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Assignment-04 (BOE405)

(Q1) Discuss the R/2R ladder DAC & binary weighted resistors DAC.

Ans:- **R/2R Ladder DAC**

- The R/2R ladder DAC is a type of digital-to-analog converter that uses just two resistor values: R and 2R.
- These resistors are arranged in a ladder-like network, making the circuit simple and easy to design, even for higher resolution (more bits).
- Each digital input bit controls a switch that connects either to a reference voltage or ground, and the ladder network divides the voltage according to the binary value of the input.
- The main advantage is that only two precise resistor values are needed, which improves accuracy and reduces cost for high-bit systems.

Binary Weighted Resistors DAC

- The binary-weighted resistor DAC uses resistors whose values are weighted according to the binary position of each bit: R, 2R, 4R, 8R, and so on.
- Each bit of the digital input controls a switch connected to its corresponding resistor, and the currents are summed to produce the analog output.

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Ans. (1) (contd.) :- ✱ This type is simple for low bit systems but becomes impractical for higher resolutions because it requires a wide range of precise resistor values, which are difficult to manufacture and match accurately.

Comparison Table

Feature	R/2R Ladder DAC	Binary Weighted DAC
Resistor Values.	Only two values (R, 2R)	Many different values.
Accuracy	Easier to match resistors	Harder to match resistors
Cost	Lower for high bits	Higher for high bits
Complexity	Simpler design	More complex for high bits
Resolution	Suitable for all bits	Limited by resistor range.

(Q2) What are the advantages and Disadvantages of R/2R Ladder DAC over Binary weighted Resistors DAC?

Ans. :- Advantages of R/2R Ladder DAC over Binary weighted DAC:

✱ Simplified Resistor Matching: Only two resistor values (R and 2R) are needed, making manufacturing easier and improving accuracy.

✱ Lower cost for High Resolution: Cheaper to produce for higher bit counts because of fewer unique resistor values.

Ans. (2) :- ★ Reduced Complexity: simpler circuit design and layout for all resolutions.
(contd.)

Disadvantages of R/2R ladder DAC (relative to Binary weighted DAC)

★ Slightly more complex circuit for low bits: Requires more resistors and switches for very low resolutions.

★ No Inherent Current Summing: Needs careful design for current summing at the output, unlike the natural summing in binary weighted DACs.

(Q3) Discuss the Operation and Application of DAS (Data Acquisition System). Draw the Block Diagram and Discuss its components.

Ans.:- Operation:

★ A Data Acquisition System (DAS) collects, processes, and analyzes physical or environmental data using sensors and electronic hardware.

★ The system converts analog signals from sensors into digital data for storage, analysis, and control.

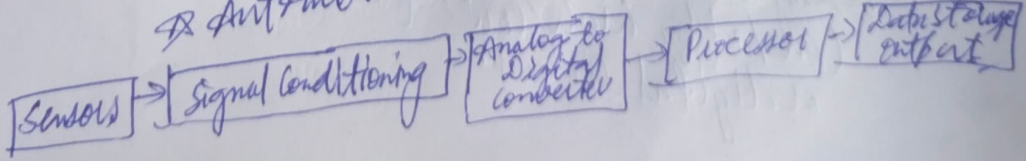
Applications:

★ Scientific Research (e.g., environmental monitoring)

★ Industrial automation (machine monitoring)

★ Medical diagnostics (patient monitoring)

★ Automotive and aerospace control systems.



Ans (3) :- Components:
(contd:)

* Sensors/Transducers: Convert quantities into electrical signals.
* Signal Conditioning: Amplifies, filters, and converts signals for processing.
* Analog-to-Digital Converter (ADC): Converts analog signals to digital data.
* Computer/Processor: Processes and analyzes digital data.
* Data Storage/Analysis/Output: Stores data, analyzes trends, and outputs results or control signals.

(Q4) Discuss the Plug-In DAQ Devices and the signals that can be acquired by DAQ

Ans.:- Plug-In DAQ Devices:

* Plug-In DAQ devices are hardware modules that connect to a computer (via USB, PCI, ethernet, etc.) to acquire data from sensors.
* These devices are modular, allowing users to customize the system for different applications.

Signals That Can Be Acquired:

* Analog Inputs (AI): continuous signals such as voltage, current, temperature, pressure, etc.
* Digital Inputs (DI): Binary signals (on/off, high/low) from switches, sensors, or digital devices.

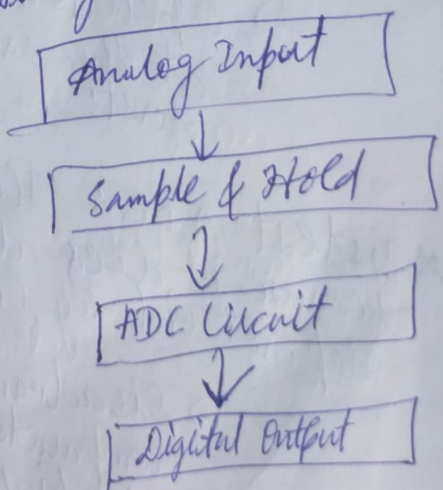
Ans. (4) :- (contd-)

- ✡ Analog Outputs (AO): Continuous control signals to relays, lights or other digital devices.
- ✡ Digital Outputs (DO): Binary control signals to relays, lights, or other digital devices.

(Q5) Describe the Block Diagram of ADC

Ans:-

- ✡ Analog Input: The physical signal (like temperature or pressure) is measured and converted to an electrical signal.
- ✡ Sample & Hold: Captures and holds the input voltage steady during conversion.
- ✡ ADC Circuit: Converts the analog signal into a digital number.
- ✡ Digital Output: The final digital value is sent to a computer or controller for processing.

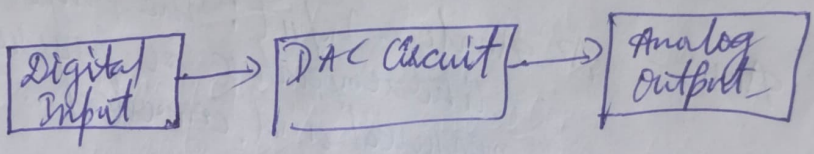


(Q6) Describe the Block Diagram of DAC (06)

Ans :- ✡ Digital Input: The digital signal (binary number) comes from a computer or controller.

✡ DAC Circuit: Converts the digital ~~display~~ signal into an analog ~~signal~~ voltage or current.

✡ Analog Output: The analog signal is used to control devices like motors or speakers.



(Q7) Explain Flash Type ADC. Which is the fastest ADC & Why?

Ans :- ✡ Flash Type ADC: uses many comparators at once to compare the input voltage to a set of reference voltages.

↳ Operation: All comparisons happen at the same time, so it is very fast.

✡ Fastest ADC: Flash ADC is the fastest because it does all comparisons in a single step, not bit by bit.

↳ Disadvantages: Needs many comparators (costly and complex for high resolution).

Q8) Discuss the Use of dockets for Network communication.

Ans:- ✡ Sockets: Allow devices or computers to connect and communicate over a network.

✡ Use in DAQ: Lets data acquisition systems send data to remote computers or servers in real time.

✡ Benefits: Enables remote monitoring, control, and sharing of data between different systems.

Q9) Discuss the Counter / Timer

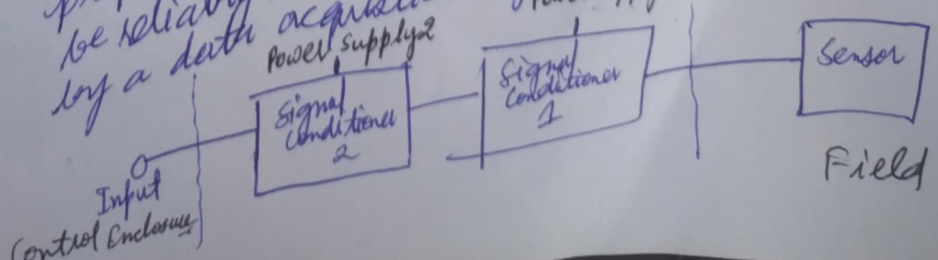
Ans:- ✡ Counter: Counts events or pulses, like how many times a button is pressed or a shaft rotates.

✡ Timer: measures time intervals or generates precise timing signals.

✡ Applications: Used for sampling data at regular times, triggering events, or counting sensor pulses.

Q10) What is Signal Conditioning? Give the various functions of Signal Conditioners.

Ans:- Signal Conditioning is the process of preparing a raw sensor signal so it can be reliably and accurately measured or processed by a data acquisition system or control system.



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Ans: (10) :- Functions of signal conditioners:

(contd--)

☆ Amplification: Increases the strength of weak signals so they can be measured more easily.

☆ Filtering: Removes unwanted noise or disturbances from the signal to improve its quality.

☆ Conversion: Changes the type of signal, such as converting current to voltage, or impedance matching for compatibility with the measurement system.

☆ Linearization: Adjusts non-linear sensor outputs so they produce a straight-line relationship between input and output.

☆ Isolation: Protects sensitive electronic equipment from high voltages or hazardous conditions that may be present in the measured environment.

→ These functions ensure that the data collected is accurate, reliable, and suitable for further processing or analysis.

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Q.11 Discuss the counter type A/D converter.

Ans:- **Counter Type ADC**

A counter type ADC (Analog to Digital Converter) uses a digital counter, a DAC (Digital to Analog Converter), and a comparator.

How it works:

- The counter starts at zero and counts up with each clock pulse.
- The DAC converts the counter value into an analog voltage.
- The comparator compares this voltage with the input analog voltage.
- When the DAC voltage matches or just passes the input voltage, the counter stops.
- The counter value at this moment is the digital output.

Key points:

- Simple and easy to design.
- Slower than some other ADC types because it counts up from zero for each conversion.
- Used in applications where speed is not critical

Q.12 Explain the working Principle of a successive Approximation ADC (SAR ADC)

Ans:- A SAR ADC finds the digital value closest to the input voltage using a step-by-step (binary search) method.

How it works:

=> The SAR sets the most significant bit (MSB) to 1 and checks if the DAC output is higher or lower than the input.

Ans. (12) :- (contd.)

- If higher, the bit is reset to 0; if lower, it stays at 1.
- The process repeats for each bit, moving from MSB to the least significant bit (LSB)
- After all bits are clocked, the final digital value is the output.

Key points :

- Faster than counter type ADC.
- Good balance between speed and accuracy.
- Commonly used in digital voltmeters and microcontrollers.

(Q13) Explain the working Principle of a Sigma-Delta ADC ($\Sigma\Delta$ ADC)

Ans. :- A Sigma-Delta ADC uses oversampling and noise shaping to convert analog signals to high-resolution digital signals.

How it works :

- It samples the input signal at a very high rate (oversampling)
- An integrator and a 1-bit DAC form a feedback loop to compare the input and output.
- The difference (error) is fed back and averaged over time, which shapes the noise to higher frequencies.

Ans. 13 :- (contd-)

☆ A digital filter (decimation) then removes the high-frequency noise and reduces the data rate.

Key points:

☆ Very high resolution and low noise.
☆ Used in audio, medical, and precision measurement applications.

Q14 Why do we need Analog to Digital Converters?

Ans. :-

☆ Reason:

Most real-world signals (like sound, temperature, and light) are analog, but computers and digital systems can only process digital data.

☆ Purpose:

ADCs convert these analog signals into digital form so they can be stored, analyzed, and used by computers and digital devices.

☆ Key point:

Without ADCs, digital systems could not interact with the real world.

Q15 What is Data Acquisition? Give its components.

Ans. :- Data Acquisition (DAQ) is the process of collecting, measuring, and analyzing physical or environmental data using sensors and electronic systems.

⇝ Main components:

☆ Sensors / Transducers: Convert physical signals (like temperature, pressure) into electrical signals.

Ans. 15 (contd--) :-

☆ Signal Conditioning: Improves the signal (amplifies, filters, etc.).

☆ Analog-to-Digital Converter (ADC): Converts analog signals to digital data.

☆ DAQ Hardware: collects and manages the data.

☆ Data Storage / Processing: Stores and analyzes the data for further use.

⇝ Key point:
DAQ systems help monitor, control, and analyze real-world processes in industries, research, and daily life.

Q16 Give the types of signals that can be acquired by DAQ.

Ans. :- A Data Acquisition (DAQ) system can collect different kinds of signals from the real world.

⇝ The main types are:

☆ Analog signals:
↳ These are continuous signals that can take any value within a range.
↳ Examples include voltage from a temperature sensor, or the output of current from a pressure sensor.
↳ Analog signals are used to represent things like temperature, sound, light, or pressure, which change smoothly over time.

Ans. (16) (contd.) :- ★ Digital signals:
↳ These signals have only two states: ON or OFF, HIGH or LOW, or 1 or 0.
↳ Examples include a switch being pressed or released, a digital pulse from a proximity sensor, or the digital sensor.
↳ Digital signals are used for simple on/off information or counting events.

(Q 17) What is the role of DAC and ADC in the data acquisition system?

Ans. :-
ADC (Analog-to-Digital Converter):
~) The ADC is a key component that takes analog signals (like voltage from a sensor) and converts them into digital data.
~) This digital data can then be processed, stored, or analyzed by computers and digital devices.
~) Without an ADC, a DAQ system cannot understand real-world analog signals.

DAC (Digital-to-Analog Converter):
~) The DAC does the opposite job: it takes digital data from the computer and turns it back into an analog signal.
~) This is useful when you want to control devices like motors, speakers, or other equipment that need analog input.

Ans. (17) :- (contd.)
★ DACs are important for sending signals back to the real world after processing.

Q(18) :- Write the application of successive approximation ADC.

Ans. :- → A Successive Approximation Register (SAR) ADC is a type of ADC that uses a step-by-step method to find the digital value closest to the input voltage.
→ It is widely used because between speed, accuracy, and cost.

Common Applications:

★ Digital Multimeters: For measuring voltages and currents accurately.
★ Industrial Automation: Used in process controllers and measurement systems.
★ Microcontroller systems: Many microcontrollers have built-in SAR ADCs for reading sensors.
★ Medical Devices: For accurate and reliable measurement of bio-signals like ECG or temperature.

Q(19) :- Write the advantage of R-2R ladder network.

Ans. :- The R-2R ladder network is a simple and effective way to convert digital signals to analog (in DACs) or analog to digital (in ADCs)

Ans. (19) (contd--) :- Main Advantages:

☆ Simplicity: It uses only two resistor values (R and 2R), making the design and manufacturing easy and cost-effective.

☆ Accuracy: Because only two resistor values are used, it is easier to match and control their precision, leading to more accurate conversions.

☆ Scalability: The design can be easily expanded for higher resolution without needing many different resistor values.

(20) Write the disadvantage of successive approximation ADC.

Ans:- ☆ A Successive Approximation Register Analog-to-Digital converter (SAR ADC) is widely used for converting analog signals into digital form due to its balance between speed, accuracy, and cost.

☆ However, it does have some notable disadvantages compared to other ADC types.

→ While SAR ADCs are popular, they do have some limitations:

☆ Speed Limitation: SAR ADCs are not as fast as flash ADCs. They convert one bit at ~~at~~ a time, so for very high-speed applications, they may not be suitable.

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Ans. (20) :- (contd--)

☆ Complex Control Logic: The step-by-step comparison process requires precise timing and control, which can make the design more complex.

☆ Not Ideal for Very High Frequencies: For applications that need extremely fast conversions, other types like flash ADCs are preferred.