JHARKHAND
Rai University
RANCHI

PRACTICAL LAB MANUAL

Digital Electronics System and Instrumentation

B.Sc. MLT (4th Semester)

INDEX

EXPERIMENT – 01

Aim: To Verification of basic Logic gates.

Principle: Logic gates are the basic building blocks of digital electronic circuits. They perform logical operations on binary inputs (0 and 1) to produce a binary output. Each logic gate follows a specific Boolean expression and truth table.

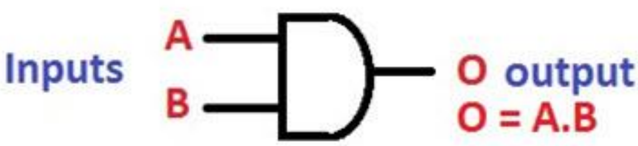
- **AND gate** gives HIGH output only when all inputs are HIGH.
- **OR gate** gives HIGH output when any input is HIGH.
- **NOT gate** inverts the input.
- **NAND, NOR** are universal gates.
- **XOR** gives HIGH when inputs are different.
- **XNOR** gives HIGH when inputs are same.

Apparatus Required:

- Digital Trainer Kit / Breadboard
- ICs:
  - AND – **7408**
  - OR – **7432**
  - NOT – **7404**
  - NAND – **7400**
  - NOR – **7402**
  - XOR – **7486**
  - XNOR – **74266** (or equivalent)
- Connecting wires
- DC Power Supply (+5 V)
- LEDs / Logic probes

Truth table & Expression:

AND gate

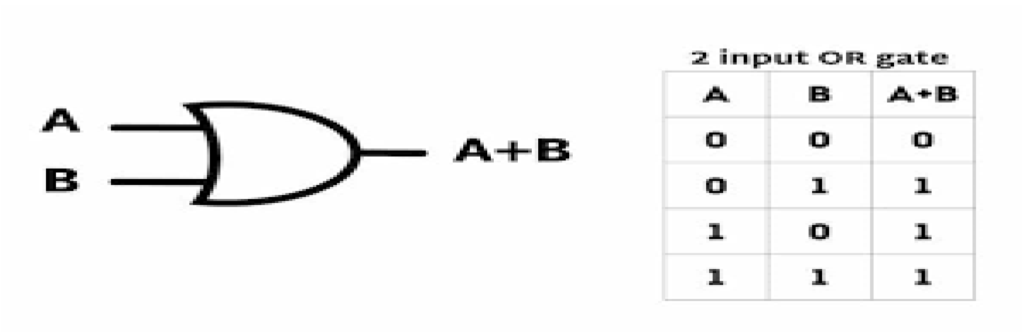


Symbol

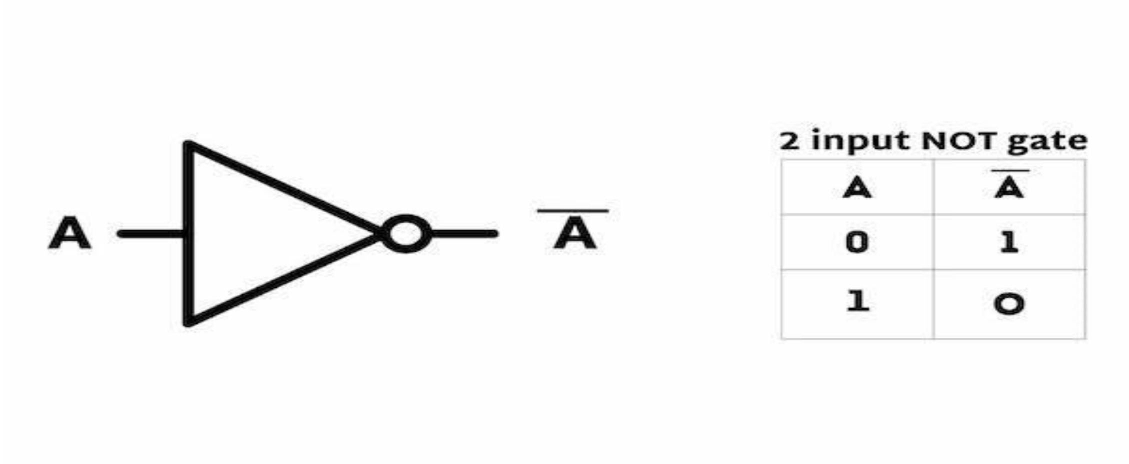
Inputs		Output
A	B	O
0	0	0
0	1	0
1	0	0
1	1	1

Truth table

OR gate

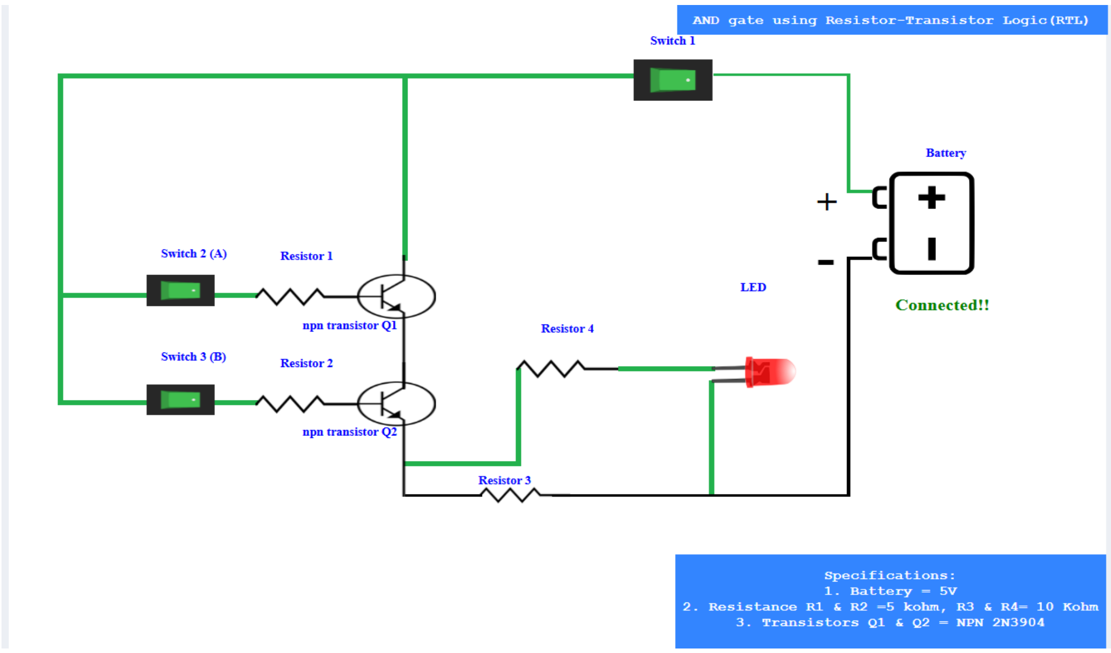


NOT gate

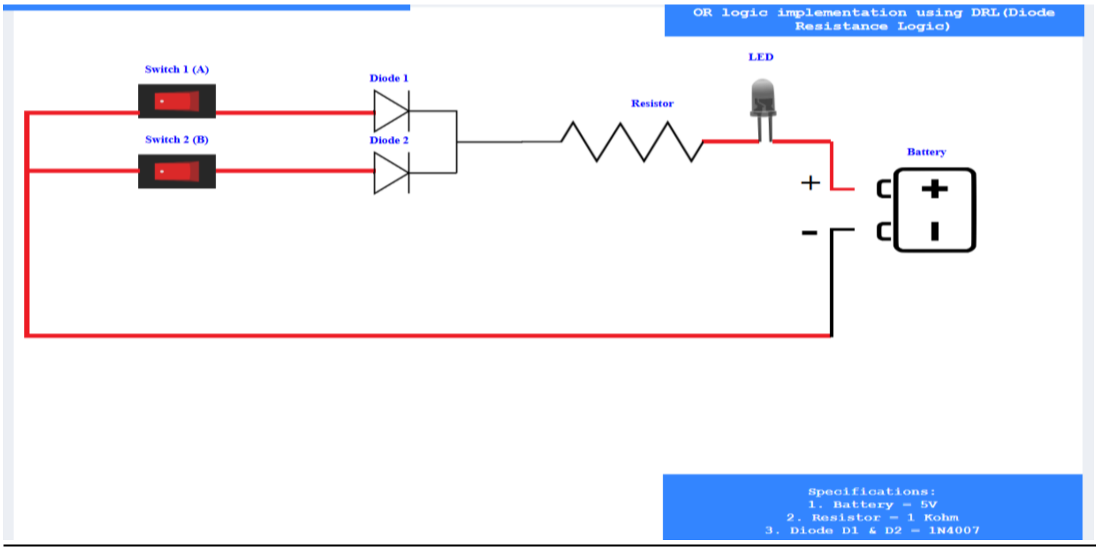


Circuit Diagram:

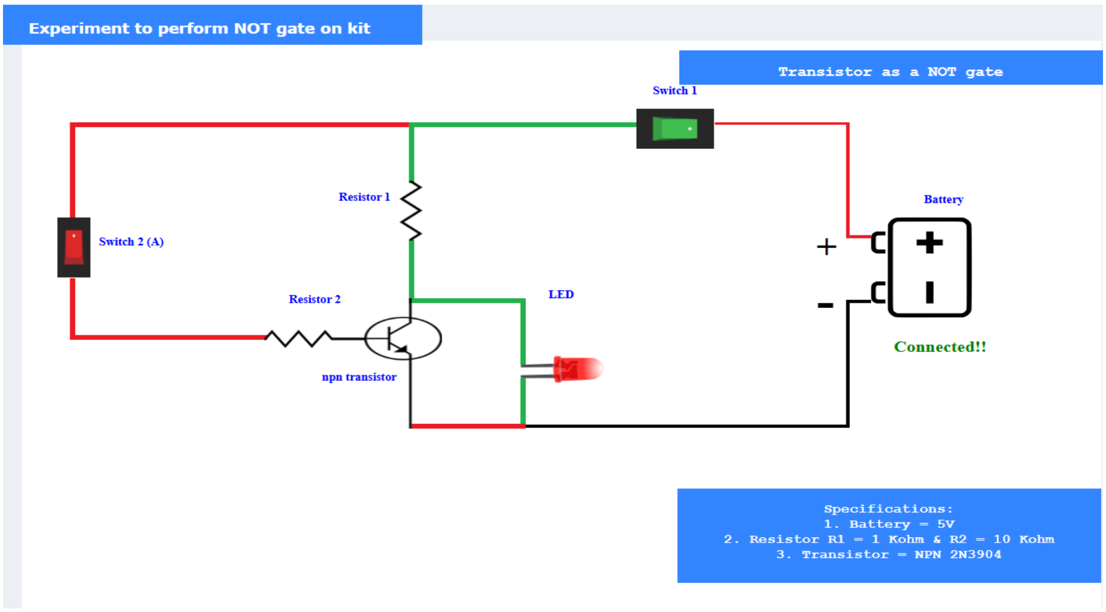
AND gate



OR gate



NOT gate



Procedure

- Connect the IC on the breadboard/digital trainer kit.
- Apply **+5 V** to the IC.
- Apply different combinations of binary inputs (0 and 1).
- Observe the output using LED or logic probe.
- Repeat for all logic gates.
- Tabulate the observed outputs.

Result:

Thus, the truth tables of **AND, OR, NOT gates** are verified successfully.

EXPERIMENT – 02

Aim: To verify the truth tables of universal logic gates:

- NAND gate
- NOR gate

To realize the following basic logic gates using only universal gates:

- AND
- OR
- NOT

Apparatus Required

- IC 7400 (Quad 2-input NAND gate)
- IC 7402 (Quad 2-input NOR gate)
- Digital trainer kit / Breadboard
- DC power supply (+5 V)
- Connecting wires
- LEDs with current-limiting resistors

Theory

Logic gates are the basic building blocks of digital electronics. Among all logic gates, NAND and NOR gates are called universal gates because any Boolean function or basic logic gate can be realized using only NAND or only NOR gates.

NAND Gate

A NAND gate is the complement of the AND gate.
Its output is LOW only when all inputs are HIGH.

Boolean expression: $Y=(A\cdot B)'$

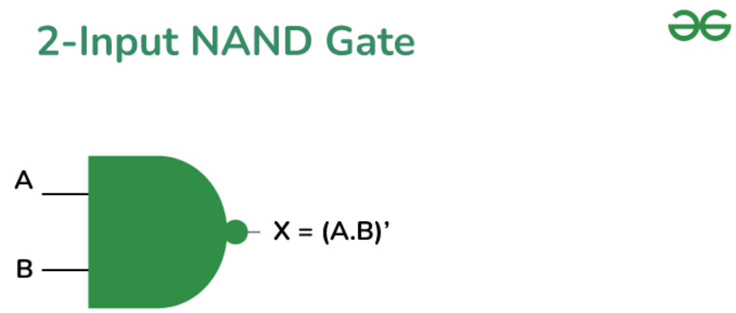
NOR Gate

A NOR gate is the complement of the OR gate.
Its output is HIGH only when all inputs are LOW.

Boolean expression: $Y=(A+B)'$

Truth Tables

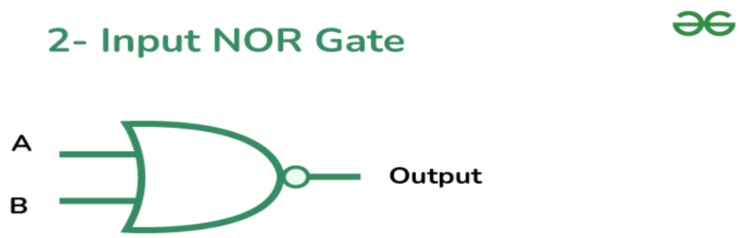
NAND Gate



Truth Table

Input A	Input B	X = (A.B)'
0	0	1
0	1	1
1	0	1
1	1	0

NOR Gate



Truth Table

Input A	Input B	0 = (A + B)'
0	0	1
0	1	0
1	0	0
1	1	0

Realization of Basic Gates Using NAND Gate

1. NOT Gate using NAND

By tying both inputs together:

$$Y = (A \cdot A)' = A'$$

2. AND Gate using NAND

- First NAND gives $(A \cdot B)'$
- Second NAND acts as NOT

$$Y = ((A \cdot B)')' = A \cdot B$$

3. OR Gate using NAND

Using De Morgan's theorem:

$$A + B = (A' \cdot B')'$$

Realization of Basic Gates Using NOR Gate

1. NOT Gate using NOR

By tying both inputs together:

$$Y = (A + A)' = A'$$

2. OR Gate using NOR

- First NOR gives $(A+B)'$
- Second NOR acts as NOT

$$Y = ((A + B)')' = A + B$$

3. AND Gate using NOR

Using De Morgan's theorem:

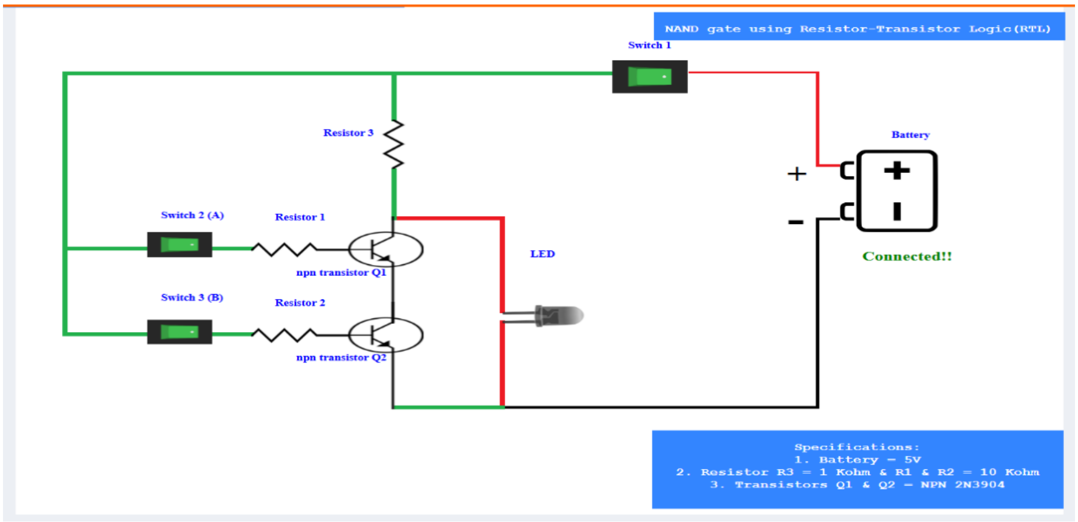
$$A \cdot B = (A' + B')'$$

Procedure

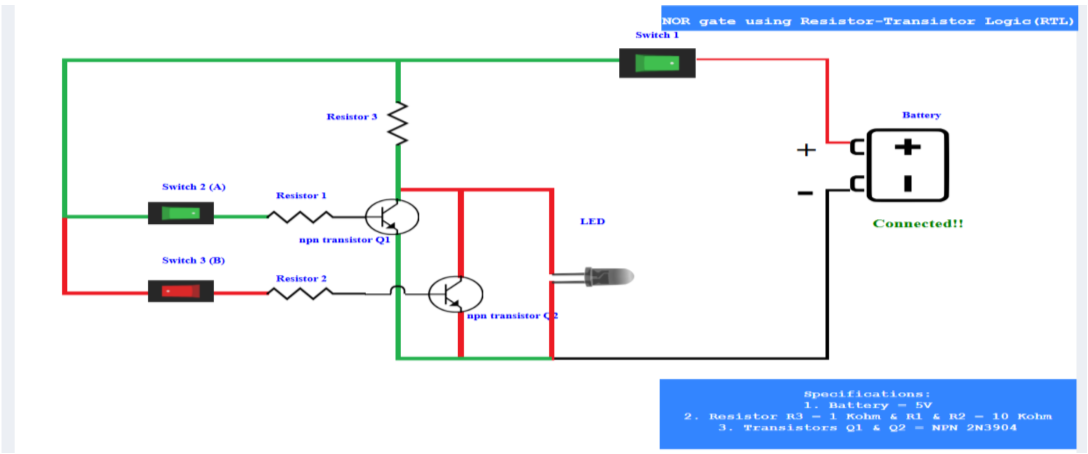
1. Connect the IC (7400 or 7402) to the digital trainer kit.
2. Apply **+5 V** to Vcc (pin 14) and **ground** to pin 7.
3. Apply binary inputs (0 or 1) to the input pins.
4. Observe the output using LED indicators.
5. Verify the output for all possible input combinations.
6. Repeat the procedure for realization of AND, OR, and NOT gates using NAND and NOR gates.

Circuit Diagrams

NAND gate verification



Nor gate verification



Observations

The outputs obtained experimentally matched the theoretical truth tables of NAND and NOR gates. The basic logic gates were successfully realized using universal gates.

Result

Thus, the **truth tables of universal logic gates (NAND and NOR) were verified**, and **basic logic gates (AND, OR, NOT)** were successfully realized using universal gates.

EXPERIMENT – 03

Aim

1. To design and implement a **BCD to Excess-3 code converter** using logic gates.
2. To design and implement an **Excess-3 to BCD code converter** using logic gates.

Apparatus Required

- IC 7404 (Hex NOT gate)
- IC 7408 (Quad 2-input AND gate)
- IC 7432 (Quad 2-input OR gate)
- Digital trainer kit / Breadboard
- +5 V DC power supply
- Connecting wires
- LEDs with current-limiting resistors

Theory

BCD Code

Binary Coded Decimal (BCD) represents decimal digits (0–9) using 4-bit binary numbers.

Excess-3 Code

Excess-3 is a non-weighted, self-complementing code obtained by adding 3 (0011) to the BCD number.

Decimal	BCD 8 4 2 1	Excess-3 BCD + 0011
0	0 0 0 0	0 0 1 1
1	0 0 0 1	0 1 0 0
2	0 0 1 0	0 1 0 1
3	0 0 1 1	0 1 1 0
4	0 1 0 0	0 1 1 1
5	0 1 0 1	1 0 0 0
6	0 1 1 0	1 0 0 1
7	0 1 1 1	1 0 1 0
8	1 0 0 0	1 0 1 1
9	1 0 0 1	1 1 0 0

Design of BCD to Excess-3 Code Converter

Let BCD inputs be **A, B, C, D**
Excess-3 outputs be **W, X, Y, Z**

Decimal	**A B C D**	**W X Y Z**
0	**0000**	**0011**
1	**0001**	**0100**
2	**0010**	**0101**
3	**0011**	**0110**
4	**0100**	**0111**
5	**0101**	**1000**
6	**0110**	**1001**
7	**0111**	**1010**
8	**1000**	**1011**
9	**1001**	**1100**

Boolean Expressions

(After K-map simplification)

$$W = A + BC + BD$$
$$X = B'C + B'D + BC'D'$$
$$Y = C'D + CD'$$
$$Z = D'$$

Design of Excess-3 to BCD Code Converter

Let Excess-3 inputs be **W, X, Y, Z**
BCD outputs be **A, B, C, D**

Truth Table

Decimal	**W X Y Z**	**A B C D**
0	0011	0000
1	0100	0001
2	0101	0010
3	0110	0011
4	0111	0100
5	1000	0101
6	1001	0110
7	1010	0111

Decimal	W X Y Z	A B C D
8	1011	1000
9	1100	1001

Boolean Expressions

(After simplification)

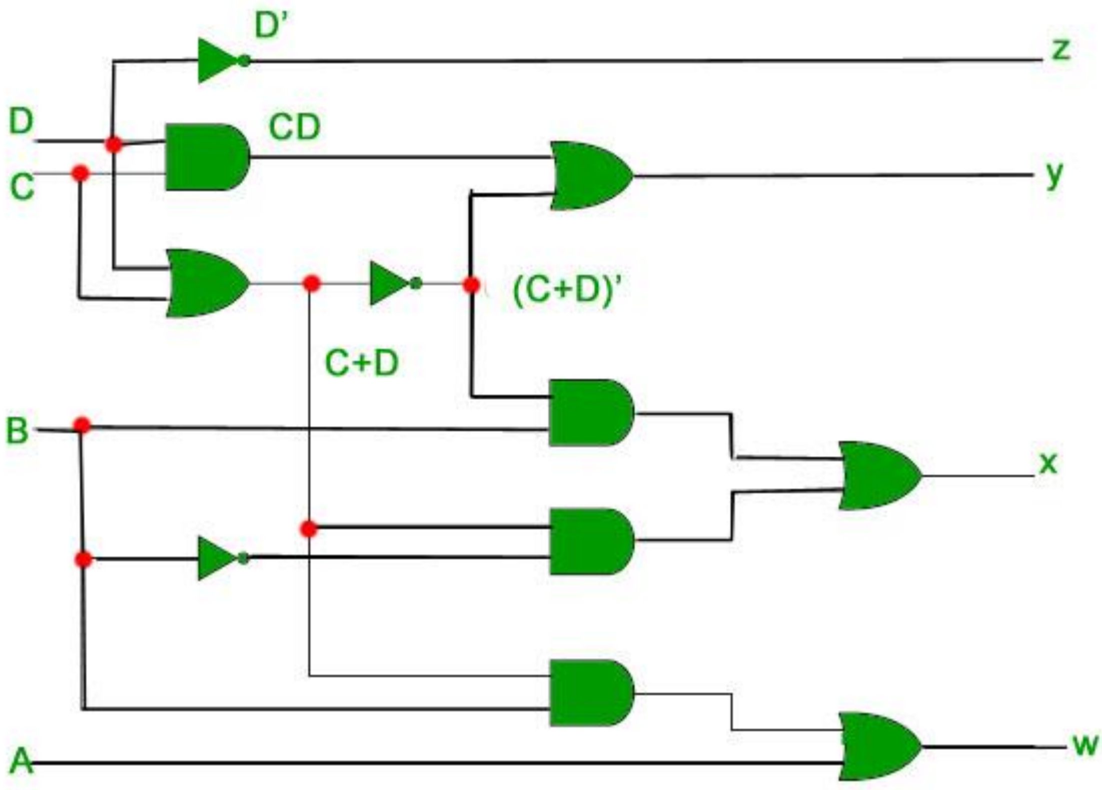
$$A = WX + WY$$
$$B = X'Y + XZ$$
$$C = Y'Z + YZ'$$
$$D = Z'$$

Procedure

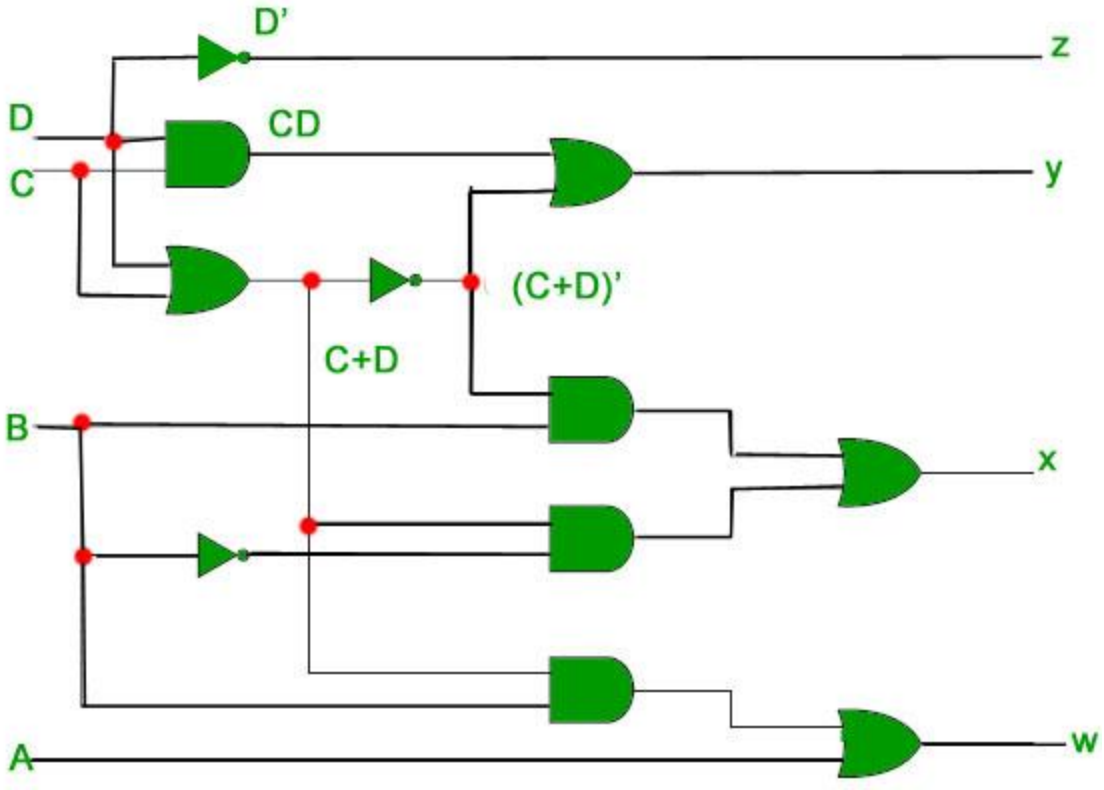
1. Verify the truth tables of BCD and Excess-3 codes.
2. Draw the logic diagrams using AND, OR, and NOT gates.
3. Make the circuit connections on the digital trainer kit.
4. Apply +5 V to the ICs (Vcc = pin 14, GND = pin 7).
5. Apply BCD inputs and observe Excess-3 outputs using LEDs.
6. Apply Excess-3 inputs and observe BCD outputs.
7. Verify the outputs with the theoretical values.

<u>**Circuit Diagrams**</u>

BCD to Excess-3 converter



Excess-3 to BCD converter



Observations

The outputs observed for all valid inputs matched the expected Excess-3 and BCD codes.

Result

Thus, the BCD to Excess-3 and Excess-3 to BCD code converters were successfully designed and implemented using logic gates, and their operation was verified.

Applications

- Digital arithmetic circuits
- Code converters
- Error detection systems
- Digital displays

EXPERIMENT – 04

Aim

To design and implement a **Binary to Gray code converter** using logic gates.

To design and implement a **Gray to Binary code converter** using logic gates.

Apparatus Required

- IC 7404 (Hex NOT gate)
- IC 7408 (Quad 2-input AND gate)
- IC 7432 (Quad 2-input OR gate)
- IC 7486 (Quad 2-input XOR gate)
- Digital trainer kit / Breadboard
- +5 V DC power supply
- Connecting wires
- LEDs with current-limiting resistors

Theory

Binary Code

Binary code represents numbers using base-2 digits (0 and 1).

Gray Code

Gray code is a unit distance code, in which only one bit changes between successive numbers, reducing errors during transitions.

Binary to Gray Code Conversion

Let the **4-bit binary input** be

$$B_3B_2B_1B_0$$

The **Gray code output** is

$$G_3G_2G_1G_0$$

Conversion Logic

$$\begin{aligned} G_3 &= B_3 \\ G_2 &= B_3 \oplus B_2 \\ G_1 &= B_2 \oplus B_1 \\ G_0 &= B_1 \oplus B_0 \end{aligned}$$

Truth Table (Binary → Gray)

Decimal	B3 B2 B1 B0	G3 G2 G1 G0
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Gray to Binary Code Conversion

Let the Gray code input be

$$G_3G_2G_1G_0$$

The Binary output is

$$B_3B_2B_1B_0$$

Conversion Logic

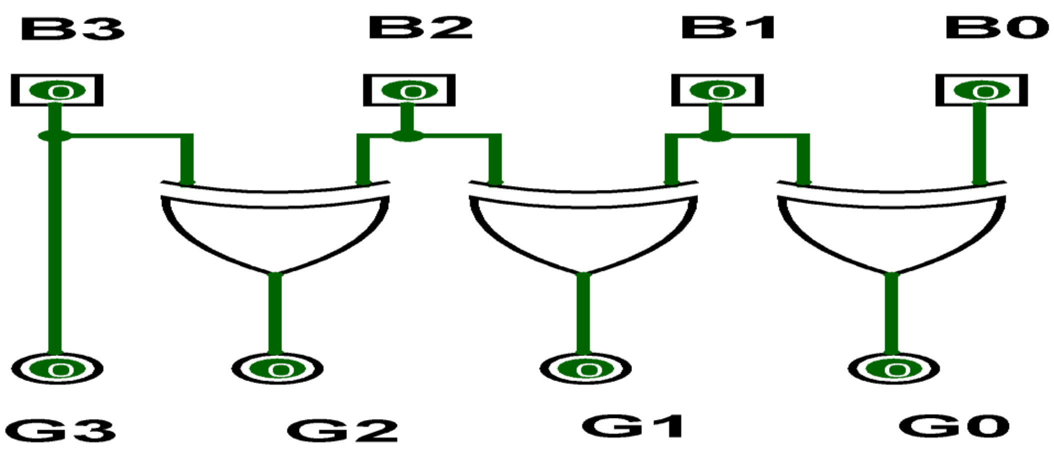
$$\begin{aligned} B_3 &= G_3 \\ B_2 &= B_3 \oplus G_2 \\ B_1 &= B_2 \oplus G_1 \\ B_0 &= B_1 \oplus G_0 \end{aligned}$$

Truth Table (Gray → Binary)

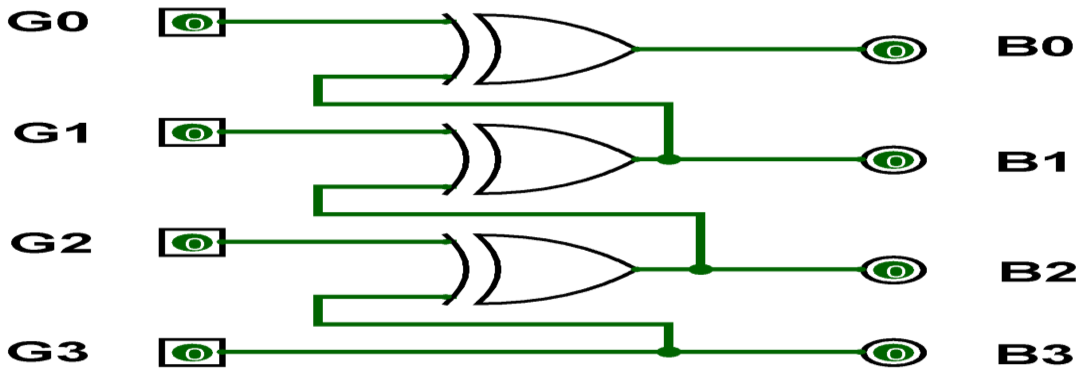
Decimal	G3 G2 G1 G0	B3 B2 B1 B0
0	0000	0000
1	0001	0001
2	0011	0010
3	0010	0011
4	0110	0100
5	0111	0101
6	0101	0110
7	0100	0111
8	1100	1000
9	1101	1001
10	1111	1010
11	1110	1011
12	1010	1100
13	1011	1101
14	1001	1110
15	1000	1111

Logic Diagram Description

Binary to Gray converter uses **XOR gates** only:



Gray to Binary converter uses a **cascade of XOR gates**:



- NOT, AND, OR gates are used if XOR IC is unavailable (XOR can be built from basic gates).

Procedure

1. Connect the required ICs on the digital trainer kit.
2. Apply +5 V to Vcc (pin 14) and ground to pin 7.
3. Provide binary inputs using switches.
4. Observe Gray code outputs using LEDs.
5. Verify the outputs with the truth table.
6. Repeat the procedure for Gray to Binary conversion.
7. Record the observations.

Observations

The experimental outputs matched the theoretical Binary–Gray and Gray–Binary conversion tables.

Result

Thus, the Binary to Gray and Gray to Binary code converters were successfully designed and implemented using logic gates, and their operation was verified.

Applications

- Analog-to-digital converters
- Shaft encoders
- Digital communication systems
- Error reduction in switching circuits

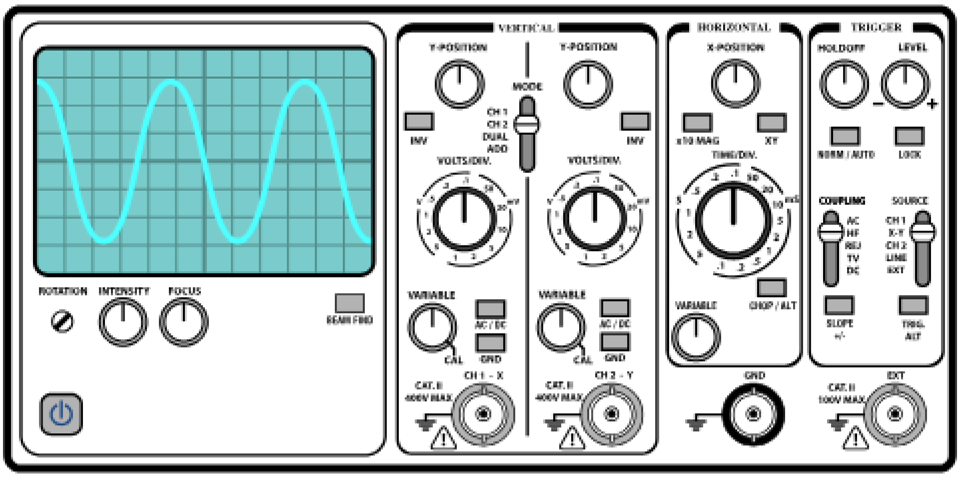
EXPERIMENT – 05

Aim

To study and understand the **function of various front panel controls** of a Cathode Ray Oscilloscope (CRO).

Apparatus Required

- Cathode Ray Oscilloscope (CRO)
- Function generator / Signal generator
- Connecting probes
- Power supply



Cathode Ray Oscilloscope (CRO)

Theory

A **Cathode Ray Oscilloscope (CRO)** is an electronic instrument used to display and analyze electrical signals in the form of waveforms. It allows measurement of voltage, time period, frequency, phase difference, and waveform shape.

The CRO consists of three main sections:

1. **Vertical (Y) section**
2. **Horizontal (X) section**
3. **Trigger and Display section**

Front Panel Controls of CRO

1. Display Controls

- **Power ON/OFF**: Switches the CRO on or off.
- **Intensity**: Controls the brightness of the trace.
- **Focus**: Adjusts the sharpness of the waveform.
- **Beam Finder**: Helps locate the trace if it goes off the screen.
- **Scale Illumination**: Controls the graticule brightness.

2. Vertical (Y-Axis) Controls

- **Vertical Position**: Moves the trace up or down.
- **Volts/Div**: Adjusts the vertical sensitivity (amplitude scale).
- **Input Coupling (AC/DC/GND)**:
    - **AC**: Blocks DC component.
    - **DC**: Allows both AC and DC signals.
    - **GND**: Grounds the input for reference.
- **Channel Selector (CH1 / CH2)**: Selects the input channel.
- **Vertical Amplifier Gain**: Fine adjustment of amplitude.

3. Horizontal (X-Axis) Controls

- **Time/Div**: Controls the time scale of the waveform.
- **Horizontal Position**: Moves the trace left or right.
- **Sweep Mode**: Selects automatic or manual sweep.

4. Trigger Controls

- **Trigger Mode (Auto/Normal)**: Stabilizes the waveform.
- **Trigger Level**: Determines the voltage level at which triggering occurs.
- **Trigger Source (Internal/External/Line)**: Selects the trigger input.
- **Trigger Slope (+/–)**: Selects rising or falling edge triggering.

5. Input Controls

- **Probe Selector (×1 / ×10)**: Adjusts probe attenuation.
- **Input Connector (BNC)**: Used to connect the test signal.

Procedure

1. Switch ON the CRO and allow it to warm up.
2. Adjust **intensity** and **focus** to obtain a clear trace.
3. Set the input coupling to **GND** and adjust vertical position to center the trace.
4. Connect the signal generator output to the CRO input.
5. Select **AC coupling** and adjust **Volts/Div** and **Time/Div**.
6. Use **trigger controls** to stabilize the waveform.
7. Observe the effect of each front panel control on the display.

Observations

Each front panel control was operated and its effect on the CRO display was observed and studied.

Result

Thus, the front panel controls of the Cathode Ray Oscilloscope were studied and understood successfully.

Applications of CRO

- Measurement of voltage and frequency
- Waveform analysis
- Phase difference measurement
- Fault diagnosis in electronic circuits

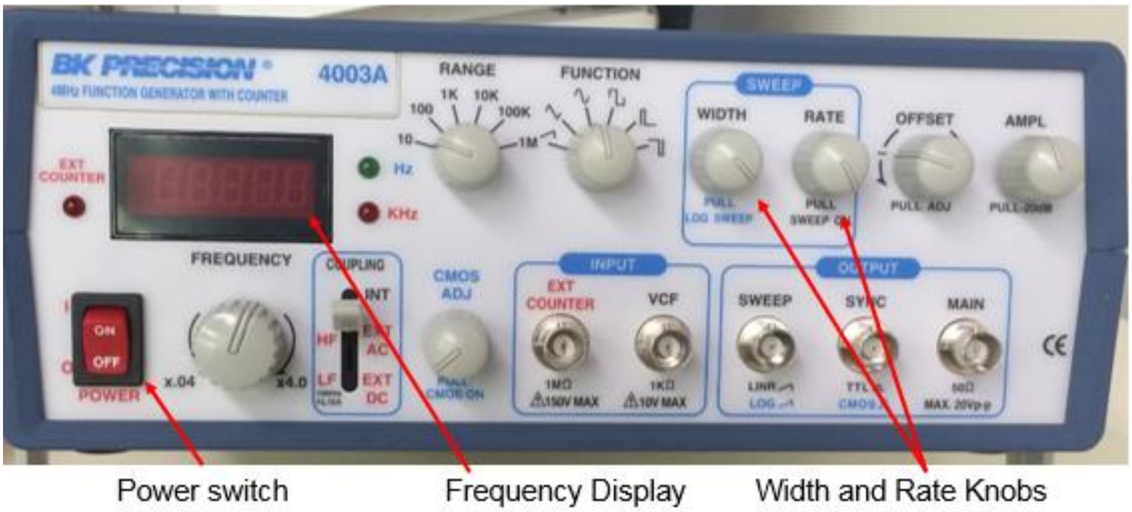
EXPERIMENT – 06

Aim

To study and understand the various front panel controls and their functions in a Function Generator.

Apparatus Required

- Function Generator
- Cathode Ray Oscilloscope (CRO)
- Connecting probes / BNC cables
- Power supply



Theory

A Function Generator is an electronic test instrument that generates different types of electrical waveforms over a wide range of frequencies. Commonly generated waveforms include sine, square, and triangular waves. It is widely used for testing and analyzing electronic circuits.

Front Panel Controls of Function Generator

1. Power Controls

- **Power ON/OFF Switch**: Turns the function generator ON or OFF.
- **Power Indicator LED**: Indicates power status.

2. Waveform Selection Controls

- **Sine Wave Selector**: Produces a sinusoidal waveform.
- **Square Wave Selector**: Produces a square waveform.
- **Triangular Wave Selector**: Produces a triangular waveform.

3. Frequency Controls

- **Frequency Range Selector**: Selects the frequency range (Hz, kHz, MHz).
- **Frequency Control Knob**: Fine adjustment of output frequency.

4. Amplitude Controls

- **Amplitude Control**: Adjusts the peak-to-peak output voltage.
- **Output Attenuator**: Reduces signal amplitude (e.g., –20 dB).

5. Offset Controls

- **DC Offset Control**: Adds a DC component to the output waveform.

6. Duty Cycle / Symmetry Controls

- **Duty Cycle Control**: Adjusts ON–OFF time ratio of square wave.
- **Symmetry Control**: Alters the rise and fall time of triangular waves.

7. Output Controls

- **Output Connector (BNC)**: Main signal output terminal.
- **TTL/CMOS Output**: Provides logic-level square wave output.

8. Modulation Controls (if available)

- **Sweep Control**: Varies frequency automatically over time.
- **Modulation Input**: Used for AM/FM modulation.

Procedure

1. Switch ON the function generator.
2. Select a waveform (sine, square, or triangular).
3. Set the frequency range using the range selector.
4. Adjust the frequency using the frequency control knob.
5. Connect the output to the CRO.
6. Adjust amplitude and observe waveform changes on CRO.
7. Vary offset, duty cycle, and symmetry controls and note their effects.
8. Study the function of each front panel control.

Observations

The effects of different front panel controls such as waveform selection, frequency variation, amplitude adjustment, offset, and duty cycle were observed on the CRO.

Result

Thus, the front panel controls of the Function Generator were studied and their functions were understood successfully.

Applications of Function Generator

- Testing amplifiers and filters
- Signal injection for troubleshooting
- Digital and analog circuit analysis
- Communication system testing

EXPERIMENT – 07

Aim

1. To measure the **peak-to-peak voltage** of a given AC signal using a CRO.
2. To measure the **frequency** of the given signal using a CRO

Apparatus Required

- Cathode Ray Oscilloscope (CRO)
- Function generator / Signal generator
- CRO probes
- Connecting leads

Theory

A Cathode Ray Oscilloscope (CRO) displays electrical signals as a function of time on its screen. Using the calibrated Volts/Div and Time/Div controls, the amplitude and time parameters of a signal can be measured accurately.

Voltage Measurement

The vertical deflection of the waveform is proportional to the input voltage.

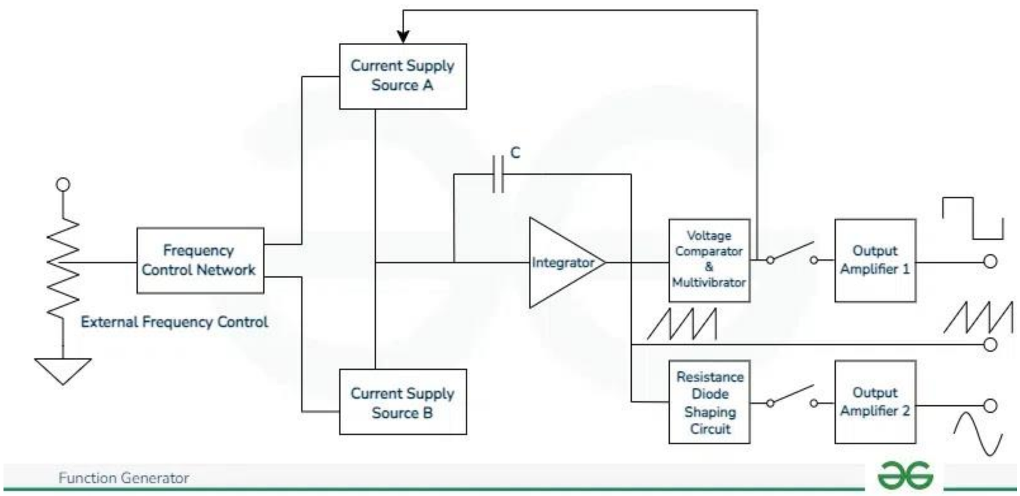
$$V_{pp} = \text{(Vertical divisions)} \times \text{(Volts/Div)}$$
$$V_p = \frac{V_{pp}}{2}, V_{rms} = \frac{V_p}{\sqrt{2}} \text{ (for sine wave)}$$

Frequency Measurement

The horizontal deflection represents time.

$$T = \text{(Horizontal divisions)} \times \text{(Time/Div)}$$
$$f = \frac{1}{T}$$

Circuit Diagram



Procedure

A. Voltage Measurement

1. Switch ON the CRO and function generator.
2. Apply a sinusoidal signal from the function generator to the CRO input.
3. Set **input coupling** to AC.
4. Adjust **Volts/Div** to obtain a suitable vertical display.
5. Count the number of vertical divisions covering the peak-to-peak waveform.
6. Calculate the peak-to-peak voltage using the formula.

B. Frequency Measurement

1. Adjust the **Time/Div** control to display one complete waveform cycle.
2. Count the number of horizontal divisions corresponding to one cycle.
3. Calculate the time period.
4. Determine the frequency using $f = 1/T$.

Observations

Voltage Measurement Table

Volts/Div	Vertical Divisions	V_{pp} (V)	V_{rms} (V)

Frequency Measurement Table

Time/Div	Horizontal Divisions	Time Period (s)	Frequency (Hz)

Example Calculation

Given

- Volts/Div setting = **2 V/div**
- Time/Div setting = **0.5 ms/div**
- Number of vertical divisions (peak-to-peak) = **4 divisions**
- Number of horizontal divisions (one cycle) = **4 divisions**

A. Voltage Measurement

Peak-to-Peak Voltage

$$V_{pp} = (\text{Vertical divisions}) \times (\text{Volts/Div})$$
$$V_{pp} = 4 \times 2 = \boxed{8\ \text{V}}$$

Peak Voltage

$$V_p = \frac{V_{pp}}{2} = \frac{8}{2} = \boxed{4\text{ V}}$$

RMS Voltage *(for sine wave)*

$$V_{rms} = \frac{V_p}{\sqrt{2}} = \frac{4}{1.414}$$
$$V_{rms} = \boxed{2.83\text{ V}}$$

B. Frequency Measurement

Time Period

$$T = (\text{Horizontal divisions}) \times (\text{Time/Div})$$
$$T = 4 \times 0.5\text{ ms} = \boxed{2\text{ ms}}$$

Frequency

$$f = \frac{1}{T} = \frac{1}{2 \times 10^{-3}}$$
$$f = \boxed{500\text{ Hz}}$$

Final Answer

- **Peak-to-Peak Voltage** = **8 V**
- **RMS Voltage** = **2.83 V**
- **Frequency** = **500 Hz**

Result

Thus, the **voltage (peak-to-peak and RMS)** and **frequency** of the given signal were **successfully measured using a CRO**.

EXPERIMENT – 08

Aim

To study the **various applications** of a **Digital Multimeter (DMM)** in measuring electrical and electronic quantities.

Apparatus Required

- Digital Multimeter
- DC power supply / Battery
- Resistors
- Connecting wires
- Breadboard (optional)

Theory

A Digital Multimeter (DMM) is an electronic measuring instrument used to measure multiple electrical parameters with high accuracy. It combines the functions of a voltmeter, ammeter, and ohmmeter in a single unit. Modern DMMs also provide additional functions such as continuity test, diode test, capacitance, frequency, and temperature measurement.

Applications of Digital Multimeter

1. Measurement of DC Voltage

- Used to measure voltage across batteries and DC power supplies.
- Range selector is set to DC voltage (V⎓).

2. Measurement of AC Voltage

- Used to measure mains voltage and AC signal sources.
- Range selector is set to AC voltage (V~).

3. Measurement of DC Current

- Used to measure current flowing through a circuit.
- Multimeter is connected **in series** with the load.

4. Measurement of Resistance

- Used to measure resistance of resistors and circuit components.
- Circuit power must be **OFF** during resistance measurement.

5. Continuity Test

- Used to check open or short circuits.
- Audible beep indicates continuity.

6. Diode Testing

- Used to check the condition of diodes.
- Displays forward voltage drop of the diode.

7. Transistor Testing (if available)

- Used to determine transistor gain (hFE).

8. Capacitance Measurement

- Used to measure the capacitance of capacitors.

9. Frequency Measurement

- Used to measure frequency of AC signals.

10. Temperature Measurement

- Used to measure temperature using an external temperature probe.

Procedure

1. Switch ON the digital multimeter.
2. Select the appropriate function and range using the selector knob.
3. Connect the test probes correctly (COM and V/Ω/mA).
4. Measure DC voltage across a battery.
5. Measure resistance of a resistor.
6. Perform continuity and diode tests.
7. Observe and note the readings.

Observations

The digital multimeter was used to measure voltage, current, resistance, continuity, and diode characteristics successfully.

Result

Thus, the applications of the Digital Multimeter were studied, and its use in measuring various electrical and electronic parameters was understood.

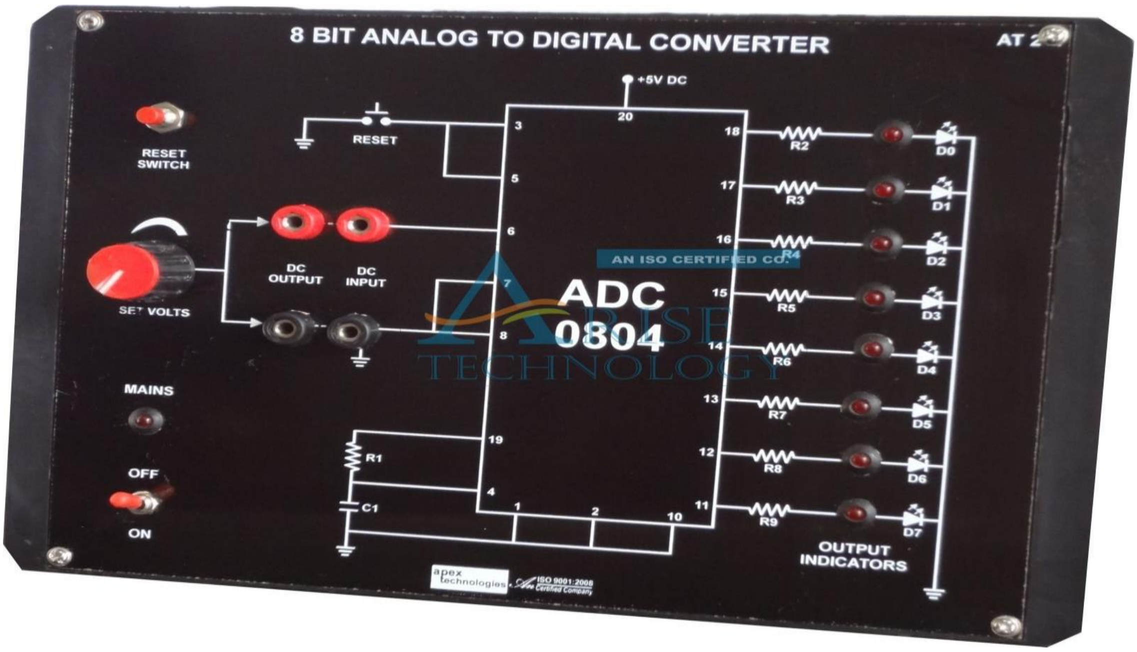
EXPERIMENT – 09

Aim:

To study the operation of a 4-bit Digital-to-Analog Converter (DAC) and observe its analog output voltage for different digital input combinations.

Apparatus Required

- 4-bit DAC (IC 0808 / R-2R ladder DAC or equivalent)
- Digital trainer kit / Binary input switches
- DC power supply (+5 V / reference voltage)
- Digital Multimeter (DMM)
- Connecting wires
- CRO (optional)



Theory

A Digital-to-Analog Converter (DAC) is an electronic circuit that converts digital (binary) data into a corresponding analog voltage or current.

In a 4-bit DAC, there are 16 possible digital input combinations (0000 to 1111), producing 16 discrete analog output levels.

Resolution of DAC

$$\text{Resolution} = \frac{V_{ref}}{2^n}$$

where
V_{ref}= Reference voltage
n= Number of bits

Output Voltage Equation

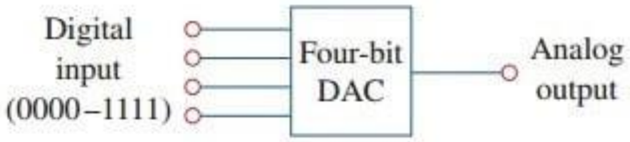
For an ideal 4-bit DAC:

$$V_{out} = V_{ref} \times \frac{D}{2^4}$$

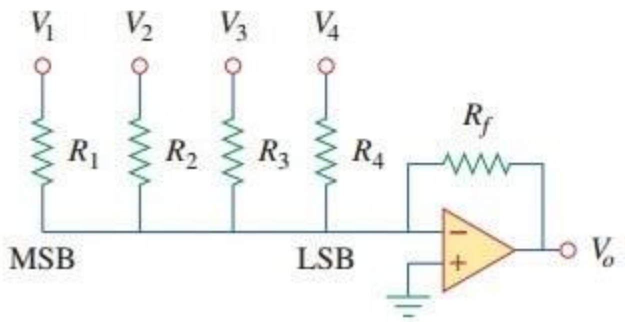
where
D= Decimal equivalent of the binary input

Block Diagram

Digital Input (4-bit) → DAC → Analog Output



(a)



<u>**Procedure**</u>

1. Connect the DAC IC on the trainer kit as per the circuit diagram.
2. Apply the reference voltage V_{ref}.
3. Provide 4-bit digital inputs using toggle switches.
4. Measure the analog output voltage using a digital multimeter.
5. Change the digital input from **0000 to 1111**.

6. Observe and record the corresponding output voltage.
7. Plot a graph of **Digital Input vs Analog Output Voltage** (if required).

<u>Observations</u>

Observation Table

Binary Input	**Decimal Value**	**Output Voltage (V)**
0000	0	0
0001	1	
0010	2	
0011	3	
0100	4	
0101	5	
0110	6	
0111	7	
1000	8	
1001	9	
1010	10	
1011	11	
1100	12	
1101	13	
1110	14	
1111	15	

<u>Sample Calculation</u>

Given

- **Reference Voltage $V_{ref} = 5$ V**
- **Digital Input = 0101**

Decimal Equivalent

$$\boldsymbol{D = 5}$$

Output Voltage

$$\boldsymbol{V_{out} = 5 \times \frac{5}{16} = \boxed{1.56\ \text{V}}}$$

<u>Result</u>

Thus, the output of a 4-bit Digital-to-Analog Converter was studied and observed, and it was found that the analog output voltage increases proportionally with the digital input.

<u>Applications of DAC</u>

- Audio signal generation
- Digital control systems
- Data acquisition systems
- Microprocessor-based systems

EXPERIMENT – 10

Aim

To study the working of an 8-bit Analog-to-Digital Converter (ADC) and to observe its digital output for different analog input voltages.

Apparatus Required

- 8-bit ADC (ADC0804 / equivalent)
- Digital trainer kit
- Variable DC power supply (0–5 V)
- Digital Multimeter (DMM)
- Clock source (internal/external)
- Connecting wires

Theory

An Analog-to-Digital Converter (ADC) is a device that converts a continuous analog voltage into a discrete digital output.

An 8-bit ADC produces 256 discrete output levels (0–255) corresponding to the applied analog input voltage.

Resolution of 8-bit ADC

$$\text{Resolution} = \frac{V_{ref}}{2^n}$$

where
V_{ref}= Reference voltage

$$n = 8$$

For $V_{ref} = 5$ V:

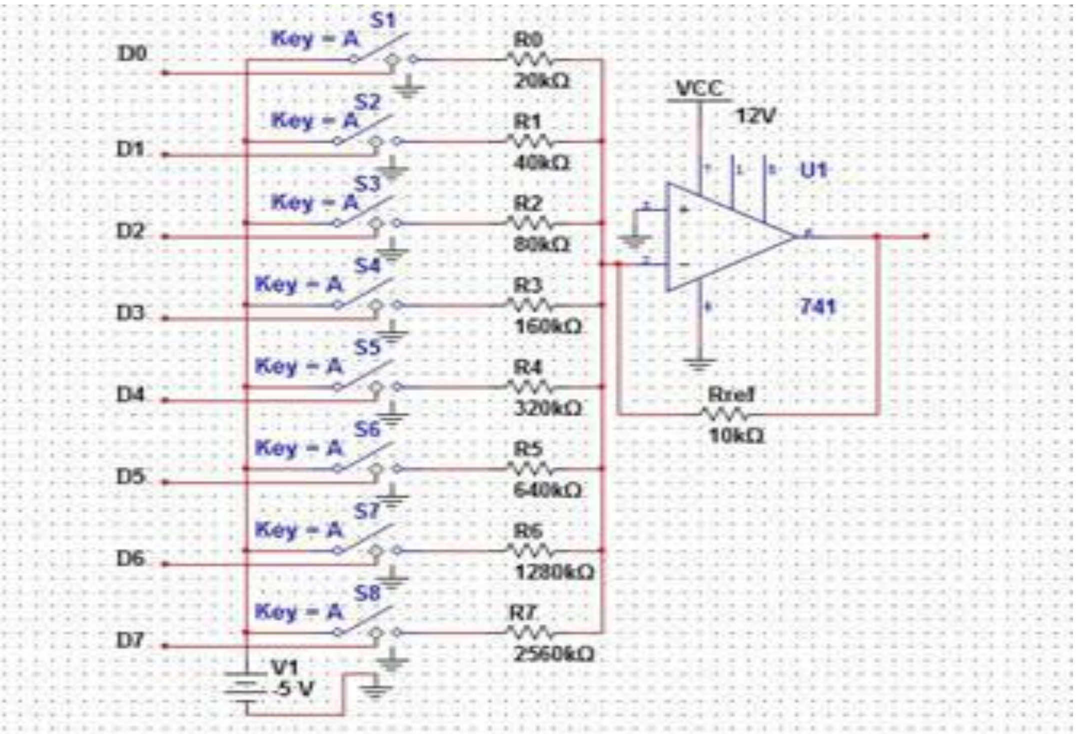
$$\text{Resolution} = \frac{5}{256} = 0.0195 \text{ V} \approx 19.5 \text{ mV}$$

Digital Output Equation

$$\text{Digital Output} = \frac{V_{in}}{V_{ref}} \times 255$$

Block Diagram

Analog Input → ADC → 8-bit Digital Output



Procedure

1. Connect the ADC IC on the trainer kit as per the circuit diagram.
2. Apply +5 V supply and proper grounding.
3. Set the reference voltage V_{ref}.
4. Apply an analog input voltage using a variable DC supply.
5. Start the conversion using the control pins.
6. Observe the 8-bit digital output using LEDs.
7. Repeat the experiment for different input voltages.
8. Record the corresponding digital outputs.

Observations

Observation Table

Analog Input (V)	Digital Output (Binary)	Decimal Equivalent
0.0	00000000	0
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0	11111111	255

Sample Calculation

Given

- Reference voltage $V_{ref} = 5$ V
- Analog input voltage $V_{in} = 2.5$ V

Digital Output

$$\text{Digital Output} = \frac{2.5}{5} \times 255$$
$$\text{Digital Output} = 127.5 \approx \boxed{128}$$

Binary Output

$$128 = \boxed{10000000}$$

Result

Thus, the **output of an 8-bit Analog-to-Digital Converter was studied and observed**, and it was found that the digital output increases proportionally with the analog input voltage.

Applications of ADC

- Data acquisition systems
- Digital voltmeters
- Microcontroller-based systems
- Sensor interfacing