Manonmaniam Sundaranar University,

Directorate of Distance & Continuing Education,

Tirunelveli - 627 012 Tamil Nadu, India

OPEN AND DISTANCE LEARNING(ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

III YEAR

B.Sc. Physics

Course Material

PP VIII – JMPHP8 - ELECTRONICS - II

(Credits – 3)

Prepared

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Tirunelveli – 12

Contents:

1. OPERATIONAL AMPLIFIER - VOLTAGE FOLLOWER

Aim

To design and construct a voltage follower (unity gain buffer) circuit using Op-Amp IC 741 and verify that the output voltage follows the input voltage while providing high input impedance and low output impedance.

Apparatus Required

S.No.	Apparatus	Range	Quantity
1	Op-Amp IC 741	-	1
2	Function Generator	0-20 MHz	1
3	Dual Power Supply	±12V, 500mA	1
4	Cathode Ray Oscilloscope (CRO)	DC-20 MHz	1
5	Digital Multimeter	-	1
6	Breadboard	-	1
7	Resistor (1kΩ)	1/4W	1
8	Capacitor (10μF)	25V	2
9	Connecting Wires	-	As required

Theory

A voltage follower is a non-inverting unity-gain amplifier where the output is directly connected to the inverting input terminal, providing 100% negative feedback. This configuration ensures that the output voltage exactly follows the input voltage.

Key Characteristics:

- Unity Gain: $A_v = 1$ (Voltage gain = 1 V/V)
- High Input Impedance: $Z_{in} \approx$ 1-2 MΩ (minimal loading on source)
- Low Output Impedance: $Z_{out} \approx 75\Omega$ (can drive heavy loads)

- Phase Shift: 0° (output in phase with input)
- Bandwidth: Typically 1 MHz for IC 741

Operating Principle

The voltage follower operates on the principle of closed-loop feedback control. The inverting input is directly connected to the output, creating a negative feedback path with a feedback factor β = 1. Due to the high open-loop gain of the op-amp (typically 100,000), any small difference between the inverting and non-inverting inputs is amplified to drive the output to a level where the two inputs are virtually equal.

Therefore: $V_{out} = V_{in}$

Pin	Function
1	Offset Null
2	Inverting Input (-)
3	Non-Inverting Input (+)
4	Negative Supply (-12V)
5	Offset Null
6	Output
7	Positive Supply (+12V)
8	No Connection

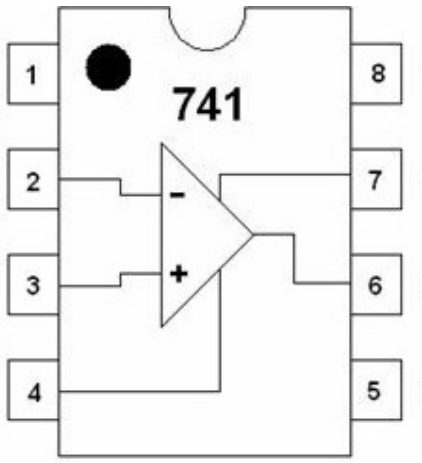


Figure 1.1 Pin Configuration of IC 741

Formula Used

1. General Gain Formula (Non-Inverting Op-Amp)

$$A_v = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_1}$$

2. Voltage Follower Condition

- $R_f = 0\,,\ R_1 = \infty$

$$A_v = 1 + \frac{0}{\infty} = 1$$

3. Output Voltage: $V_o = V_i$

Circuit Diagram

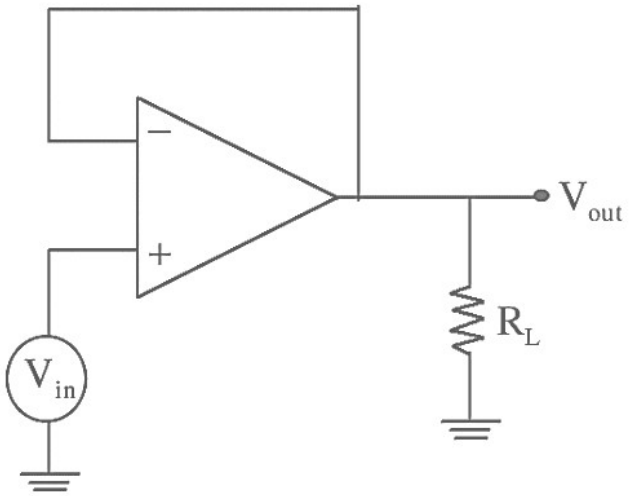


Figure 1.2 Voltage Follower Circuit

Procedure

Step 1: Check the continuity of all connecting wires using a multimeter set to resistance mode.

Step 2: Insert the IC 741 into the breadboard ensuring proper alignment with the pin configuration diagram provided.

Step 3: Connect the power supply terminals:

- Pin 7 to +12V supply
- Pin 4 to -12V supply
- Pins 1 and 5 to ground

Step 4: Place 10μF capacitors across the power supply lines (between pin 7 and ground, and between pin 4 and ground) to filter noise.

Step 5: Connect the input signal from the function generator to the non-inverting input (pin 3) through the breadboard.

Step 6: Connect pin 6 (output) directly to pin 2 (inverting input) using a short connecting wire to complete the unity-gain configuration.

Step 7: Connect a 1kΩ resistor from the output to ground as a load.

Step 8: Switch on the power supply and function generator.

Step 9: Set the function generator to produce a sinusoidal signal of 1 kHz frequency and 2V peak-to-peak amplitude.

Step 10: Connect both input and output signals to the CRO (Y1 and Y2 channels respectively) to observe both waveforms simultaneously.

Step 11: Observe and verify that:

- Output voltage matches input voltage
- No phase shift exists between input and output
- Output amplitude remains stable with load

Step 12: Measure the peak-to-peak voltages of both input and output using the CRO.

Step 13: Repeat the observation for different input frequencies: 100 Hz, 500 Hz, 5 kHz, and 10 kHz.

Step 14: Measure the input current and output current using a digital multimeter to verify impedance characteristics.

Observation

Table 1.1 Observation table for the voltage follower circuit

S.No.	Input Frequency (Hz)	Input Voltage V_{in} (V)	Output Voltage V_{out} (V)	Voltage Gain A_v	Phase Difference (°)	Load Current (mA)
1	**100**					
2	**500**					
3	**1000**					
4	**5000**					
5	**10000**					

Graph

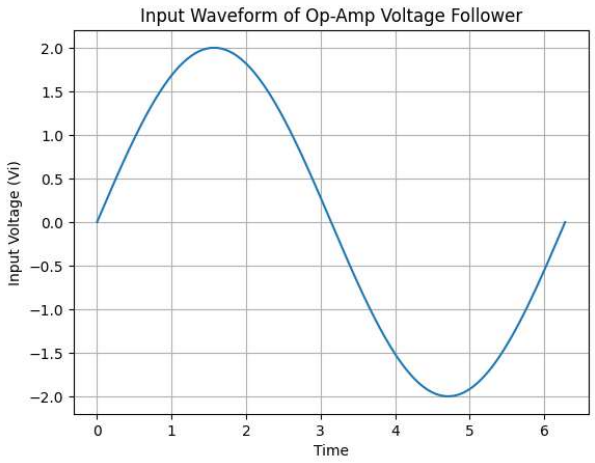


Figure 1.3

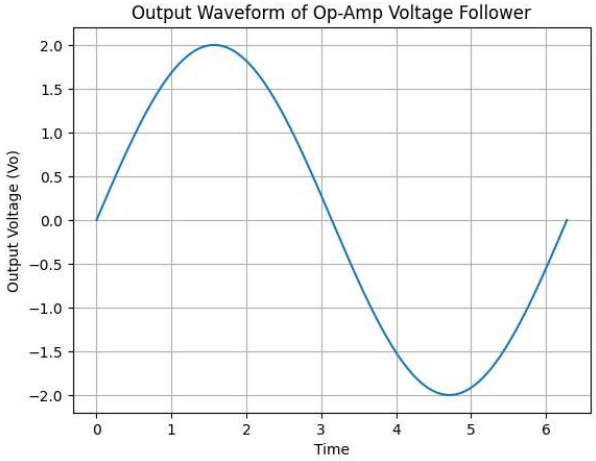


Figure 1.4

Observation from Waveforms

- Output waveform **exactly overlaps** the input waveform
- No phase shift
- No amplification or attenuation

Result

The voltage follower using IC 741 was designed, constructed, and tested. The output followed the input with unity gain, no observable phase shift, and negligible loading, confirming proper buffer/impedance-matching operation.

Viva Questions

1. What is a voltage follower and why is its gain equal to unity?
2. Why does a voltage follower have high input impedance and low output impedance?
3. What is the role of negative feedback in this circuit?
4. Where is a voltage follower used in practical systems?

2. OPERATIONAL AMPLIFIER - DIFFERENTIATOR & INTEGRATOR

Aim

To design and construct differentiator and integrator circuits using Op-Amp IC 741, study their frequency response characteristics, and verify their operation with different input waveforms.

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	Op-Amp IC 741	–	2
2	Dual DC Power Supply	±12 V (or similar)	1
3	Function Generator	Up to a few 100 kHz	1
4	CRO / DSO	Dual channel	1
5	Breadboard	–	1
6	Resistor 15 kΩ	1/4 W	2
7	Resistor 470 kΩ	1/4 W	2
8	Capacitor 0.01 µF	50 V	2
9	Capacitor 10 µF	25 V (decoupling)	2–4
10	Connecting Wires/Probes	–	As required

FORMULAS

Differentiator

- Output voltage:

$$V_{out} = -R_f C_i \frac{dV_{in}}{dt}$$

- Gain vs frequency:

$$A_v = 2\pi f R_f C_i$$

Integrator

- Output voltage: $V_{out} = -\frac{1}{R_i C_f} \int V_{in}\, dt$

Gain vs frequency:

$$A_v = \frac{1}{2\pi f R_i C_f}$$

Circuit Diagram

Differentiator:

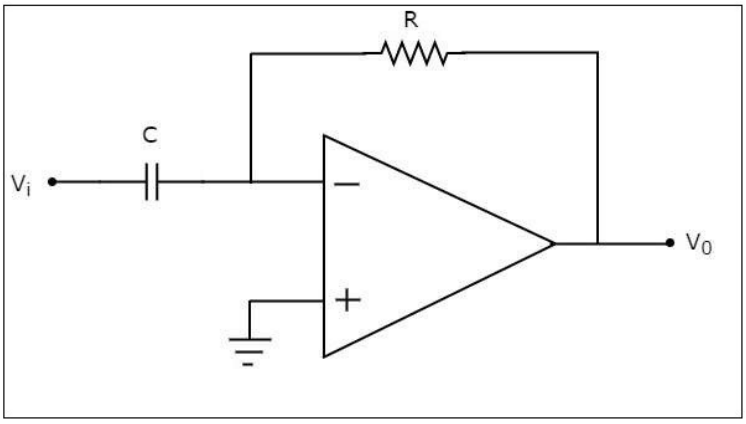


Figure 2.1 Differentiator Circuit using Op-Amp

Integrator:

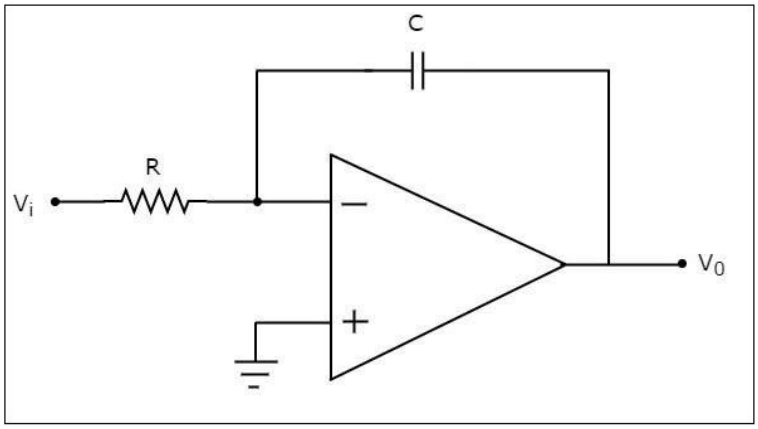


Figure 2.2 Integrator circuit using Op-Amp

Procedure

Part A: Differentiator

1. Insert IC 741 on the breadboard and give ±12 V supply to pins 7 and 4; ground pin 3 through 470 kΩ.
2. Connect the input square wave to a 0.01 μF capacitor, then from the capacitor to the inverting input (pin 2).
3. Connect a 15 kΩ feedback resistor between output (pin 6) and inverting input (pin 2).
4. Set the function generator to ±5 V, 1 kHz square wave and observe input and output on the CRO.

5. Note that the output shows sharp spikes at each rising and falling edge of the square wave.
6. Change frequency to 500 Hz, 2 kHz, and 5 kHz and record the change in output amplitude and shape.
7. Apply a 1 kHz sine wave and verify that the output leads the input by about 90°.

Part B: Integrator

1. Insert a second IC 741 and give the same ±12 V supply; ground pin 3.
2. Connect a 15 kΩ resistor from the input signal to the inverting input (pin 2).
3. Connect a 0.01 μF capacitor from output (pin 6) to pin 2, and connect a 470 kΩ resistor in parallel with this capacitor.
4. Apply a ±5 V, 1 kHz square wave and observe that the output becomes a triangular wave.
5. Vary frequency to 500 Hz, 2 kHz, and 5 kHz and note changes in slope and amplitude of the triangular waveform.
6. Apply a 1 kHz sine wave and verify that the output lags the input by about 90°.
7. Measure input and output voltages for each frequency and fill the observation tables.

Observation

Differentiator:

Table 2.1 Observation Table for the Differentiator Circuit

S.No.	Input Frequency f (Hz)	Input Waveform	Input Voltage $V_{in}(V_{p\text{-}p})$	Output Voltage $V_{out}(V_{p\text{-}p})$	Gain $A_v = V_{out}/V_{in}$	Phase Difference (°)
1	500	Square	10			
2	1000	Square	10			
3	2000	Square	10			
4	5000	Square	10			
5	1000	Sine	4			

Integrator:

Table 2.2 Observation Table for the Integrator Circuit

S.No.	Input Frequency f(Hz)	Input Waveform	Input Voltage $V_{in}(V_{p\text{-}p})$	Output Voltage $V_{out}(V_{p\text{-}p})$	Gain $A_v = V_{out}/V_{in}$	Phase Difference (°)
1	500	Square	10			
2	1000	Square	10			
3	2000	Square	10			
4	5000	Square	10			
5	1000	Sine	4			

Graph

Differentiator:

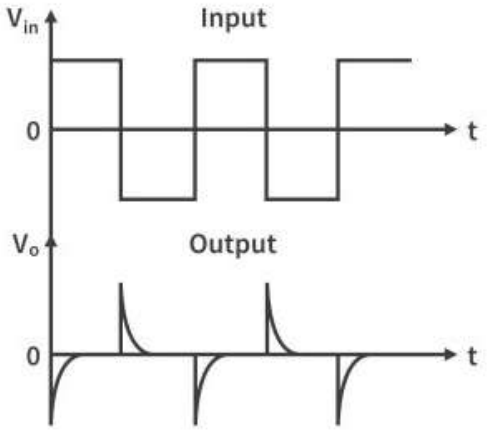


Figure 2.3 Input and Output Waveforms in Differentiator Circuit

Integrator:

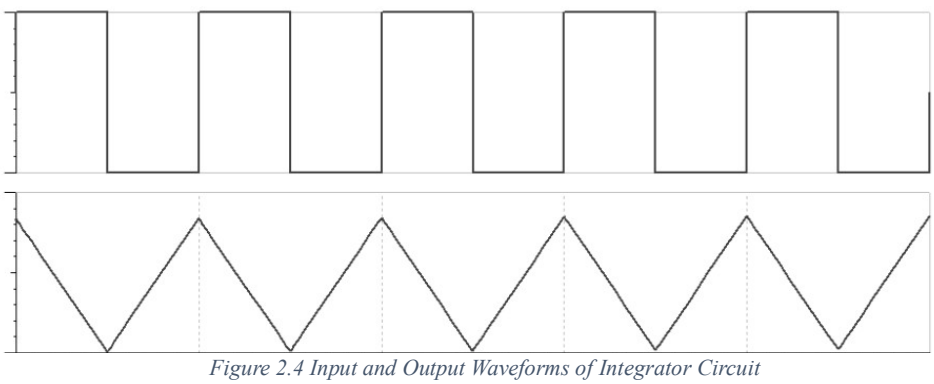


Figure 2.4 Input and Output Waveforms of Integrator Circuit

Differentiator – Square Wave Input

- **Input waveform:** Symmetrical square wave (alternating +V and −V with fast rising and falling edges).
- **Output waveform:** Narrow spikes at each edge.
  - At each rising edge of the input, the output gives a sharp negative spike.
  - At each falling edge of the input, the output gives a sharp positive spike.
  - Between edges, the output is approximately zero.

Integrator – Square Wave Input

- **Input waveform:** Symmetrical square wave (alternating +V and −V with flat tops).
- **Output waveform:** Symmetrical triangular wave.
  - When the input is at +V, the output ramps linearly in one direction (up or down, depending on inversion).
  - When the input is at −V, the output ramps linearly in the opposite direction.
  - The result is a continuous up-down triangular waveform corresponding to the square input.

Result

The differentiator and integrator circuits using IC 741 were successfully constructed and tested. For a square-wave input, the differentiator produced spikes at the transitions and the integrator produced a triangular waveform, confirming the expected operation of both circuits.

Viva Questions

1. What is the basic function of an op-amp differentiator circuit?
2. What is the basic function of an op-amp integrator circuit?
3. Write the ideal output equation of a differentiator in terms of V_{in}.
4. Write the ideal output equation of an integrator in terms of V_{in}.
5. What output waveform is obtained from an integrator when the input is a square wave?

3. WIEN'S BRIDGE OSCILLATOR USING IC 741

Aim

To design and construct a Wien's bridge oscillator using Op-Amp IC 741, measure its frequency of oscillation, and verify the Barkhausen conditions for sustained oscillation.

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	Op-Amp IC 741	–	1
2	Dual DC Power Supply	±12 V	1
3	CRO / DSO	Dual channel	1
4	Breadboard	–	1
5	Resistor 1.5 kΩ	1/4 W	2
6	Resistor 1 kΩ	1/4 W	1
7	Resistor 2.2 kΩ	1/4 W	1
8	Capacitor 0.01 µF	50 V	2
9	Capacitor 10 µF	25 V	2
10	Connecting Wires	–	As required

Formula

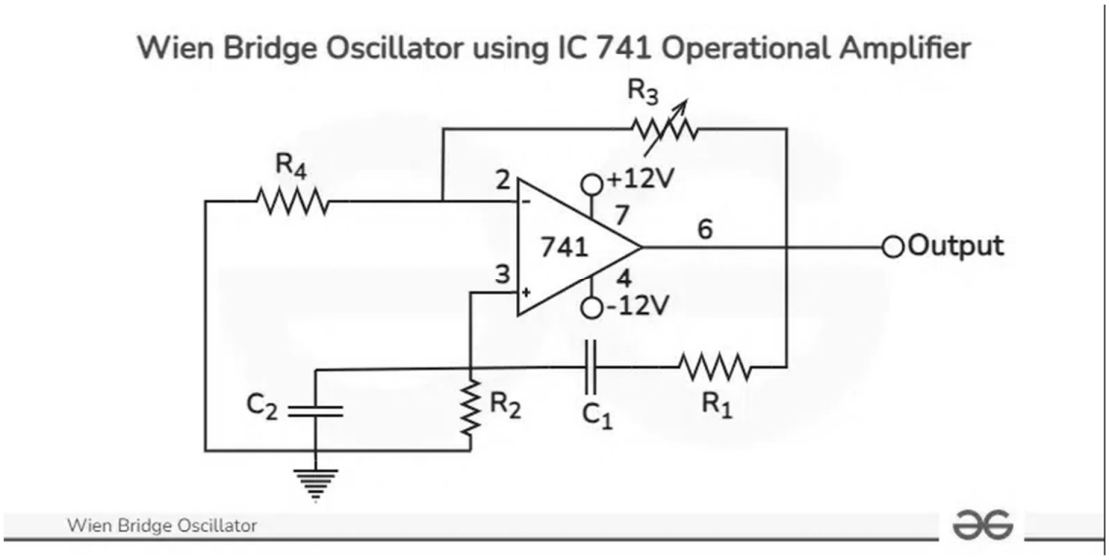
Frequency of oscillation:

$$f_0 = \frac{1}{2\pi RC}$$

Required amplifier gain:

$$A_v = 1 + \frac{R_f}{R_i} = 3$$

Circuit Diagram



Procedure

1. Insert IC 741 on breadboard. Connect pin 7 to +12 V and pin 4 to –12 V. Add 10 µF capacitors near power pins.
2. **Build the Wien bridge:**
    - Connect R_1 (1.5 kΩ) in series with C_1 (0.01 µF) from output (pin 6) to point A.
    - Connect R_2 (1.5 kΩ) in parallel with C_2 (0.01 µF) from point A to ground.
    - Connect non-inverting input (pin 3) to point A.
3. **Set up the feedback gain:**
    - Connect 1 kΩ resistor from inverting input (pin 2) to ground.
    - Connect 2.2 kΩ resistor from output (pin 6) to inverting input (pin 2).
4. Turn on power supply.
5. Observe the CRO output. A clean sine wave should appear.
6. If oscillation doesn't start, gently tap the breadboard or adjust the 2.2 kΩ resistor slightly.
7. Measure the frequency by counting cycles on the CRO.
8. Repeat with different R values: 1 kΩ, 2 kΩ, 3 kΩ and record frequencies.

Observation

S.No.	R(kΩ)	C(μF)	Theoretical f_0(Hz)	Measured f_0(Hz)	Output $V_{p\text{-}p}$(V)
1	1.5	0.01	1061.5		
2	1.0	0.01	1591.5		
3	2.0	0.01	795.8		
4	3.0	0.01	530.8		

Result

The Wien's bridge oscillator using IC 741 was successfully constructed and tested. Oscillations started at gain ≈ 3 and produced a clean sinusoidal output. The measured frequency matched the theoretical value calculated from $f_0 = 1/(2\pi RC)$. The circuit showed good frequency stability and the frequency was easily adjustable by changing R or C values.

Viva Questions

1. What is the frequency formula for a Wien's bridge oscillator?
2. What is the required gain for sustained oscillation?
3. Write the two Barkhausen conditions for oscillation.
4. Why is the Wien's bridge oscillator preferred for audio frequencies?
5. How can the frequency of oscillation be changed in this circuit?

4. HARTLEY OSCILLATOR - TRANSISTOR

Aim

To design and construct a Hartley oscillator using a transistor, measure its frequency of oscillation, and verify that the output frequency depends on the tank circuit parameters (L and C).

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	BJT Transistor	2N2222 or similar	1
2	DC Power Supply	+12 V	1
3	CRO / DSO	Dual channel	1
4	Digital Multimeter	–	1
5	Breadboard	–	1
6	Inductor L_1	5–20 µH	1
7	Inductor L_2	5–20 µH	1
8	Capacitor (Tank)	50–100 pF	1
9	Resistor 10 kΩ	1/4 W	1
10	Resistor 1 kΩ	1/4 W	2
11	Resistor 100 Ω	1/4 W	1
12	Capacitor (Coupling)	0.1 µF	1
13	Connecting Wires	–	As required

Formula

Frequency of oscillation:

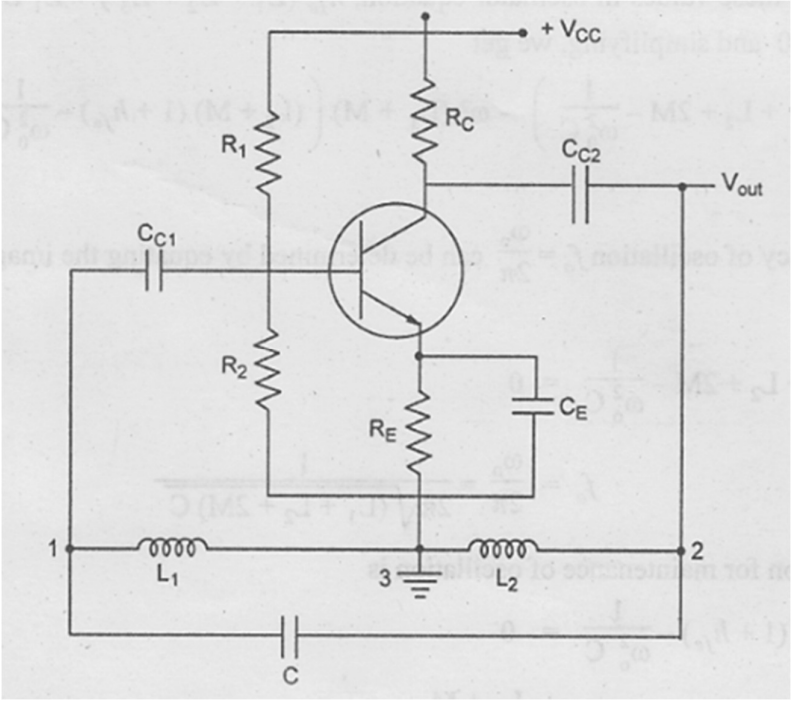
$$f_0 = \frac{1}{2\pi\sqrt{(L_1 + L_2)C}}$$

Equivalent inductance:

$$L_{eq} = L_1 + L_2$$

(When mutual inductance is present: $L_{eq} = L_1 + L_2 + 2M$)

Circuit Diagram



Procedure

1. Insert the 2N2222 transistor into the breadboard.
2. Connect +12 V power supply to the collector through a 1 kΩ resistor (collector load).
3. Build the tank circuit:
    - Connect inductors L_1 and L_2 in series with mutual coupling between them.
    - Connect capacitor C in parallel with the series inductors.
    - Connect the tank circuit between collector and ground.
4. Set up the bias network:
    - Connect 10 kΩ resistor from +12 V to the base.
    - Connect 100 Ω resistor (emitter resistor) from emitter to ground.
5. Connect the coupling capacitor (0.1 μF) from the junction between L_1 and L_2 to the base.
6. Turn on the +12 V power supply.
7. Observe the CRO output at the collector. A sinusoidal oscillation should appear.
8. If oscillation is weak, adjust the 10 kΩ base resistor slightly.

9. Measure the frequency by counting cycles on the CRO.
10. Change capacitor C to different values (50 pF, 75 pF, 100 pF) and record frequencies.
11. Verify that frequency follows $f_0 = 1/(2\pi\sqrt{(L_1 + L_2)C})$.

Observation

S.No.	L_1(µH)	L_2(µH)	L_{eq}(µH)	C(pF)	Theoretical f_0(kHz)	Measured f_0(kHz)	Output $V_{p\text{-}p}$(V)
1	10	10	20	50			
2	10	10	20	75			
3	10	10	20	100			
4	5	15	20	50			
5	15	5	20	50			

Result

The Hartley oscillator using a transistor was successfully constructed and tested. Oscillations were obtained in the expected frequency range. The measured frequency matched the theoretical calculated frequency within acceptable error. The frequency varied inversely with the square root of capacitance, confirming the relationship $f_0 \propto 1/\sqrt{C}$. The oscillation amplitude was stable and depended on the tank circuit quality factor.

Viva Questions

1. What is the frequency formula for a Hartley oscillator?
2. Why is mutual inductance important in the Hartley oscillator?
3. How does changing the capacitance affect the oscillation frequency?
4. What is the equivalent inductance of L_1 and L_2 in the tank circuit?
5. What is the purpose of the coupling capacitor between the tank circuit and the base?

5. STUDY OF LOGIC GATE ICs - BASIC GATES

Aim

To study and verify the truth tables of basic logic gates: NOT (7404), OR (7432), AND (7408), NOR (7402), NAND (7400), and XOR (7486).

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	IC 7404 (NOT gate)	–	1
2	IC 7432 (OR gate)	–	1
3	IC 7408 (AND gate)	–	1
4	IC 7402 (NOR gate)	–	1
5	IC 7400 (NAND gate)	–	1
6	IC 7486 (XOR gate)	–	1
7	Logic Trainer Kit / Breadboard	–	1
8	Power Supply	+5 V	1
9	LED Indicators	–	6
10	Resistor 470 Ω	1/4 W	6
11	Connecting Wires	–	As required

IC 7408: AND Gate

$$Y = A \cdot B$$

A	***B***	***Y***
0	0	0
0	1	0
1	0	0
1	1	1

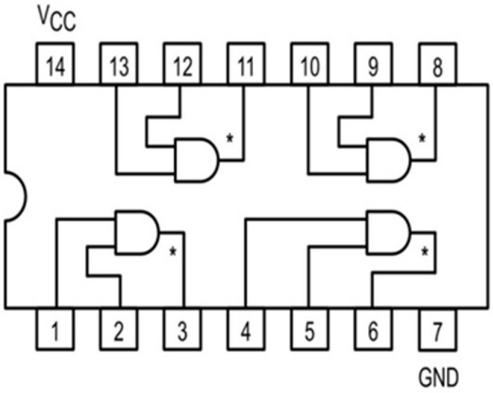


Figure 5.1 Pin configuration of IC 7408 AND Gate

IC 7432: OR Gate

$$Y = A + B$$

A	***B***	***Y***
0	0	0
0	1	1
1	0	1
1	1	1

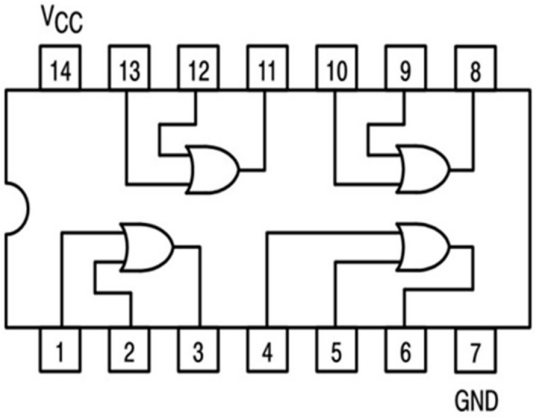


Figure 5.2 Pin Configuration of IC 7432 OR Gate

IC 7400: NAND Gate

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

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

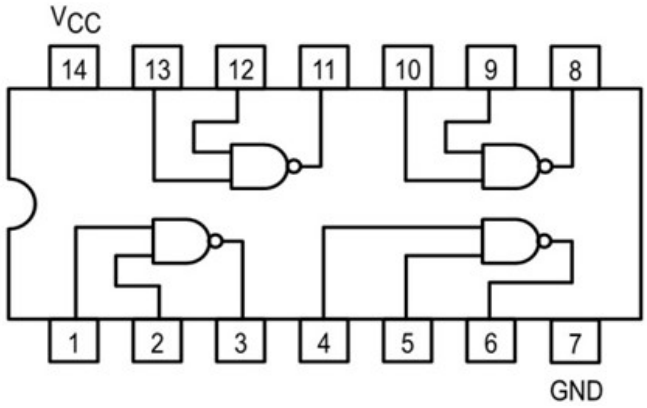


Figure 5.3 Pin Configuration of IC 7400 NAND Gate

IC 7402: NOR Gate

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

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

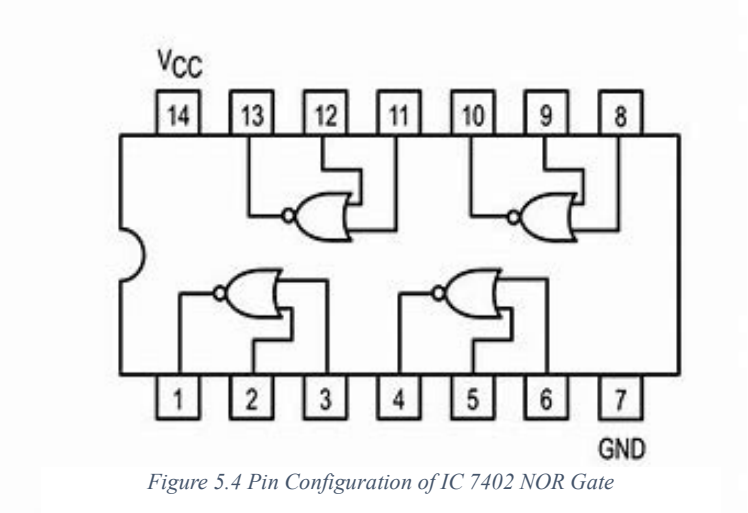


Figure 5.4 Pin Configuration of IC 7402 NOR Gate

IC 7486: XOR Gate

$$Y = A \oplus B$$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

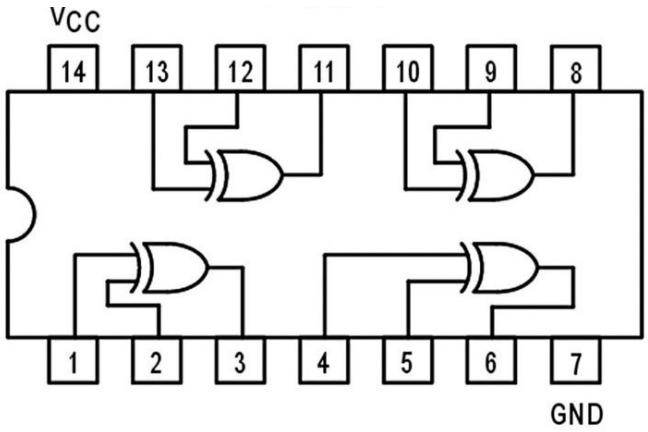


Figure 5.4 Pin Configuration of IC 7486 XOR Gate

IC 7404: NOT Gate

$$Y = \bar{A}$$

A	Y
0	1
1	0

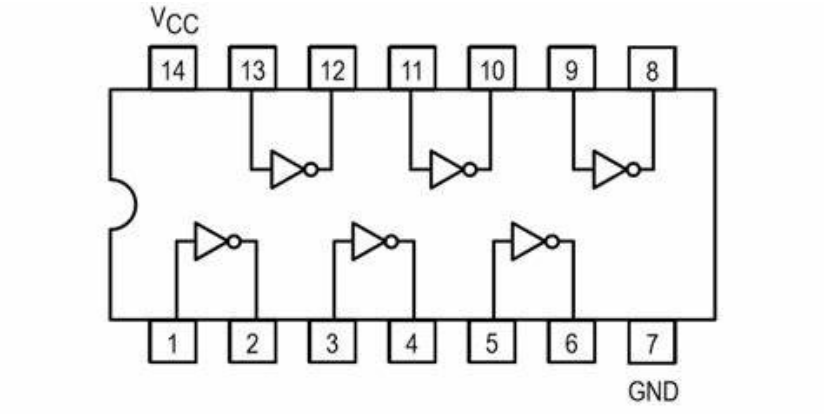


Figure 5.4 Pin Configuration of IC 7404 NOT Gate

Procedure

1. Set up the Logic Trainer Kit with +5 V power supply.
2. Insert the first IC (e.g., IC 7400 NAND) into the breadboard.
3. Connect pin 14 (VCC) to +5 V and pin 7 (GND) to ground.
4. Select one gate from the IC.
5. Connect input switches to the two input pins of the selected gate.
6. Connect the output through a 470 Ω resistor to an LED indicator.
7. Apply input combination 0-0 (both inputs low):
    - Observe whether the LED is ON (logic 1) or OFF (logic 0).
    - Record in the observation table.
8. Apply input combination 0-1:
    - Observe and record the output.
9. Apply input combination 1-0:
    - Observe and record the output.

10. Apply input combination 1-1:
    - Observe and record the output.
11. Compare the observed truth table with the theoretical truth table.
12. Repeat steps 2–11 for all other IC gates (7408, 7432, 7402, 7486, 7404).

Result

All logic gate ICs have been successfully tested and their truth tables verified experimentally. The measured outputs matched the theoretical truth tables for all input combinations, confirming the correct operation of each gate.

Viva Questions

1. What is the function of a NAND gate?
2. What is the difference between NAND and AND gates?
3. Write the Boolean expression for an OR gate.
4. What is the function of an XOR gate?
5. How many logic gates are present in IC 7408?

6. VERIFICATION OF DE MORGAN'S THEOREMS USING NOT, AND, OR GATES

Aim

To verify De Morgan's first and second theorems using NOT, AND, and OR gates by comparing the left-hand side and right-hand side expressions for all input combinations.

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	IC 7404 (NOT gate)	Hex inverter	1
2	IC 7408 (AND gate)	Quad 2-input AND	1
3	IC 7432 (OR gate)	Quad 2-input OR	1
4	Logic trainer / Breadboard	–	1
5	DC power supply	+5 V	1
6	LEDs / Logic indicators	–	2–4
7	Resistors	470 Ω (for LEDs)	As required
8	Connecting wires	–	As required

STATEMENT OF THEOREMS

First De Morgan theorem

$$\overline{A \cdot B} = \bar{A} + \bar{B}$$

Second De Morgan theorem

$$\overline{A + B} = \bar{A} \cdot \bar{B}$$

PROCEDURE

Part A: Verification of first theorem

$$\overline{A \cdot B} = \bar{A} + \bar{B}$$

1. Give +5 V to pin 14 and ground to pin 7 of IC 7404, 7408, and 7432.
2. LHS implementation:

- Connect inputs A and B to an AND gate (7408) → output is $A \cdot B$.
- Connect this output to a NOT gate (7404) → output is $A \bar{\cdot} B$.

3. RHS implementation:
   - Connect A to another NOT gate → $\bar{A}$.
   - Connect B to another NOT gate → $\bar{B}$.
   - Feed $\bar{A}$ and $\bar{B}$ to an OR gate (7432) → output is $\bar{A} + \bar{B}$.
4. Connect LEDs (through 470 Ω resistors) to LHS and RHS outputs.
5. Apply all four input combinations: (A,B) = (0,0), (0,1), (1,0), (1,1).
6. For each combination, note both outputs and check if they are equal.

Part B: Verification of second theorem

$$A \bar{+} B = \bar{A} \cdot \bar{B}$$

1. Keep IC power connections as before.
2. LHS implementation:
   - Connect A and B to an OR gate (7432) → output is $A + B$.
   - Connect this output to a NOT gate (7404) → output is $A \bar{+} B$.
3. RHS implementation:
   - Use NOT gates to get $\bar{A}$ and $\bar{B}$ from A and B.
   - Feed $\bar{A}$ and $\bar{B}$ to an AND gate (7408) → output is $\bar{A} \cdot \bar{B}$.
4. Connect LEDs to the LHS and RHS outputs.
5. Again apply all four input combinations and record outputs for both sides.

Truth Tables

First theorem: $A \bar{\cdot} B = \bar{A} + \bar{B}$

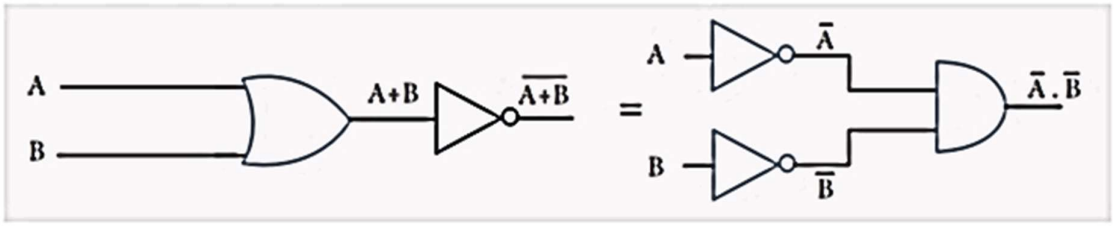
A	B	$A \cdot B$	$A \bar{\cdot} B$	$\bar{A}$	$\bar{B}$	$\bar{A} + \bar{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

Second theorem: $A \overline{+} B = \bar{A} \cdot \bar{B}$

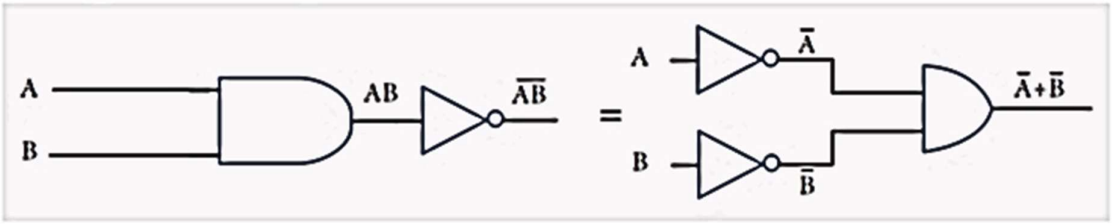
A	B	$A + B$	$A \overline{+} B$	$\bar{A}$	$\bar{B}$	$\bar{A} \cdot \bar{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Circuit Diagram

De Morgan's first theorem



De Morgan's second theorem



Result

For all four input combinations, the outputs of the left-hand side and right-hand side were identical for both theorems. Hence, De Morgan's first and second theorems are verified experimentally using NOT, AND, and OR gates.

7. VERIFICATION OF BOOLEAN ALGEBRA LAWS (ANY FOUR)

Aim

To verify any four basic Boolean algebra laws using logic gates.

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	IC 7408 (AND gate)	Quad 2-input AND	1
2	IC 7432 (OR gate)	Quad 2-input OR	1
3	IC 7404 (NOT gate)	Hex inverter	1
4	Logic trainer / Breadboard	–	1
5	DC power supply	+5 V	1
6	LEDs / Logic indicators	–	4–6
7	Resistors	470 Ω (for LEDs)	As required
8	Connecting wires	–	As required

LAWS SELECTED (ANY FOUR)

Here four standard laws are chosen:

1. Commutative law of OR
$$A + B = B + A$$
2. Commutative law of AND
$$A \cdot B = B \cdot A$$
3. Identity law of OR
$$A + 0 = A$$
4. Identity law of AND
$$A \cdot 1 = A$$

(You can change to other laws like $A + A = A$, $A \cdot A = A$, $A + \bar{A} = 1$, etc., if needed.)

THEORETICAL TRUTH TABLES

1. Commutative law of OR: $A + B = B + A$

A	B	$A + B$	$B + A$
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	1

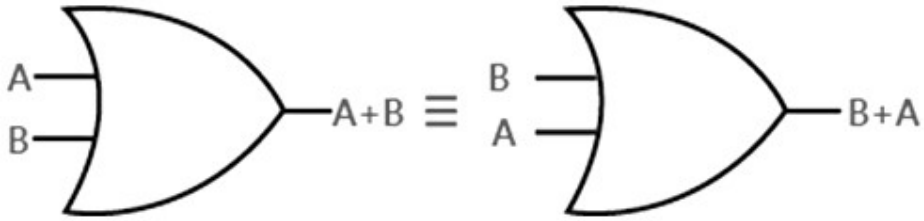


Figure 7.1 commutative law of OR

2. Commutative law of AND: $A \cdot B = B \cdot A$

A	B	$A \cdot B$	$B \cdot A$
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

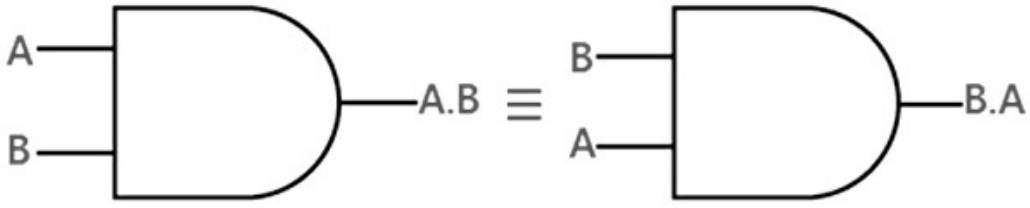


Figure 7.2 commutative law od AND

3. Identity law of OR: $A + 0 = A$

A	Constant 0	$A + 0$	A
0	**0**	**0**	**0**
1	**0**	**1**	**1**

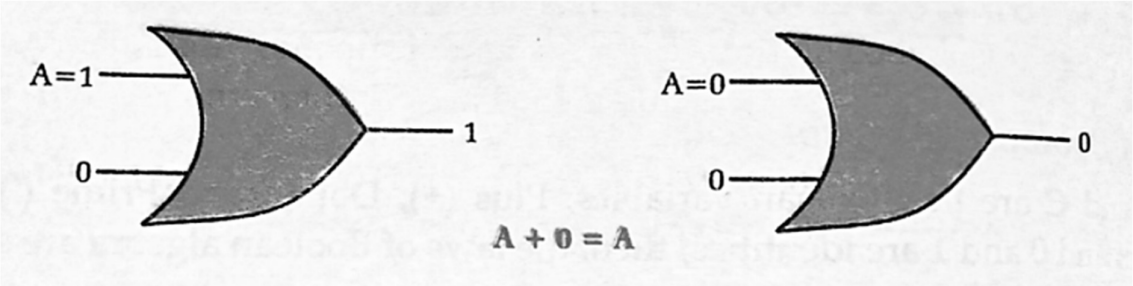


Figure 7.3 Identity law for OR

Identity law of AND: $A \cdot 1 = A$

A	Constant 1	$A \cdot 1$	A
0	1	0	0
1	1	1	1

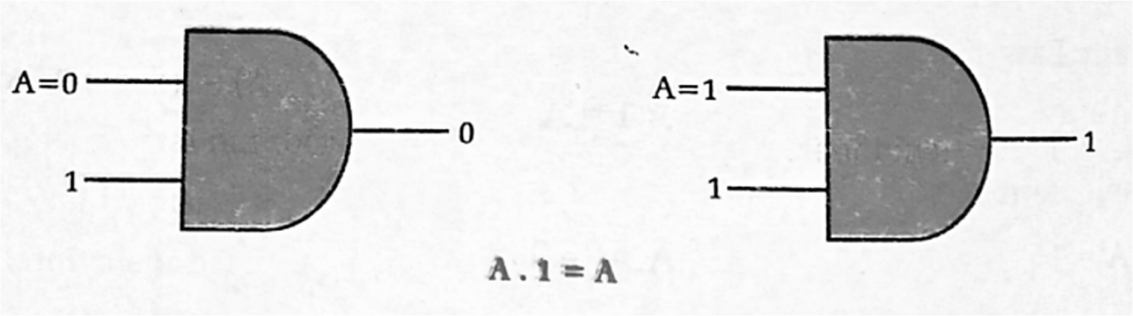


Figure 7.4 Identity law for AND

PROCEDURE

Common steps

1. Place IC 7408, 7432, and 7404 on the breadboard.
2. Connect pin 14 of each IC to +5 V and pin 7 to ground.
3. Connect LEDs (through 470 Ω resistors) to the outputs you want to observe.

4. Use trainer switches or jumper wires to apply logic 0 (ground) and logic 1 (+5 V) to inputs.

Law 1: $A + B = B + A$ (Commutative law of OR)

1. Feed A and B to an OR gate → output is $A + B$.
2. Feed B and A (inputs swapped) to another OR gate → output is $B + A$.
3. Connect LEDs to both outputs.
4. Apply all four input combinations of A, B.
5. For each combination, verify both outputs are identical.

Law 2: $A \cdot B = B \cdot A$ (Commutative law of AND)

1. Feed A and B to an AND gate → output is $A \cdot B$.
2. Feed B and A (swapped) to another AND gate → output is $B \cdot A$.
3. Connect LEDs to both outputs.
4. Apply all four input combinations of A, B.
5. Verify both outputs are equal for all rows.

Law 3: $A + 0 = A$ (Identity law of OR)

1. Connect input A to one input of an OR gate.
2. Tie the other input of the OR gate permanently to logic 0 (ground).
3. Output of OR gate is $A + 0$.
4. Take A directly to another LED for comparison.
5. Apply $A = 0$ and $A = 1$ and compare both outputs.

Law 4: $A \cdot 1 = A$ (Identity law of AND)

1. Connect input A to one input of an AND gate.
2. Tie the other input of the AND gate permanently to logic 1 (+5 V).
3. Output of AND gate is $A \cdot 1$.
4. Take A directly to another LED for comparison.
5. Apply $A = 0$ and $A = 1$ and compare both outputs.

Result

The outputs of both sides of each Boolean expression were found to be identical for all input combinations. Hence, the selected four Boolean algebra laws are verified experimentally using logic gates.

8. MONOSTABLE MULTIVIBRATOR USING 555 IC TIMER

Aim

To design and study a monostable multivibrator using IC 555 timer and to measure the output pulse width for a given R and C.

Apparatus Required

S.No.	Apparatus	Specification	Quantity
1	IC 555 timer	–	1
2	DC power supply	+5 V to +12 V	1
3	Resistor R	e.g. 100 kΩ	1
4	Capacitor C	e.g. 0.1 µF or 1 µF	1
5	Capacitor (noise bypass)	0.01 µF	1
6	Push button / trigger switch	–	1
7	CRO / DSO	Dual channel	1
8	Breadboard and wires	–	As required
9	LED + 470 Ω resistor	For output indication	1

Circuit Diagram

Pin Configuration (IC 555)

1. Pin 1 – GND: Ground (0 V reference).
2. Pin 2 – TRIG: Starts timing (< 1/3 V_{cc}).
3. Pin 3 – OUT: Output terminal.
4. Pin 4 – RESET: Active low; usually tied to V_{cc}.
5. Pin 5 – CTRL: Control voltage (bypass 0.01 µF to GND).
6. Pin 6 – THR: Ends timing (> 2/3 V_{cc}).
7. Pin 7 – DISCH: Discharges capacitor.
8. Pin 8 – V_{cc}: Supply voltage (+5 V – 15 V).

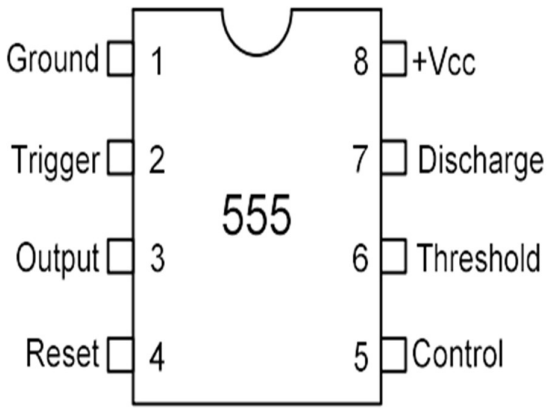


Figure 8.1 *pin configuration of 555 IC Timer*

Circuit Diagram

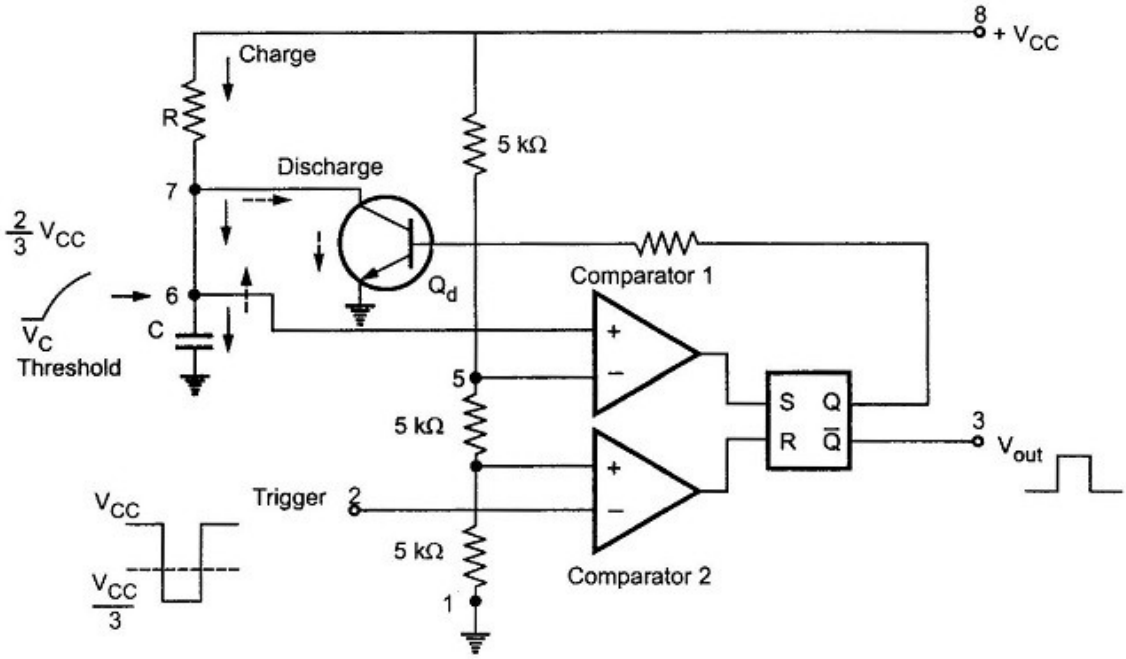


Figure 8.2 *Equivalent circuit diagram of 555 IC timer*

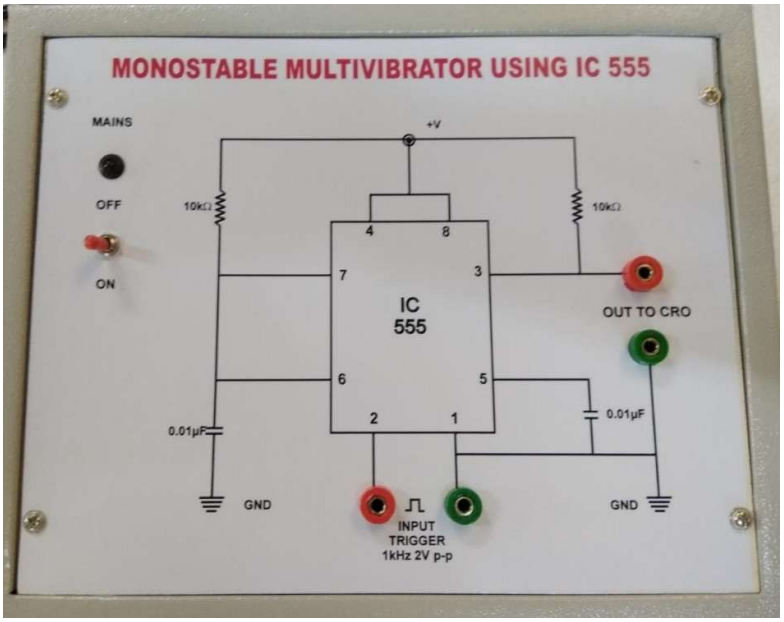


Figure 8.3 Monostable Multivibrator using 555 IC Trainer Kit

THEORY

- A monostable multivibrator has one stable state (output low) and one quasi-stable state (output high for a fixed time).

- When a negative trigger pulse is applied, the 555 output goes high for a time T, then automatically returns low.
- The time for which the output remains high is controlled by an external resistor R and capacitor C.

Pulse width (time period) formula

$$T = 1.1\,R\,C$$

- T: output pulse width (seconds)
- R: timing resistor (ohms)
- C: timing capacitor (farads)

Example:
If $R = 100$ kΩ and $C = 0.1$ μF,

$$T = 1.1 \times 100 \times 10^{3} \times 0.1 \times 10^{-6} \approx 11 \text{ ms}$$

PROCEDURE

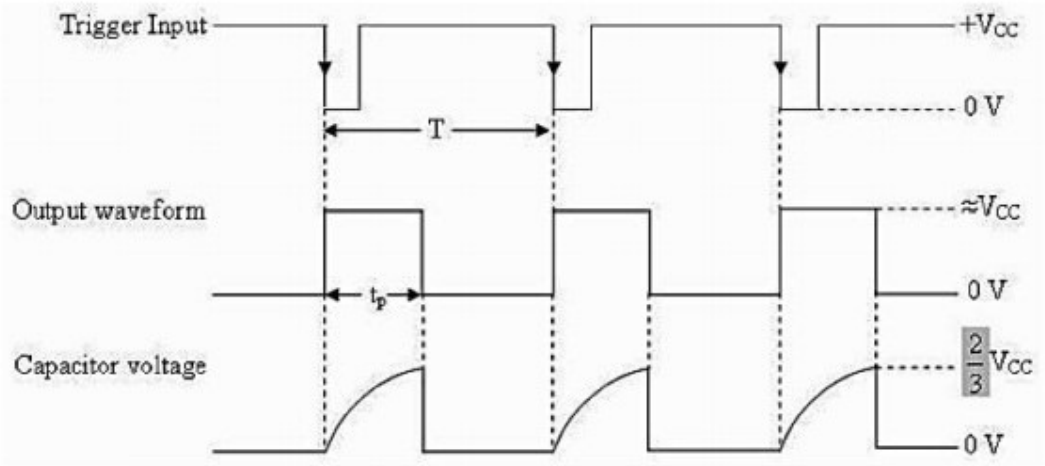
1. Place IC 555 on the breadboard and connect pin 1 to ground, pin 8 to $+V_{CC}$ (5–12 V).
2. Tie RESET (pin 4) to $+V_{CC}$. Connect 0.01 μF from pin 5 to ground.
3. Connect resistor R between $+V_{CC}$ and pins 6 and 7 (joined).
4. Connect capacitor C between pins 6–7 (joined) and ground.
5. Connect pin 2 (TRIGGER) to $+V_{CC}$ via a pull-up resistor (e.g. 10 kΩ), and also to a push button that connects to ground when pressed.
6. Connect pin 3 (OUTPUT) to the CRO (and optionally to an LED through 470 Ω).
7. Switch on the power supply.
8. Press and release the trigger button to give a short negative pulse on pin 2.
9. Observe the output waveform on the CRO:
    - Output goes high when triggered, stays high for time T, then returns low.
10. Measure the high-time T from the CRO time base.
11. Compare the measured T with the theoretical value $T = 1.1RC$.
12. Change R or C and repeat steps 8–11, noting how T changes.

Observation Table

S.No.	R(kΩ)	C(μF)	Theoretical $T = 1.1RC$(ms)	Measured T(ms)
1	100	0.1	11	
2	100	1.0	110	
3	47	0.1	5.17	
4	220	0.1	24.2	

Graph

Plot the output waveform observed on CRO.



Graph 8.1 Input and Output waveforms in CRO

Result

The monostable multivibrator using IC 555 was successfully designed and tested. A single output pulse was obtained for each trigger, and the measured pulse width agreed with the theoretical value given by $T = 1.1RC$ within experimental error.