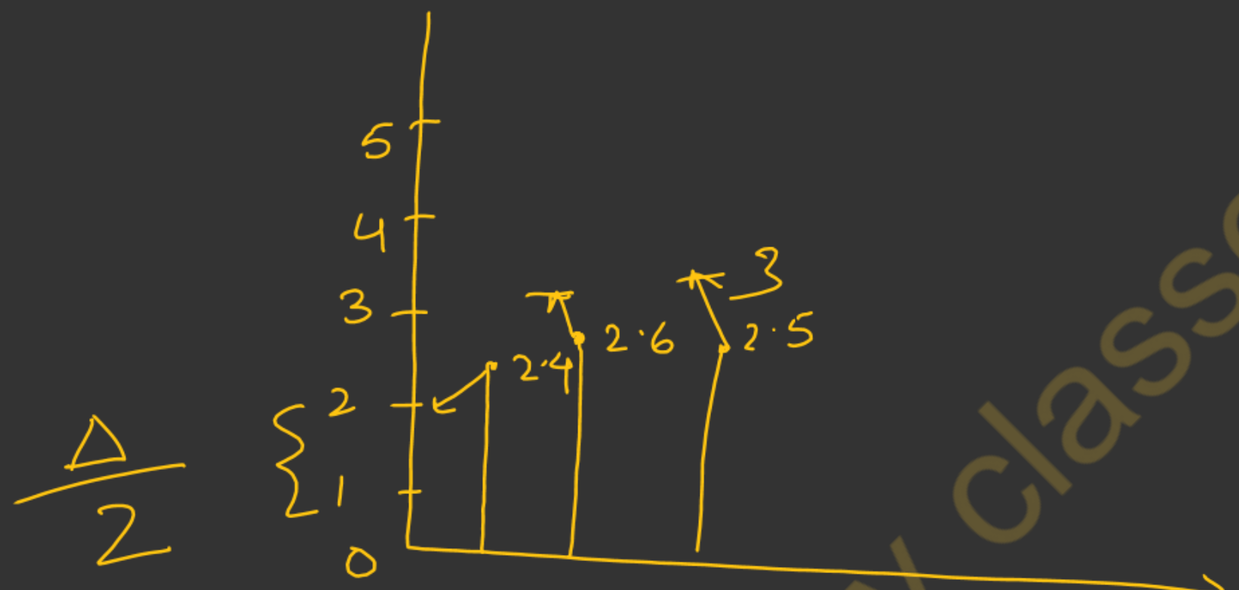
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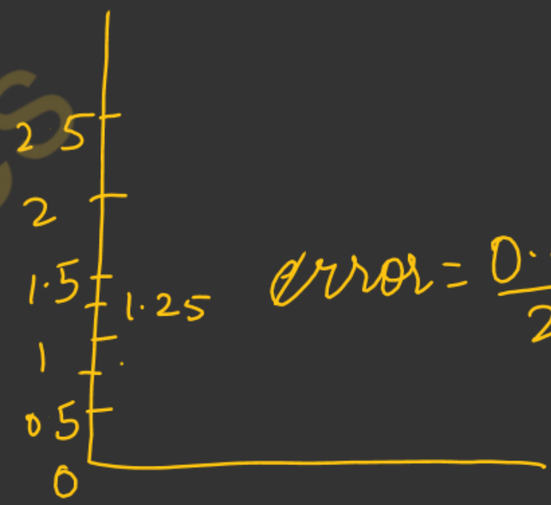
ADC Process

- Sampling and Holding:
- In the process of Sample and hold (S/H), the continuous signal will gets sampled and freeze (hold) the value at a steady level for a particular least period of time.
- It is done to remove variations in input signal which can alter the conversion process and thereby increases the accuracy.
- The minimum sampling rate has to be two times the maximum data frequency of the input signal.
- Quantizing:
- It is the process in which the reference signal is partitioned into several discrete quanta and then the input signal is matched with the correct quantum.
- For understanding quantizing, we can first go through the term Resolution used in ADC.
- It is the smallest variation in analog signal that will result in a variation in the digital output.
- This actually represents the quantization error.
  Resolution $\Delta V = VR / 2^N$
- V → Reference voltage range
  2^N → Number of states

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$\frac{\Delta}{2}$



$error = \frac{0.5}{2} = 0.25$



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Encoding

- For each quantum, a unique digital code will be assigned and after that the input signal is allocated with this digital code.
- The process of quantizing and encoding is demonstrated in the table beside:
- Only one digital value is used to represent the whole range of voltage in an interval.
- Thus, an error will occur and it is called quantization error. This is the noise introduced by the process of quantization.
- The maximum quantization error is: $\pm (1/2)\,\Delta V = \pm 0.5$ V

Analog signal			Digital o/p
7.5	7	7Δ=7V	111
6.5	6	6Δ=6V	110
5.5	5	5Δ=5V	101
4.5	4	4Δ=4V	100
3.5	3	3Δ=3V	011
2.5	2	2Δ=2V	010
1.5	1	1Δ=1V	001
0.5	0	0Δ=0V	000

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Types of Analog to Digital Converter

- Successive Approximation ADC: This converter compares the input signal with the output of an internal DAC at each successive step. It is the most expensive type.
- Dual Slope ADC: It have high accuracy but very slow in operation.
- Pipeline ADC: It is same as that of two step Flash ADC.
- Delta-Sigma ADC: It has high resolution but slow due to over sampling.
- Flash ADC: It is the fastest ADC but very expensive.
- Other: Staircase ramp, Voltage-to-Frequency, Switched capacitor, tracking, Charge balancing, and resolver.

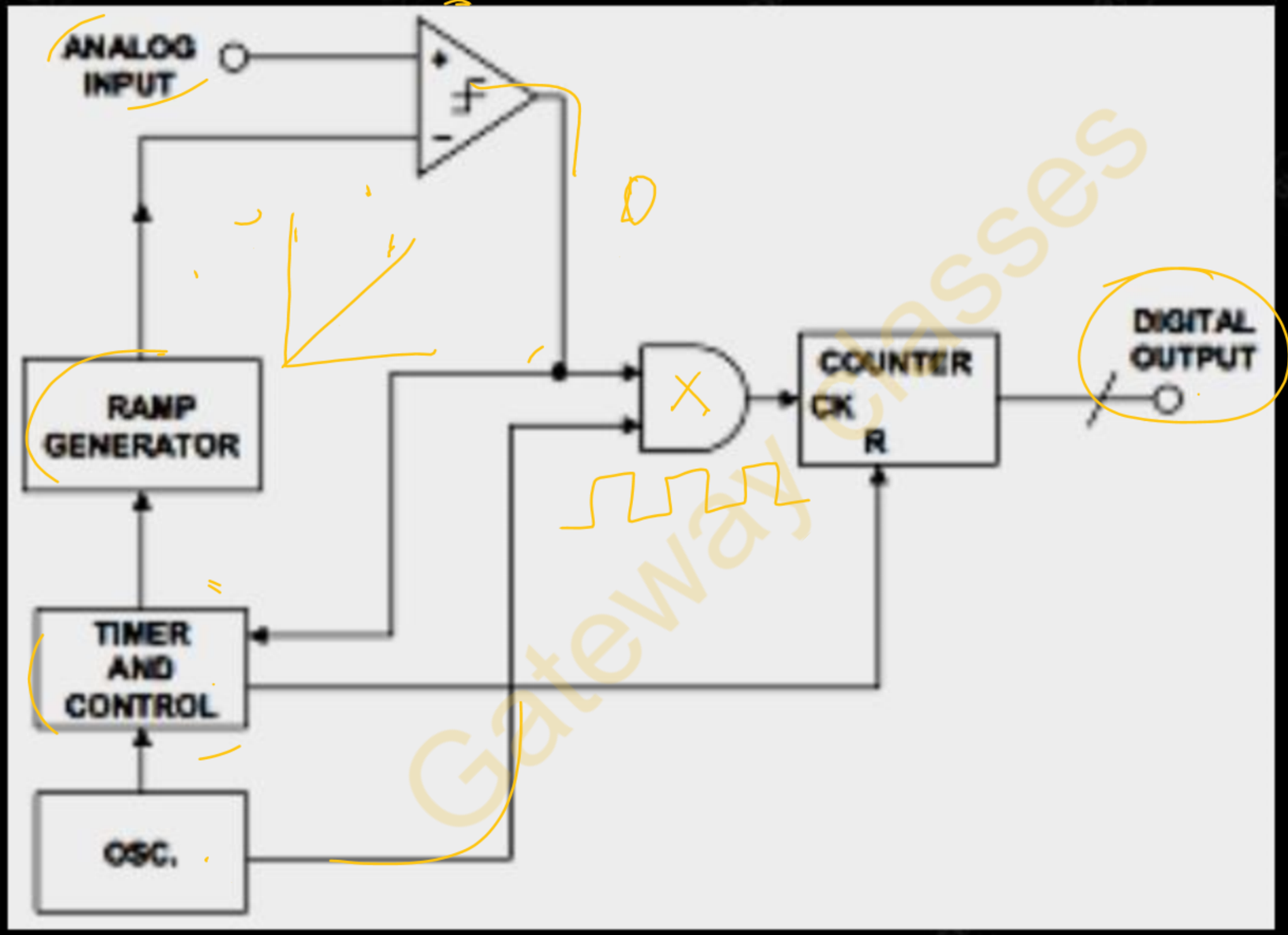
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Application of ADC

- Used together with the transducer.
- Used in computer to convert the analog signal to digital signal.
- Used in cell phones.
- Used in microcontrollers.
- Used in digital signal processing.
- Used in digital storage oscilloscopes.
- Used in scientific instruments.
- Used in music reproduction technology etc.

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SINGLE SLOPE ADC



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WORKING

- As soon as input appears, comparator gives positive pulse.
- This pulse triggers AND gate which triggers counter. Counter starts counting.
- Comparator also triggers timer and control which triggers ramp generator.
- Ramp generator generates constant slope ramp signal until the time this ramp exceeds input signal.
- As soon as ramp signal > analog input, comparator generates negative pulse and closes AND gate, stops counter, stops timer and ramp generator.
- The count obtained by counter equals the value of analog input signal.

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Problems in Single Slope ADC

- single-slope A/D can only measure voltages whose sign differs from that of the reference voltage.
- The values of resistors and capacitors are more problematic while dealing with accuracy of the circuit.
- Vsignal being measured ≈ −Vref *Ts *n /RC.
- Thus, n is proportional to the voltage being measured, and n is the digital output of the A/D.

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Thank You