↳ Branch - CSE (CS)
↳ sem — 4th

Q1 What is the primary function of digital-to-analog converter (D/A Converter)?

Ans, A Bridge between Digital and Analog worlds.

The Primary function of a digital to analog converter (DAC) is to convert digital signal; which are represented as discrete Binary values (typically in the form of 0s and 1s) into devices, such as speakers, display - The DAC enables digital devices to produce audio. vedio other analog signals that can be perceived and used in the real world.

→ The exact implementation various; but most DAC use a combination of resistor. Switches and operational amp's to generates an analog output voltage proportional to the input digital code.

Q2 Explain the working principle of a weighted resistor D/A converter?

Ans, A weight resistor Digital-to-Analog Converter (D/A C) operates based on the principle of summing currents or voltages that correspond to the digital input bits using a resistor Network.

Working principle,

1.) Binary input:- The digital input to the DAC is a binary number, with each bit representing a different weight. For intance, n-bit DAC, the MSB has highest weight and LSB lowest weight.

2.) Register Network, Each bit of the digital input is connect to a corresponding resistor in the network

for. Exa
- MSB is connected to a resistor of R
- Next significant bit is connected to a resistor 2R
- Following bit is connected to resistor of 4R.

3) Current Generation, Each digital bit control a switch that either connects the corresponding resistor to a reference voltage or ground. This setup generats current prop^n to the binary weight of the active bits.

4) Summing Nodes, The current from all the resistors are summed at a common point, typically the inverting input of an operationl amplifiers.

5) Analog output, The summed current is converted to a voltage using the operational amplifiers. The output voltage is proportinal to the weight sum of the binary inputs bits, giving a corresponding analog signal.

This method provides a simple and direct way to convert digital signals to analog, though it is typically limited to low-bit resolution due to the impracticaly of precise resistor for higher bits.

Q3 ⇒ Why are only two-resister values (R and 2R) used in a R-2R ladder?

Ans, The R-2R ladder DAC uses only two resistor values beca it offers several key advantages:

- Simplified Manufacturing:- Using only two resistor values significantly simplify the manufacturing process. It reduce → the number of different resistor values the need to be pricely manufactured and stocked leading to lower production cost
- Reduced Sensitivity to Resistor Tolerance:- In a weighted resistor DAC, the accuracy of the output voltage heavily relies on the precise ratios between resistor.

→ In contrast, R-2R ladder's reliance on only two resistor values minizes the impact of resistor tolerance on the overall accuracy.

- **Modular design:-** The R-2R ladder architecture is inherently modular.
  → Adding more bits to the DAC simply involves adding more section to the ladder, making it easy to expand.
- **Improved Accuracy:** By using only two resistor values, the R-2R ladder minimizes the impact of resistor mismatches on the overall accuracy of the DAC.
  → This leads to a more predictable and consistance output voltage.

It provides significants advantage in terms of manufacturing simplicity, cost-effectiveness, accuracy and modularity.

Q4. Define resolution in the context of D/A converters. How does it affect the output signal?

Ans → Resolution in a Digital-to-Analog Converter (DAC) refers to the smallest changes in the analog output voltage that can be produced by a change in the least significant bit (LSB) of the digital input.
→ Essentially, it determines the "fineness" or granularity of the analog output signal.
→ It is determined by the number of bit n in the digital input word.
→ The resolution is typically expressed in terms of bits or as a percentage of the full-scale output.

Calculation of Resolution,

$$\text{Resolution} = \frac{1}{2^n}$$

n is the number of bits in the digital input.

How Resolution Affects the output Signal:

1.) Step size (Granularity): Higher resolution results in finer granularity, meaning the DAC can produce smaller changes in the output voltage for each step in the digital input

2.) Quantization Error: It is the difference bet^n the actual analog value and the nearest representable value by the DAC.

→ Lower resolution increses quantization error, making the output signal less accurate and pontentially.

3.) Dynamic Range: Higher Resolution extends the dynamic range, which is the ratio bet^n the Largest and Smallest possible output values.

→ This allow the DAC to handle a wider range of single amplitudes.

→ lower resolution restrict the dynamic range.

Q5 ⇒ Compare the features of DAC0808 and DAC1210.

Features	DAC0808	DAC1210
1.) Resolution	8-bits	12 bits
2.) output Type	Current output	Voltage output
3.) Conversion Speed	Modrate (typically: 150ns)	High speed (typically: 1 μs)
4.) Monotonicity	Monotonic	Guaranteed monotonic
5.) Achitecture	R-2R ladder network	Internal architecture typically uses R-2R
6.) Linearity Error	±0.19% (typical)	±0.021% (typical)
7.) Reference Voltage	External reference required	internal or external reference options.
8.) Application	General-purpose, audio instrumentation	High-precision instrumentation, Industrial Control.

key considerations for choosing Between two:

1) Resolution: If you require higher accuracy and finer Control over the analog output the 12-bit DAC1210 would be better

2.) output type:- your application requires a voltage output the DAC1210 is the suitable option. If you need current output the DAC0808 's ~~150ns~~ setting.

3.) Speed: If fast setting time is critical, the DA0808 150ns setting time might be an advantage

4.) Power Consumption:- If Power consumption is a major concern, the DAC0808 low power consumption could be a factor.

Q6 How does a sample and hold circuit help reduce error during Conversion?

Ans, A sample and hold (S/H) circuit plays a crucial role in analog-to-digital conversion (ADC) by reducing errors and ensuring accurate conversion.

Functions of a sample and Hold circuit:-

1.) Sampling: when triggered, the circuit quickly "grabs" the instantaneous values of the input analog signal.
2.) Holding: It then "holds" this sampled value constant, effectively freezing the signal in time.

How Reducess Errors:

→ Eliminates input signal Changs:- By holding the input voltage steady, the sample and hold circuit prevents any variations in the input signal from affecting the ADC's measurement.

→ Improves Accuracy:- The stability significantly improves the accuracy of the ADC conversion, especially for high speed signals or signals with significant noise.

→ Reduces Quantization Noise:- Holding a stable input value reduces the quantization noise that can arise from a ADC trying to convert a fluctuating signal, leading to a cleaner or.

Sample and Hold circuits are essential components in many high-performance ADC system

→ The sample and Hold circuit acts as a buffer, isolating the ADC from the dynamic variations of the input signal

Q7. what is the significance of quantization in A/D Conversion and how does it intrace error?

Ans. Significance of Quantization in A/D conversion

1.) Digital Representation:- It allow us to represent an infinite range of analog values using finites set of digital codes.

2.) Simplifies processing:- Quantized ~~singt~~ signals are easier to manipulate, store and transmit in digit system

3.) Practical Implementation: Quantization makes it possible to process and store analog information within the constraints of digital electronics.

Introduce of Quantization Error:-

This error arises due to the difference between the actual analog input values and the nearest representable digital value.

1.) Nature of Quantization Error: (Discrete level, Difference)
2.) Magnitude of Error: (Max Error: $V_{ref}/2^{n+1}$
3.) Effect on signal: (Distortion, Noise)

Minimizing Quantization Error:-

1) Increasing Resolution:- using more bits in the ADC increases the number of discrete level.

2) Oversampling :- sampling the signal at a higher rate than the Nyquist rate and then digitally filtering can help reduce the preeeived quazation Noise.

→ Quantization is an inherent limition of A/D Conversion.
→ Higher resolution redues qudization Error and improves the accuracy of the Conversion.

Q8
⟹ Explain the operation of a flash A/D Converter?

Ans ⟹ A Flash ADC also known as a parallel ADC, is a type of analog-to-digital converter known for its high speed conversion.
→ It one of the fastest ADC types available.

Componant :-
1.) Resistor ladder Network
2.) Comparators
3) Encoders

1.) A key components is a resistor ladder that generats a series of rebrence voltage
→ Each rung of the ladder provides a unique ref^{n} vol

2.) com^{s} :- An array of comparators is connects to the resistor ladder
→ Each comparator compares the input analog sing to its corrspending reberence voltege

3.) Encoders :- The output of all the comparators are fed into a priority encoder
→ The encoder analyzes the pattern '1's and '0' from

Application,
↳ Digital Oscalloscopes
↳ High speed and acqusition system
↳ Radar and Communicato system

→ High speed : Flash ADC are the fasted ADCs due their parallel Architecture.
→ Power Consumption: Higher Power con^{n} due to large number of active compon

Q9. Describe the working principle of successive approximation A/D Converter.

Ans. A successive Approximation ADC is a type of analog-to-digital converter that converts an signal to a digital output by interatively approximation the input signal.

Working Process:-

1.) Initalization:-

→ The SAR is initialized with the most significant bit (MSB) set to 1 and all other bits set to 0.

2.) Comparison:-

The DAC output voltage is compared to the input analog signal using a comparator

3.) Bit Determination:-

→ If the DAC's output is greater than input signa the MSB is reset to 0.

→ If the DAC's output is less than input voltage, the MSB remains set to 1.

4.) Next Bit:-

this process of setting a bit, comparing and the DAC's output is updated accordingly.

5.) Iteration:

This process of setting a bit comparing and adjusting continues for all bits in the digital outs

6.) Final output:

After processing all bits the SAR holds the final digital code that represents the closest approximation of the input analog signal.

→ Efficiency and Accuracy. SAR ADC interatively refines its digital output by successively approximation the input signal.

Q10 ⟹ How does a counting A/D converter determine the digital equivalent of an analog input?

Ans ⟶ In a counting ADC, the digital equivalent of an analog input is determined through a sequential counting process

Componants:-

1) Counter
2) Digital-to-Analog Converter
3) Comparator
4) Control logic

Working Process ⟶

1) Initialization:

The counter is set to zero (0) at the beginning of conversion process.

2) Counting up:

The counter starts incrementing at a constant clock rate

3) Comparison:

A comparator continuously compares the DAC's output voltage to the input analog signal.

4) Completion:

When the DAC output equals or exceeds the input voltage, the comparator signal the control logic to stop the counter.

5) Output:

The final count is the digital output, which corresponding to the input analog signal

→ After outputting the result the counter is reset to 0.

Application ⟶

1) Digital Voltmeters
2) Low speed data acqusition system

The counting ADC determine the digital equivalent of an analog input by incrementally increasing its digital output until it matches the input signal providing a simple and direct conversion method.

Q11 ⇒ what is meant by "word size" in memory organization, and how does it affect memory operations?

Ans → Word size in memory organization refers to the number of bits that a processor or memory system can process, transfer, or store in a single operation.

→ It is typically expressed in bits (e.g. - 8-bits, 16-bit, 32 bit)

→ It's a fundamental characteristic of a computer system arch.

How word size Affects Memory operations:-

1.) Data Processing :-

•) Larger Word size:- A system with a Larger word size can process more bit of data simultaneously, leading to faster data processing and computation.

•) smaller word size:- System with smaller word size may require more cycle to process the same amount of data, Potentially reducing performace.

2.) Address space:-

•) word size directly influences the amount of memory that a processor can directly address.

E.g: a 32-bit processor can directly address 2^{32} bytes.

3.) Data Types:-

word size determines the natural size of data types supported by the processor.

Memory Aligment: Data structure are often aligned to word boundries. Larger word size can reduce the number of memory access needed for large

4.) Instruction set:-

•) The word size of a processor influences the design of its instruction set.

•) Larger word size allow for more complex instruction and larger operands.

5.) Performace! speed: larger word size typically lead to higher performance, especially in tasks involving large datasets.

→ Larger words size generally lead to better performance

→ ~~Increase~~.

Q12 ⟹ How can multiple smaller memory chips be combined to expand memory size in terms of capacity or data width?

Ans, To expand the memory size of a system, smaller memory chips can be combined in two main ways:

i) Increasing capacity
ii) Expanding data width.

*) Increasing Capacity :-

- Method :- connect multiple memory chips in parallel, effectively increasing the total number of memory
- Implementation:
  - ↳ Address Decoding: use an address decoder to select the appropriate chip based on the higher order bit
  - ↳ Data Bus: connect all the data lines of the chips together to form a wider data bus.

E.g., memory chip 4MB, total memory = 16MB

chip 1 : 0x0000000 to 0x003ffffff

chip 2 : 0x004000 to 0x007fffff

chip 3 : 0x00080000 to 0x00Bffff

*) Increasing data width :-

- Method : connect multiple memory chip in parallel, but each chip stores a portion of the overall data wo
- Implementation :-
  - ↳ Address lines :- share the same address line among all chips.
  - ↳ Data Bus : Divide the data bus into segments, with each segment connected to a different chip.
  - ↳ Controllines :- Share Common control signal among all ch

Eg → 16-bit wide memory using 8-bit chips :

- Two 8-bit chips are connected in parallel.
- first chip handle the lower 8 bit (D0-D7) Second chip the upper 8 bits (D8 - D15) 16-bit data bus.

Q13 Differentiate between volatile and non-volatile memories with examples:

Volatile Memory	Non-volatile memory
1.) Losses data when power is off	1.) Retains data without power
2.) Fast read / write speeds	2.) Slower read / write speeds
3.) It use in Temporary storage	3.) Permanent storage
4.) Limited storage capacity	4.) Larger storage capacity
5.) It Requires continuous power supply	5.) Does not require power for data retention
6.) Generally more expensive per bit	6.) Less expensive per bit compared volatile memory
7.) Example, RAM (Random Access Memory) chache memory	7.) Exmple:- ROM (Read-Only Memory) flash memory.

Q14 What is sequential memory, and how does it differ from random-access memory?

Ans, Sequential memory refers to a types of memory where data is accessed in a fixed, predetermind order.

→ It is commonly used in devices where data is stored and retrieved in a linear fashion.

Access Method, Data can accessed in a linear order, one after the other (sequential

Access Time, Access Time can vary depending on the position of the data; it takes longer to retrive data

Example, Magnatic Tape : data store linearly

Some optical Disk : certain disc formate or playback

Sequential Memory	Random Access Memory
1.) Data accessed in linear (Sequential)	1.) Data accessed randomly, any location
2.) Varies; depends on the position of the data Access Time	2.) Access Time constant; independent of data position.
3.) speed Generally slower due to sequential	3.) Speed faster due to direct access.
4.) usage suitable for sequential data storage	4.) usage suitable for temporary storage of active data
5.) cost is cheaper	5.) Cost is higher
6.) Eg:- magnatic tape. optical discs.	6.) Eg:- DRAM, SRAM

Q.15 How does CAM differ from traditional RAM in terms of data access?

CAM (Content-Addressable Memory)	Traditional Random-Access Mem
1.) Data Access : CAM searches for data based on its content rather than a specific memory. Parrell Search, which allow it to find data very quickly	1.) Data Access: RAM retrieves data based on a specific memory address. RAM provide direct access to any location in memory
2.) Speed faster for searches	2.) Faster for Direct Access
3.) Storage Efficiency for searchs CAM store data in a way that facilitates rapid search	3.) Storage Efficient for storage! RAM is optimize for storing large data efficently
4.) Data matching using content matching	4.) Data Matching Address-Based Access : it require exact address to retrives.
5.) It usage in:- Networking, cache memory, Data base engine	5.) It usage in Running application, store temporary.

→ CAM and Traditional RAM different purpose in computing CAM excles in scenarios requiring fast searches based on data content while RAM is used for general data storage and retrival based on specific address.

→ CAM Parallel search capability makes it ideal for specific application like Network (IP address Matching.)