

*A Product of Electrical Engineering Services*

# LOGIC DESIGN LABORATORY

# Digital Logic Trainer AM-2000 Manual

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**Printed in Pakistan by Digifast Computing Services**  
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Phone. 042-7552686

## Preface

Logic Design in the modern era forms a major component of the Digital System Design process. It also contributes with the derivation and synthesis of sequential and combinational switching circuits.

This manual contains sufficient material for the Logic Design Laboratory to supplement a comprehensive one-semester course in Digital Logic and Circuits. It is written to bridge the gap between theoretical derivation of switching functions and their implementation.

We would like to explain the philosophy underlying the material presented in this manual. The students are given situations as close as possible to reality so that they are aware of the types of problems that occur in real systems. In line with this philosophy, the students are required to wire-up their own circuits rather than using sophisticated black boxes with well-debugged circuitry hidden behind cosmetic block diagrams. In doing this, we expect students to get exposure to all kinds of real world problems and it will give them the patience to trace out bugs in their own circuitry.

This manual requires no background in circuit theory or electronics and can be used for an introductory course in Digital Logic. The logic gates are treated as black boxes that perform logic operations.

All experiments included in this manual have been performed on the AM-2000 Logic Trainer developed by Electrical Engineering Services. The experiments are performed using Low Power Schottky TTL ICs.

The experiments included contain a large variety of difficulty levels. Some are as simple as testing of gates and flip-flops, others include the design of counters, shift register and coding circuits. The procedure for each experiment is given in small and easy to follow steps. Empty tables are provided for convenience so that the students can fill them up while performing the experiments. Results are also provided wherever needed for students instructor convenience. Pin diagrams of ICs are also included where ever needed for easy reference, since the students are not expected to be able to search for the information independently from data books/hand books at this level.

For the convenience of the instructor and students, a list of tools and components required for each experiment is also provided so that all the equipment can be organized before the experiment begins.

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## List of Tools Needed:

Sr. No.	Tools Name
1	Digital Logic Trainer
2	Multimeter
3	Cutter
4	Single Core Wires
5	Tweezers
6-	Pair of Pliers

# List of Components Needed

S. No.	Experiments Name	74 LS 00	74 LS 01	74 LS 02	74 LS 04	74 LS 08	74 LS 32	74 LS 47	74 LS 49	74 LS 74	74 LS 75	74 LS 76	74 LS 85	74 LS 86	74 LS 93	74 LS 139	74 LS 157	74 LS 170
1-	FAMILIARIZATION WITH Am2000																	
2-	AND Gate Operation							1										
3-	OR Gate Operation								1									
4-	NOT Gate Operation							1										
5-	NAND Gate Operation	1																
6-	NOR Gate Operation					1												
7-	XOR Gate Operation														1			
8-	XOR From NAND Gates	1																
9-	Half Adder Operation							1							1			
10-	Full Adder Operation								1	1					1			
11-	Half Subtractor Operation						1	1							1			
12-	Full Subtractor Operation						1	1	1						1			
13-	7-Segment Disp. Operation																	
14-	Decoder Operation															1		
15-	BCD To 7-Segment Display										1							1
16-	Multiplexer Operation																	1
17-	Mux /Demux Operation																	
18-	Comparator Operations														1			
19-	D Latch And Flip-Flop													1	1			
20-	Latching BCD Data									1				1				
21-	Recirculating Data									2								
22-	JK Flip-Flop Operation															1		
	Project 1 (Multiplexing 7-Segment Displays)											1					1	1
23-	Random Access Memories																1	

## List of Other Components:

1. Common – cathode display x 2
2. Common – anode display x 1
3. 74LS49 x 1, 74LS138 x 1, 74LS151 x 1.(For Experiment 17 & Project 1)
4. 180 Ω resistance x 8.

# Digital Logic Trainer AM-2000

AM-2000 logic trainer is a low cost, high performance digital logic teaching system. It is designed to provide all the basic tools necessary to conduct logic experiments. It is also ideally suited for developing, debugging, integrating and testing digital systems.

AM-2000 becomes a high performance 16 and 32 bits (80286 and 80386) CPU microcomputer teaching system for PC AT computer when an interface card is added to the trainer.

## Specifications

- Input voltage 220V 50 Hz AC
- Circuit type TTL compatible
- 16 lamp monitors-transistor buffered
- 8 logic switches
- 2 logic switches with debouncing circuitry
- Logic probe with pulse detection
- One clock timer- 7 to 65Hz (Optional for two ranges)
- Three 7-segment decoders / drivers displays
- Output voltage = +12V, -12V, and +5V at 1A

## Components of the AM-2000 Trainer

- Sixteen LED's with drivers
- Eight logic switches with two outputs, each the complement of the other
- Two simple logic switches with debouncing circuit
- Logic probe with LOW, HIGH and PULSE indicators
- Two push pull switches for generating negative-going pulse
- One timer based on NE 555 with variable control
- Three 7-segment displays with BCD decoders/drivers
- One linear variable 10K
- One linear variable 100K
- Computer interface card (optional)
- Two or four breadboards

## **Special Features of the AM-2000 Trainer**

### **Regulated Power Supply**

Power supply with short circuit protection that provides +5V, +12V and -12V with power indicators and protection fuse. Push-in wire terminals at right hand edge of the trainer are provided for each supply.

### **State Monitors**

State monitors are simply light-emitting diodes, which are used to indicate the state of a logical output. Lighted diode represents a "1" and an unlighted diode represents as "0". The input to these monitors LED's are available at SBB-63 board which are labeled as:

**L0 L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L11 L12 L13 L14 L15**

In order to avoid any current loading on the various test circuits, LED's are provided with drivers.

### **Logic Switches**

Logic switches, S2 through S9 are special types of switches, designed to produce two TTL compatible logic outputs which are complement of each other. Switches S0 and S1 are simple logic switches with each has one output and provided with debouncing circuitry. The output from these 10 switches are made available at SBB-63 board and is labeled as:

**S0 S1 S2 S2' S3 S3' S4 S4' S5 S5' S6 S6' S7 S7' S8 S8' S9 S9'**

### **Digital Display**

Three 7-segment decoders/drivers and displays are provided. Each consists of a 74LS47 BCD to 7-segment decoder/driver and S806RWB common anode display. The BCD input for these three 7-segment displays are made available at SBB-63 board and is labeled as:

**8 4 2 1 8 4 2 1 8 4 2 1**

If a BCD logic input is applied to the four input terminals (8 4 2 1), it will be decoded and displayed on the corresponding display.

The 7-segment display is a common anode type and cannot be directly interchanged with the common cathode type.

### **Digital Logic Probe**

Digital logic probe is provided for detecting and indicating logic states as well as pulses. The indicator system consists of three LED's. A red LED lights up to indicate logic 1, while a yellow LED lights for logic 0. A green LED comes ON for approximately 500 ms to indicate a pulse without regard to its width. This feature enables one to observe a short-duration pulse that would otherwise not be seen on the logic 1 and 0 LED's.

In operation, for a logic 0 input signal, both the 0 LED and the pulse LED will come ON, for a logic 1 input only the logic 1 LED will be lit. The logic probe will indicate if a negative-going pulse has occurred at the input. Pulse LED will be ON for approximately 500 ms to indicate a negative-going pulse.

### **Clock Timer**

A 555-clock/timer circuit with a range of 7 to 65 Hz is used as a pulse source. The frequency is adjusted by turning the variable 500K pot provided on the left hand side edge of the trainer. The output is available at SBB-63 board, which is labeled as CLK.

# **Experiment 1: - Familiarization with AM-2000**

All experiments included in this manual have been performed on the AM-2000 logic trainer using low power Schottky TTL ICs. Before starting actual experiments, let us first familiarize ourself with the use of AM-2000 trainer.

## **Measuring Power Supplies**

Now that you're ready to experiment, it may be worthwhile to become familiar with the hardware. Connect the AM-2000 Trainer to the 220V AC power source and turn ON the Trainer. Observe +5V, +12V and -12V LED's ON, indicating these supplies are available for experimentation. Verify +5V, +12V and -12V voltages using a multimeter

## **Measuring Logic Levels**

Try using the LED's (L0-L15) to monitor the logic level.

- Connect +5V power to the LED indicator L0. The LED should be ON indicating logic 1.
- Connect LED indicator L0 to GND. The LED should be OFF indicating logic 0.

## **Test the Clock**

Rotate the *timer rate* knob to counterclockwise position until extreme position is reached. Connect the output CLK to the input of LED L0. The light should blink ON and OFF slowly. The light blinks rapidly as the *timer rate* knob is rotated clockwise. It will stop blinking at some point, and then LED will be ON indicating a higher frequency.

## **Measure the Logic Level coming from one of the Logic Switch (S2 to S9)**

Connect the outputs S2 and S2' of switch (S2) to L0 and L1 respectively. The LED's should indicate the logic levels originating from the S2 switch.

- Set switch S2 at a higher position, L0 should be OFF and L1 should be ON.
- Set switch S2 at a lower position, L0 should be ON and L1 should be OFF.

## **Measure Logic Level by using the Logic Probe**

A logic probe is provided to display status of a point in a digital circuit. Connect the pointed probe to the input of the logic probe and make contact at the desired point. If the logic level is low, LED marked LOW will lit and if logic level is high, the LED marked HIGH will lit.

## **Pulse Detection**

Connect switch S2 output to the input of the logic probe. Generate negative-going pulse by setting S2 to HIGH-LOW and then back to HIGH (1-0-1) quickly. Observe the pulse LED will be ON for approximately 500ms indicating the detection of negative – going pulse.

## **BCD Logic Input**

Connect switches S2, S3, S4 and S5 to the four input marked as 8 4 2 1 on the SBB-63 board. Applied BCD input using switches, it would be decoded and displayed on the 7-Segment display.

- Set switch S2 at logic ‘1’ and rest of the switches at 0, BCD digit ‘8’ will be displayed.
- Set switch S3 at logic ‘1’ and rest of the switches at 0, BCD digit ‘4’ will be displayed.
- Set switch S4 at logic ‘1’ and rest of the switches at 0, BCD digit ‘2’ will be displayed.
- Set switch S5 at logic ‘1’ and rest of the switches at 0, BCD digit ‘1’ will be displayed.
- Set switches at the appropriate positions to display BCD numbers (0-9).

## Experiment 2: - AND Gate Operation

### Objective

To check the operation of AND gate according to the AND's truth table, using the IC 74LS08.

### Equipment

#### Component

1. 74LS08 x 1

#### Tools

1. AM2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

### Diagram

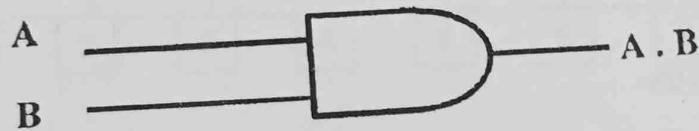


Figure 2.1

### Procedure

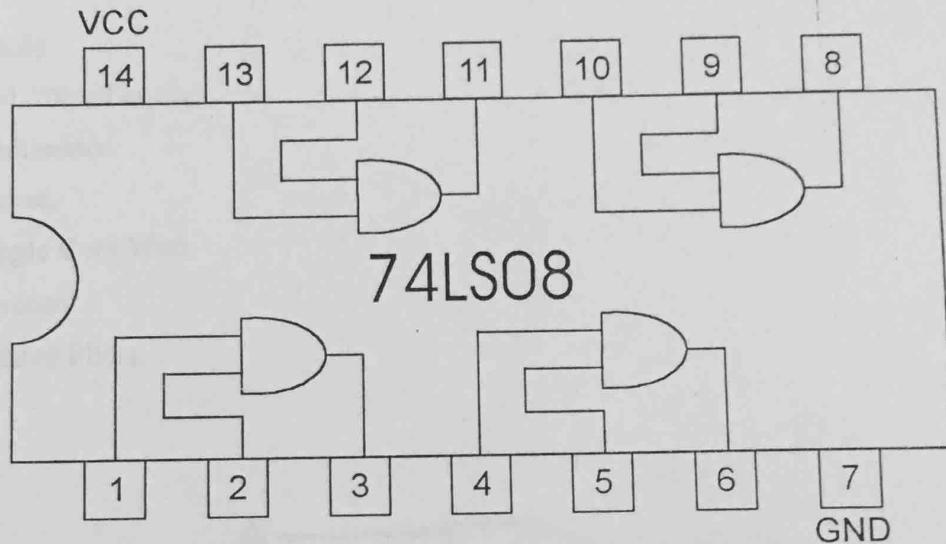
1. Connect the AM2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS08 on the trainer's breadboard.
4. Wire the circuit according to the diagram in figure 2.1 by consulting AND gate IC's data sheet in fig.2.2
5. Use any of the two logic switches from S2 to S9 for inputs A and B respectively.
6. For output indication use any of the LED's from (LO - L15)
7. Supply the +5V and GND to the pins 14 and 7 of the IC.

8. Test all the possible combinations of inputs and verify the output according to the truth table of AND gate.
9. Fill the truth table given below according to the results.

Table 1. Truth Table for AND Gate

Inputs		Output AND
A	B	
0	0	
0	1	
1	0	
1	1	

Figure 2.2



### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 3: - OR Gate Operation

## Objective

To check the operation of OR gate according to the OR's truth table, using the IC 74LS32.

## Equipment

### Component

1. 74LS32 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

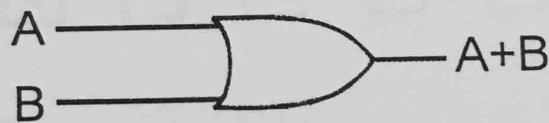


Figure 3.1.

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS32 on trainer's breadboard.
4. Wire the circuit according to the diagram in fig.3.1 by consulting OR gate IC's data sheet in fig 3.2.
5. Use any of the two logic switches S2 to S9 for inputs to OR gate.
6. For output indication use any of the LED's from (L0 – L15).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.

8. Test all the possible combinations of inputs and verify the output according to the truth table of OR gate.
9. Fill the truth table given below according to the results.

Table1. Truth Table For OR Gate

Inputs		Output OR
A	B	
0	0	
0	1	
1	0	
1	1	

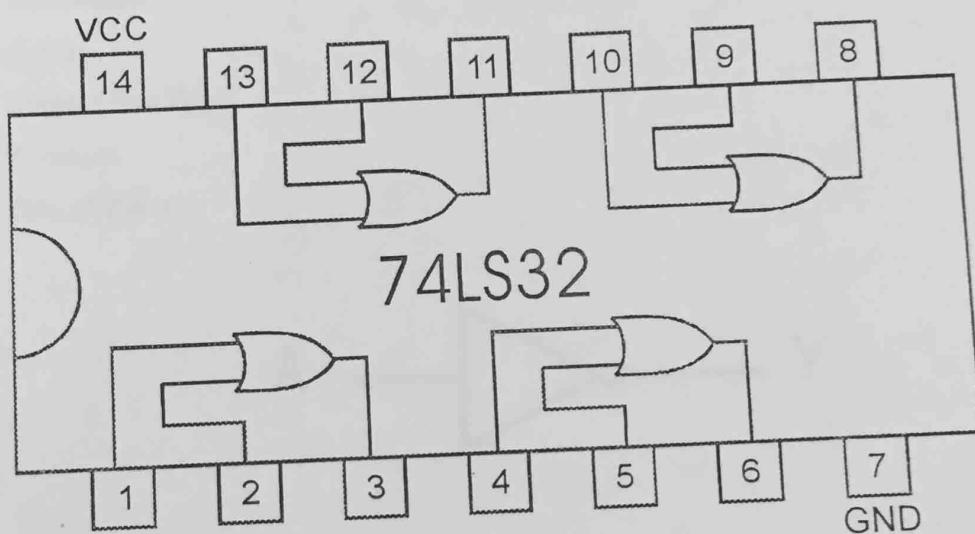


Figure 3.2

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 4: - NOT Gate Operation

## Objective

To check the operation of NOT gate according to the NOT's truth table, using the IC 74LS04.

## Equipment

### Component

1. 74LS04 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

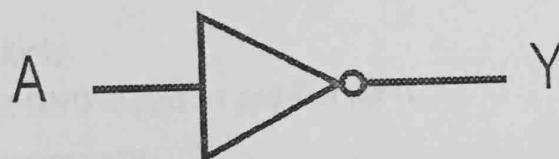


Figure 4.1

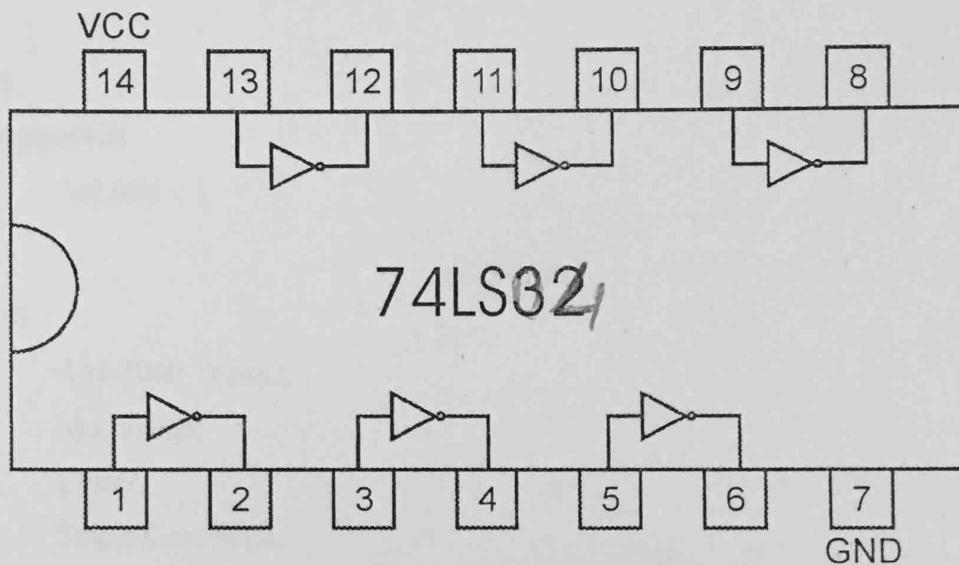
## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS04 on the trainer's breadboard.
4. Wire the circuit according to the diagram in fig.4.1 by consulting NOT gate IC's data sheet in fig 4.2.
5. Use any of the logic switches from S2 to S9 for input A.
6. For output Y use any of the LED's from (L0 – L15).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of NOT gate.
9. Fill the truth table 1 according to the results.

Table 1. Truth Table for NOT Gate

Input	Output
A	NOT
0	
1	

Figure 4.2



### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 5: -NAND Gate Operation

## Objective

To check the operation of NAND gate according to the NAND's truth table, using the IC 74LS00.

## Equipment

### Component

1. 74LS00 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram



Figure 5.1

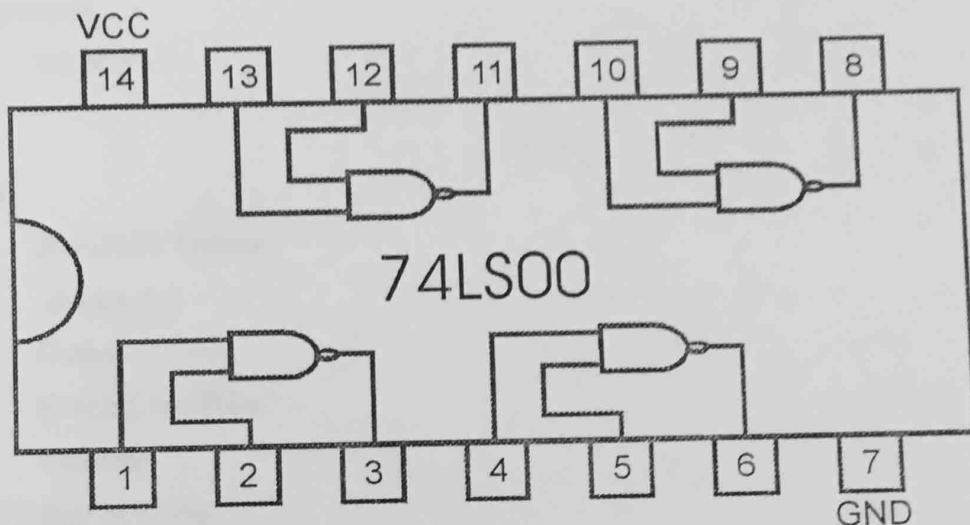
## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the IC 74LS00 on trainer's breadboard.
4. Wire the circuit according to the diagram in fig.5.1 by consulting NAND gate IC's data sheet in fig 5.2.
5. Use any of the two logic switches from S2 to S9 for inputs to NAND gate.
6. For output indication use any of the LED's from (L0 – L15).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of NAND gate.

9. Fill the truth table given below according to the results.

Table1. Truth Table for NAND Gate

Inputs		Output
A	B	NAND
0	0	
0	1	
1	0	
1	1	



Figures 5.2

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 6: - NOR Gate Operation

## Objective

To check the operation of NOR gate according to the NOR's truth table, using the IC 74LS02.

## Equipment

### Component

1. 74LS02 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram



Figure 6.1

## Procedure

1. Connect the AM-2000 trainer to the 220 V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the IC 74LS02 on the trainer's breadboard.
4. Wire the circuit according to the diagram in fig. 6.1 by consulting NOR gate IC's data sheet in fig. 6.2.
5. Use any of the two logic switches from S2 to S9 for inputs to NOR gate.
6. For output indication use any of the LED's from (L0 – L15).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of NOR gate.

9. Fill the truth table given below according to the results.

Table1. Truth Table For NOR Gate

Inputs		Output
A	B	NOR
0	0	
0	1	
1	0	
1	1	

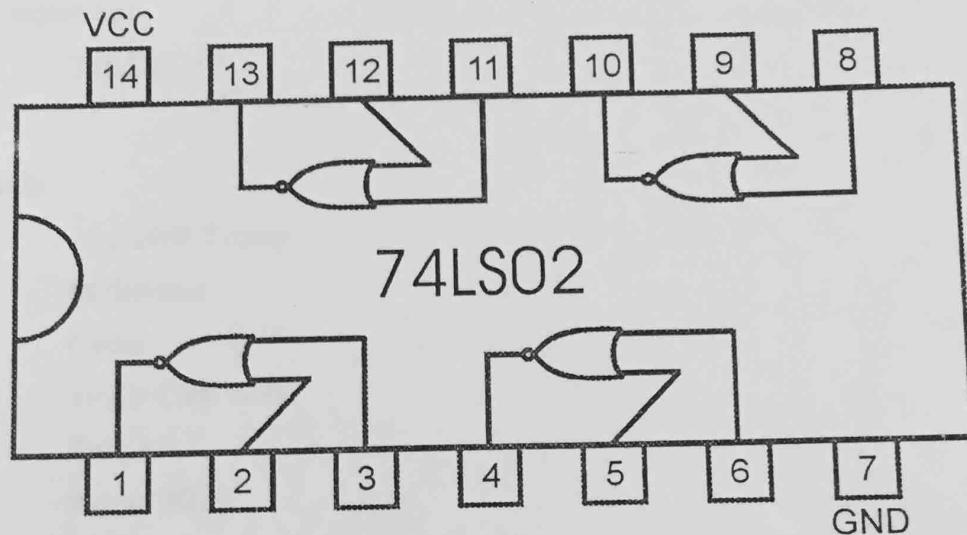


Figure 6.2

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 7: -XOR Gate Operation

## Objective

To check the operation of XOR gate according to the XOR's truth table, using the IC 74LS86.

## Equipment

### Component

1. 74LS86 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram



Figure 7.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the IC 74LS86 on trainer's breadboard.
4. Wire the circuit according to the diagram in fig. 7.1 by consulting XOR gate IC's data sheet in fig. 7.2.
5. Use any of the two logic switches from S2 to S9 for inputs to XOR gate.
6. For output indication use any of the LED's from ( L0 – L15 ).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of XOR gate.

9. Fill the truth table given below according to the results.

Table 1. Truth Table for XOR Gate

Inputs		Output
A	B	XOR
0	0	
0	1	
1	0	
1	1	

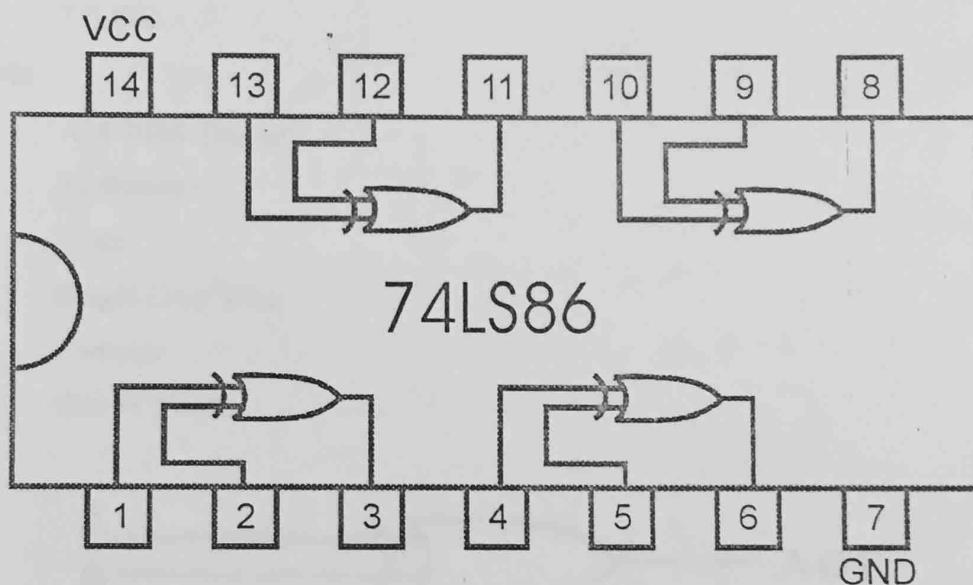


Figure 7.2

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

# Experiment 8: - Construction of XOR Gate from NAND Gates

## Objective

To check the operation of XOR gate according to the NAND's truth table, using the IC 74LS00.

## Equipment

### Component

1. 74LS00 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram



Figure 8.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS00 on the trainer's breadboard.
4. Wire the circuit according to the diagram in figure 8.3.
5. Use any of the two logic switches from S2 to S9 for inputs A and B respectively.
6. For output indication use any of the LED's from ( L0 – L15 ).
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of XOR gate.
9. Fill the truth table given below according to the results.

Table1. Truth Table For XOR Gate

Inputs		Output
A	B	XOR
0	0	
0	1	
1	0	
1	1	

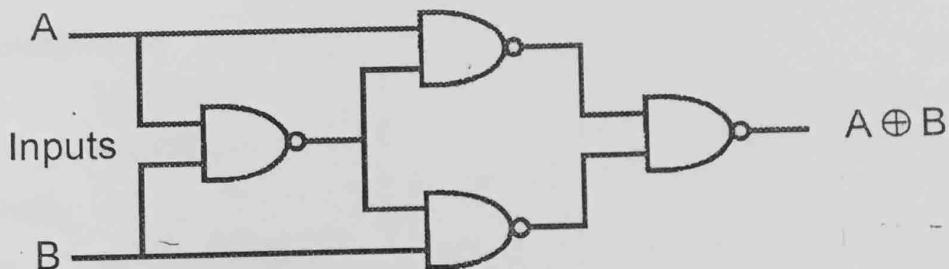


Figure 8.2

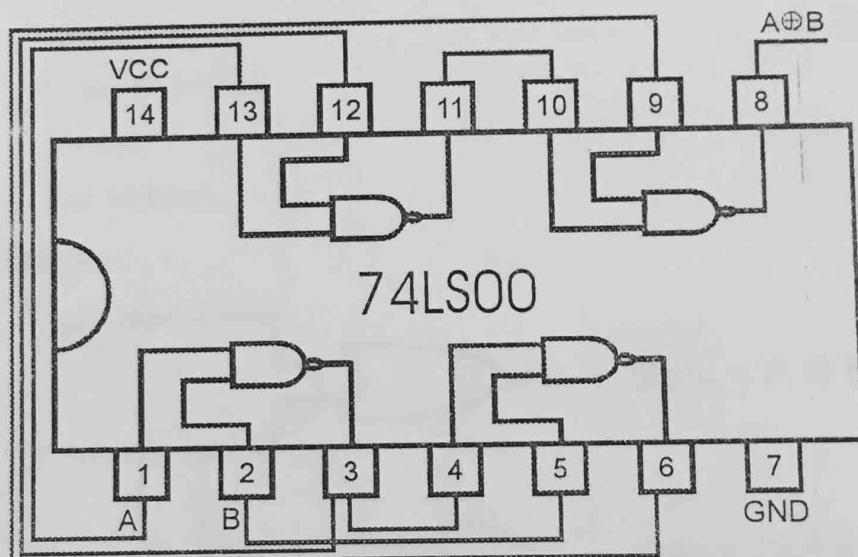


Figure 8.3

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

## Experiment 9: - Half Adder Operation

### Objective

To design half adder circuit using XOR and AND gates.

### Equipment

#### Components

1. 74LX86 x 1
2. 74LX08 x 1

#### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

### Symbolic Diagram

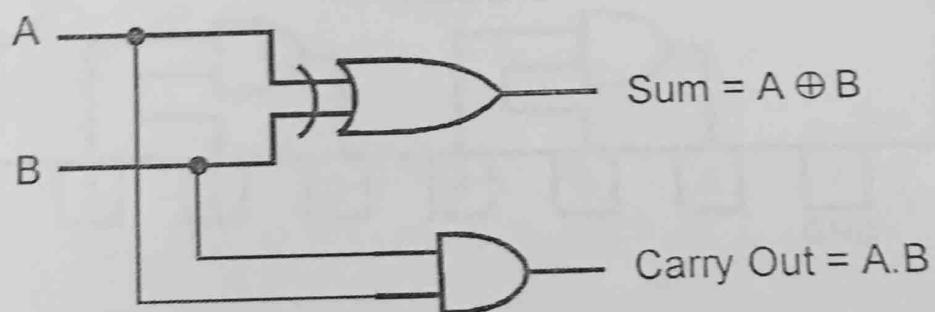


Figure 9.1

**Circuit Diagram**

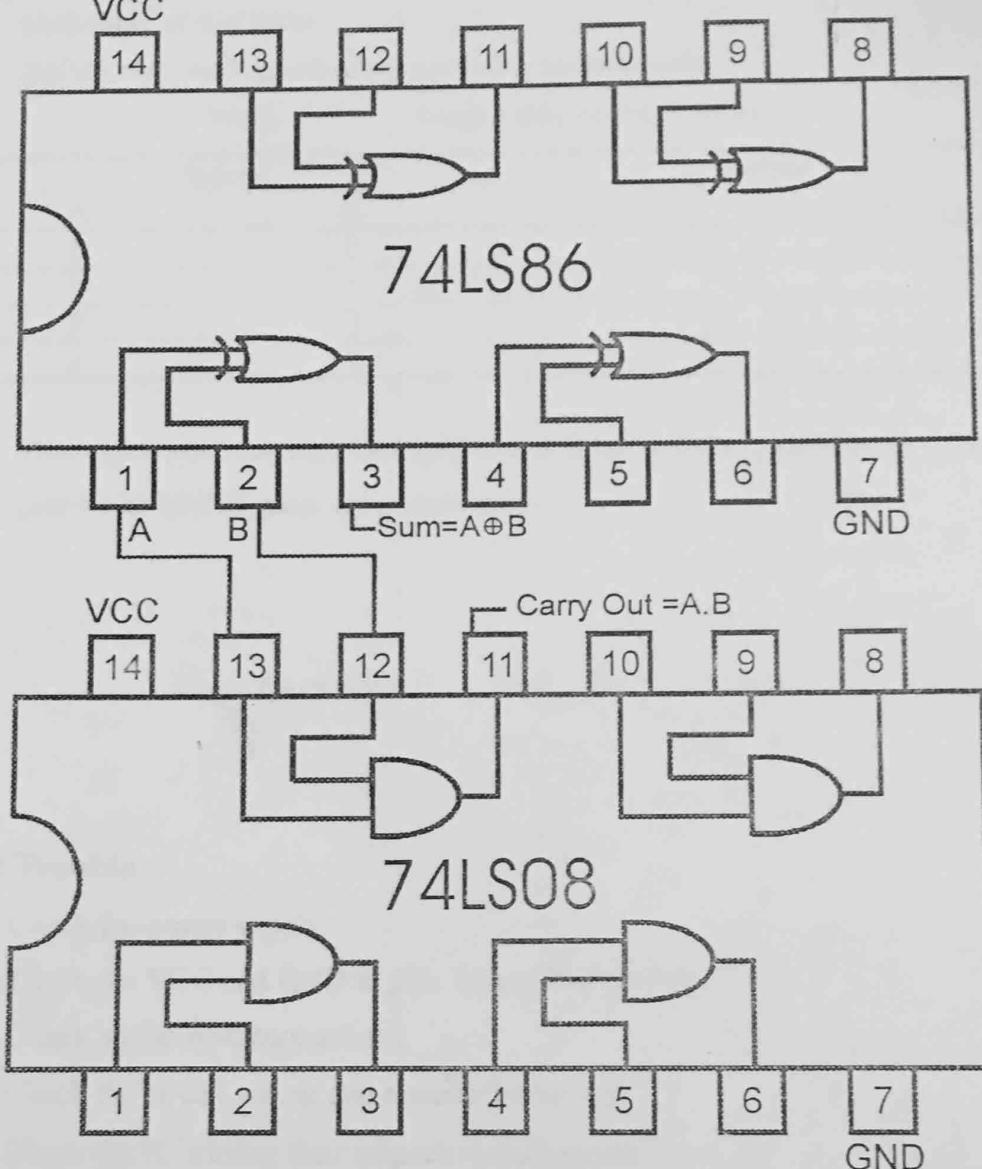


Figure 9.2

### Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS08 & IC 74LS86 on trainer's breadboard.
4. Wire the circuit according to the diagram shown in Figure 9.2.
5. Use any of the two logic switches from S2 to S9 for inputs A and B.
6. For output Sum, use LED L0 and for output Carry, use LED L1.
7. Supply the VCC= +5V and GND to the pins 14 and 7 of both the ICs.

8. Test all the possible combinations of inputs and verify the outputs according to the truth table of half adder.
9. Fill the truth table given below according to the results.

Table 1. Truth Table For Half Adder

Inputs		Output	
A	B	Sum	Carry out
0	0		
0	1		
1	0		
1	1		

10. This experiment can also be implemented using NAND gates only by replacing XOR gate by its NAND gates equivalent circuit.

## Results

Logic Functions:

Sum	=	$A \oplus B$
Co	=	$A \cdot B$

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the ICs.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC's using their respective data sheets.

# Experiment 10:- Full Adder Operation

## Objective

To design full adder circuit using XOR, AND & OR gates.

## Equipment

### Components

1. 74LS86 x 1
2. 74LS08 x 1
3. 74LS32 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Symbolic Diagram

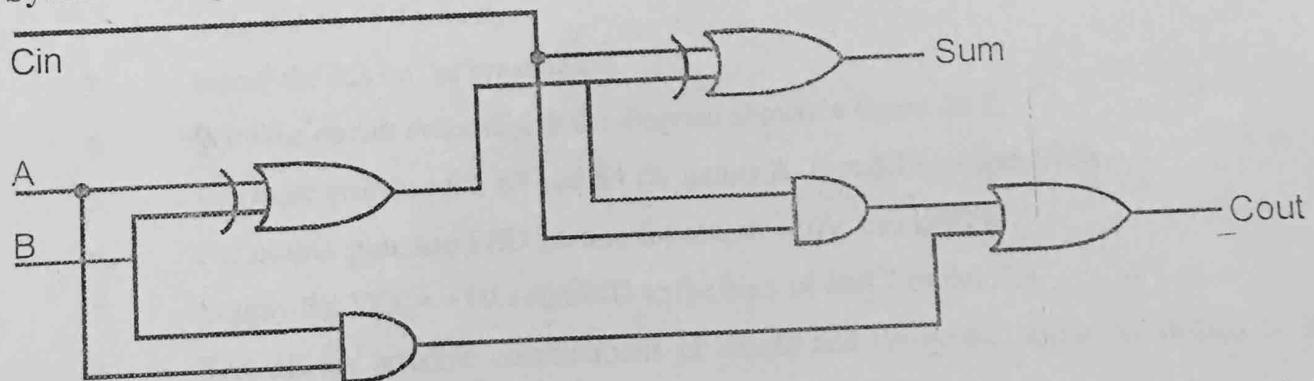


Figure 10.1

## Circuit Diagram

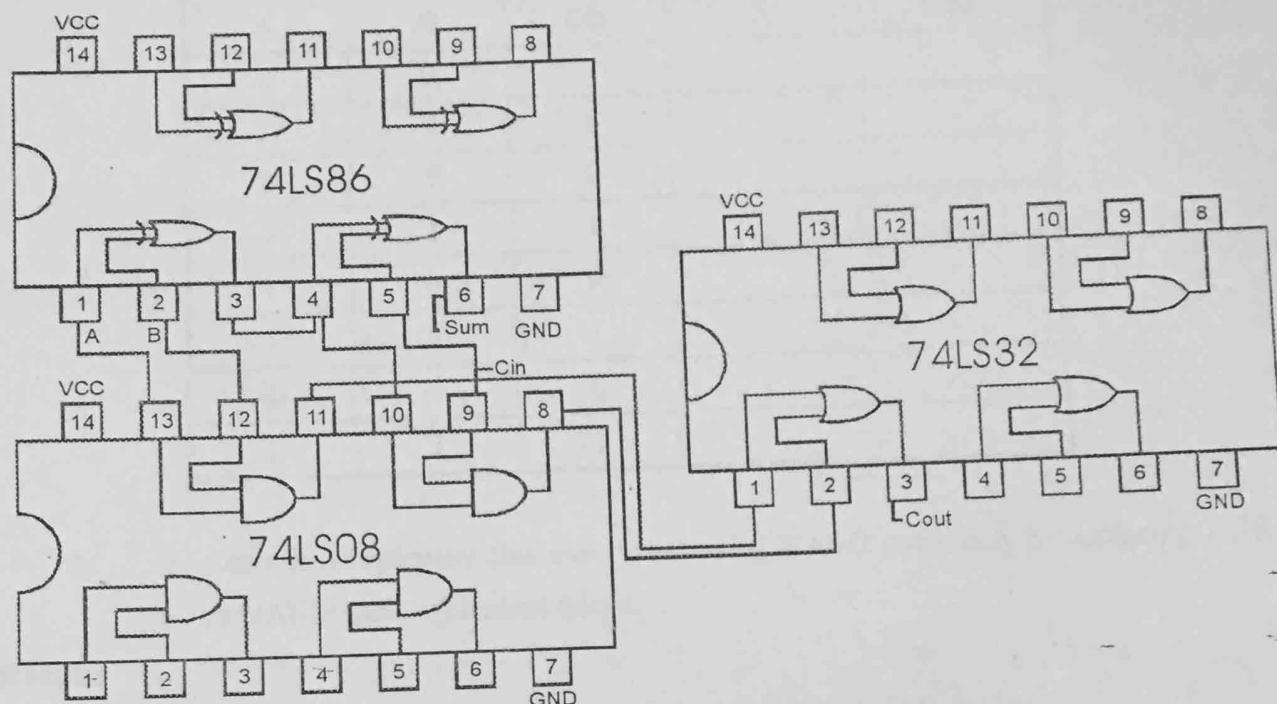


Figure 10.2

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the ICs on the breadboard.
4. Wire the circuit according to the diagram shown in figure 10.2.
5. Use logic switches S<sub>2</sub>, S<sub>3</sub> and S<sub>4</sub> for inputs A, B and Cin respectively.
6. For output sum, use LED L<sub>0</sub> and for output carry, use LED L<sub>1</sub>.
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the ICs.
8. Test all the possible combinations of inputs and verify the output according to the truth table of full adder.
9. Fill the truth table given below according to the results.

Table 1. Truth Table For Full Adder

Inputs			Outputs	
A	B	Cin	S	Cout
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

10. You can also implement this experiment using NAND gates only by replacing XOR by its NAND gates equivalent circuit.

## Results

Logic Functions:

Sum =	$A \oplus B \oplus Cin$
Cout =	$(A \oplus B) Cin + (A \cdot B)$

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the ICs.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the ICs using their data sheets.

# Experiment 11:- Half Subtractor Operation

## Objective

To design half subtractor circuit using XOR, AND and NOT gates.

## Equipment

### Components

1. 74LS86 x 1
2. 74LS08 x 1
3. 74LS04 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Symbolic Diagram

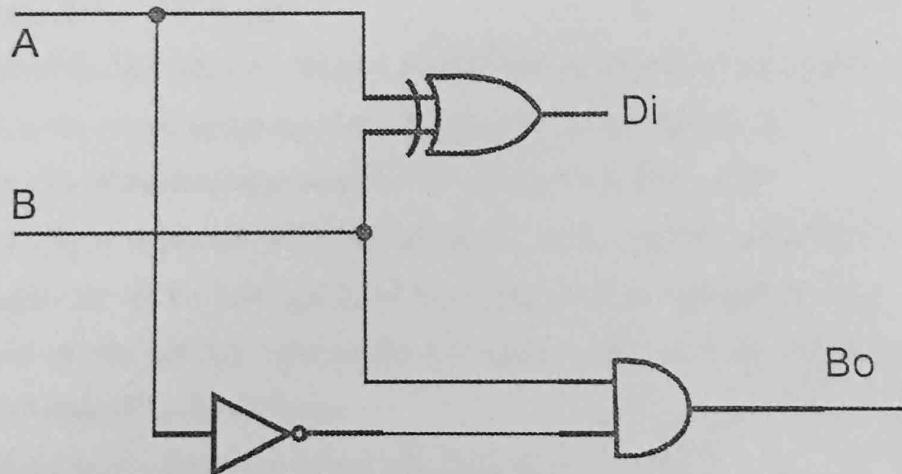


Figure 11.1

## Circuit Diagram

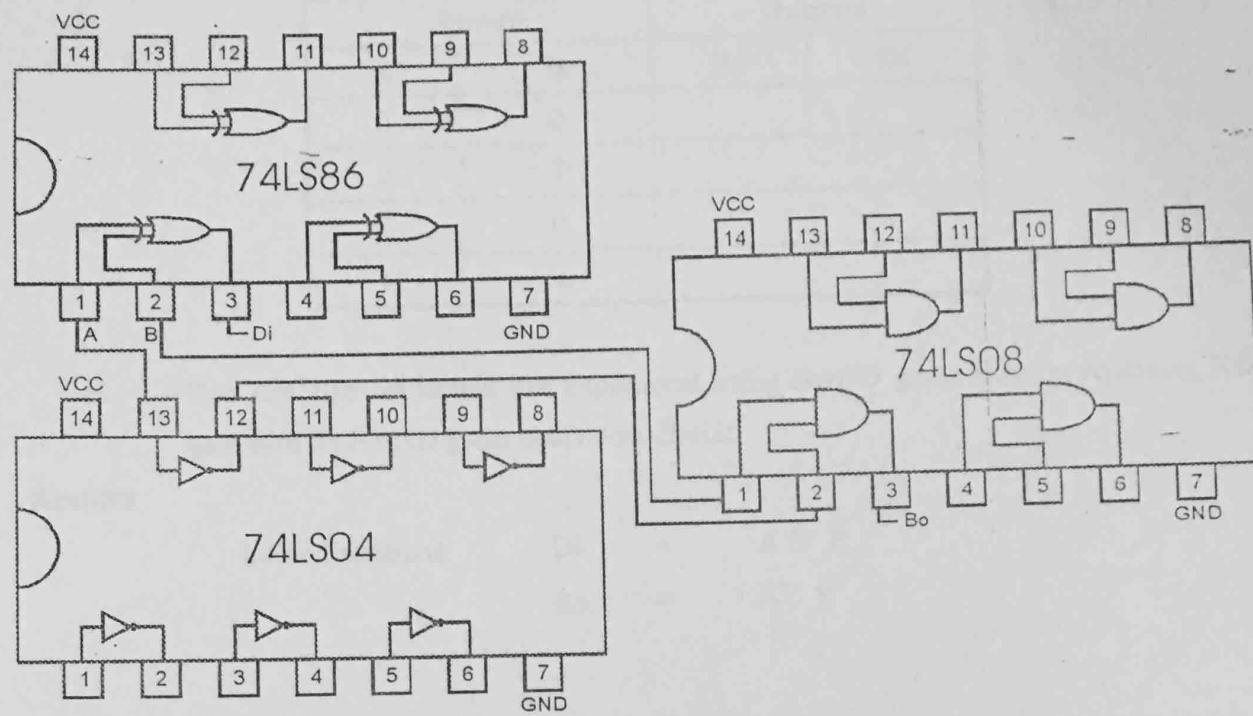


Figure 11.2

### Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the ICs 74LS08, 74LS86 and 74LS04 on the trainer's breadboard.
4. Wire the circuit according to the diagram shown in figure 11.2.
5. Use any of the two logic switches S2 to S9 for inputs A and B.
6. For output difference, use LED L0 and for output borrow, use LED L1.
7. Supply the VCC= +5V and GND to the pins 14 and 7 of both the ICs.
8. Test all the possible combinations of inputs and verify the output according to the truth table of half subtractor.
9. Fill the truth table given below according to the results.

Inputs		Outputs	
A	B	Bo	Di
0	0		
0	1		
1	0		
1	1		

10. You can also implement this experiment using NAND gates only by replacing XOR gate with its NAND gates equivalent-circuit.

## Results

Logic Functions:

$$\begin{aligned} Di &= A \oplus B \\ Bo &= \overline{A} \cdot B \end{aligned}$$

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the ICs.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the ICs using their data sheets.

# Experiment 12:- Full Subtractor Operation

## Objective

To design full subtractor circuit using XOR, AND, NOT & OR gates.

## Equipment

### Components

1. 74LS86 x 1
2. 74LS08 x 1
3. 74LS04 x 1
4. 74LS32 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Symbolic Diagram

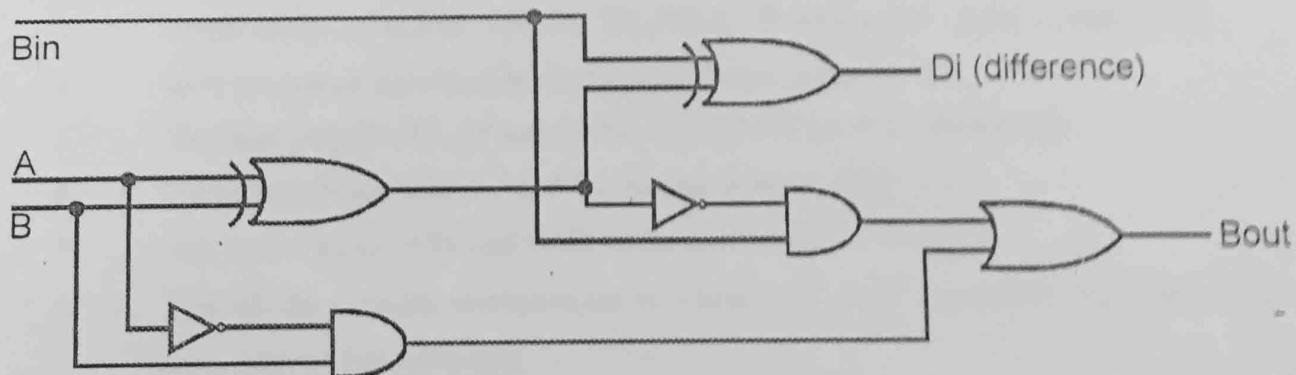


Figure 12.1

## Circuit Diagram

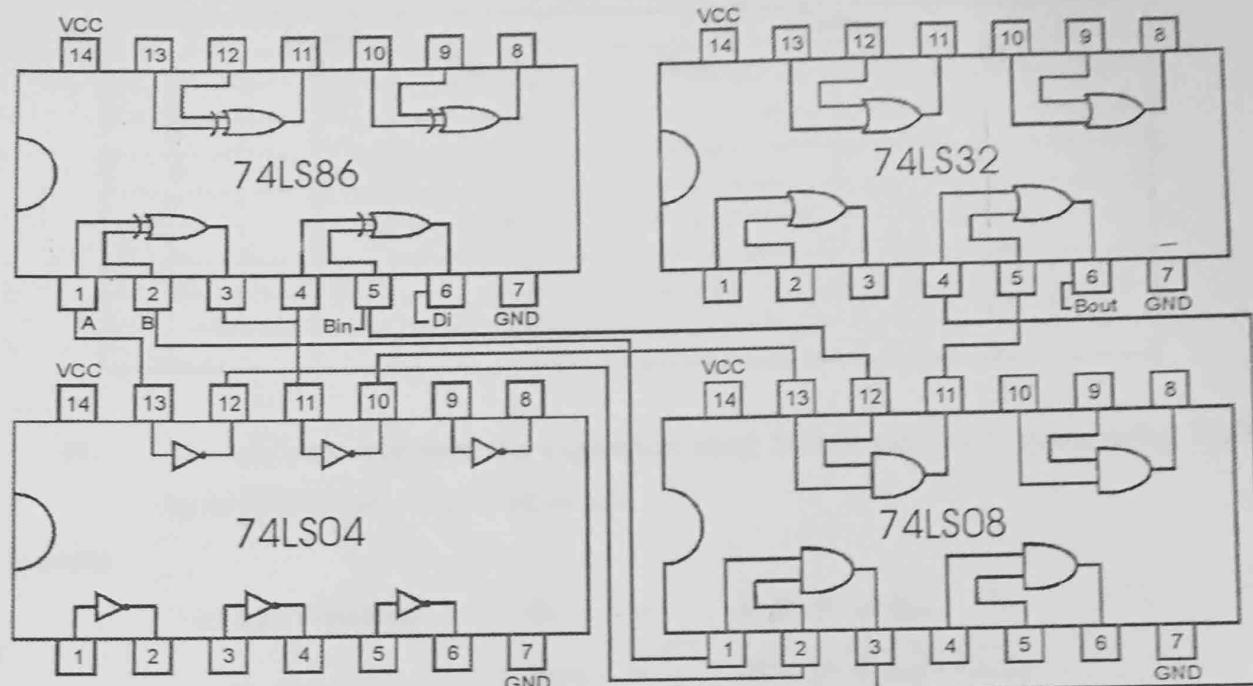


Figure 12.2

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC's 74LS86, 74LS32, 74LS08 & 74LS04 on the trainer's breadboard.
4. Wire the circuit according to the diagram shown in figure 12.2.
5. Use logic switches S2, S3 and S4 for inputs A, B, and Bin respectively.
6. For output Di use LED L0 and for Output Bout use LED L1.
7. Supply the VCC= +5V and GND to the pins 14 and 7 of the ICs.
8. Test all the possible combinations of inputs and verify the output according to the truth table of full subtractor.
9. Fill the truth table given below according to the results.

Table 1. Truth Table For Full Subtractor

Inputs			Outputs	
A	B	Bin	Bout	Di
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

10. You can also implement this experiment using NAND gates only by replacing XOR by its NAND gates equivalent circuit.

## Results

Logic Functions:

$$\begin{aligned} Di &= A \oplus B \oplus \overline{\text{Bin}} \\ \text{Bout} &= (\text{Bin} \cdot (\overline{A \oplus B})) + (\overline{A} \cdot B) \end{aligned}$$

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the ICs.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the ICs using their data sheets.

# Experiment 13:- 7-Segment Display operation

## Objective

To check the operation of common anode 7-segment display.

## Equipment

### Components

1. 7-segment display (common anode) x 1.
2. 180 ohms resistances x 8.

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

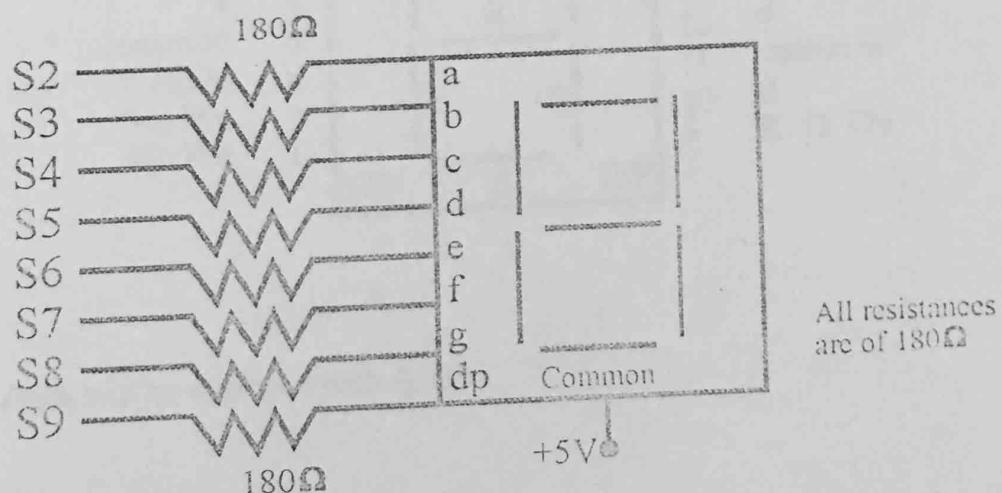


Figure 13.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter.  
It should be +5V exactly.
3. Install the 7-segment display on trainer's breadboard.
4. Wire the circuit according to the diagram shown above by consulting data sheet of Common Anode display in fig. 13.2.

5. Use logic switches S2 through S9 for inputs a through g and dp respectively.
6. Connect the common pin of 7-segment display to +5V.
7. Test all the possible combinations of inputs as shown in table-1 and see the results.
8. Fill the truth table given below according to the results.

Table 1. Truth Table For 7-Segment Display

S2 a	S3 b	S4 c	S5 d	S6 e	S7 f	S8 g	S9 dp	Digit Displayed
0	0	0	0	0	0	1	0	
1	0	0	1	1	1	1	0	
0	0	1	0	0	1	0	0	
0	0	0	0	1	1	0	0	
1	0	0	1	1	0	0	0	
0	1	0	0	1	0	0	0	
1	1	0	0	0	0	0	0	
0	0	0	1	1	1	1	0	
0	0	0	0	0	0	0	0	
0	0	0	1	1	0	0	0	

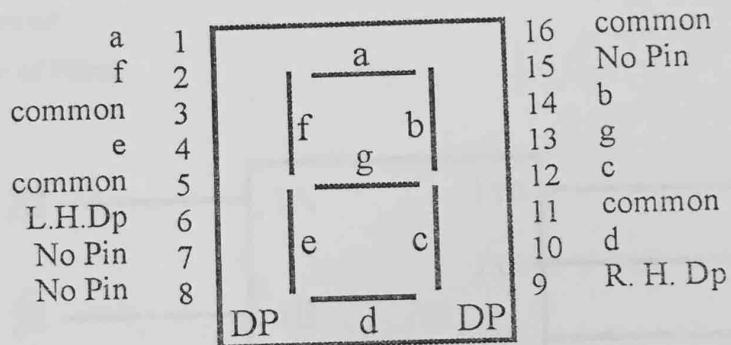


Figure 13.2

## Results

0-9 digits will be displayed with dp ON.

## In Case of Trouble

1. Check the power supply.
2. Check +5V to common pin of 7-segment display.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the individual segments of 7-segment display by consulting its data sheet.

# Experiment 14:- Decoder Operation

## Objective

To check the operation of 2 to 4 line decoder, using the IC 74LS139.

## Equipment

### Component

1. 74LS139 x 1

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

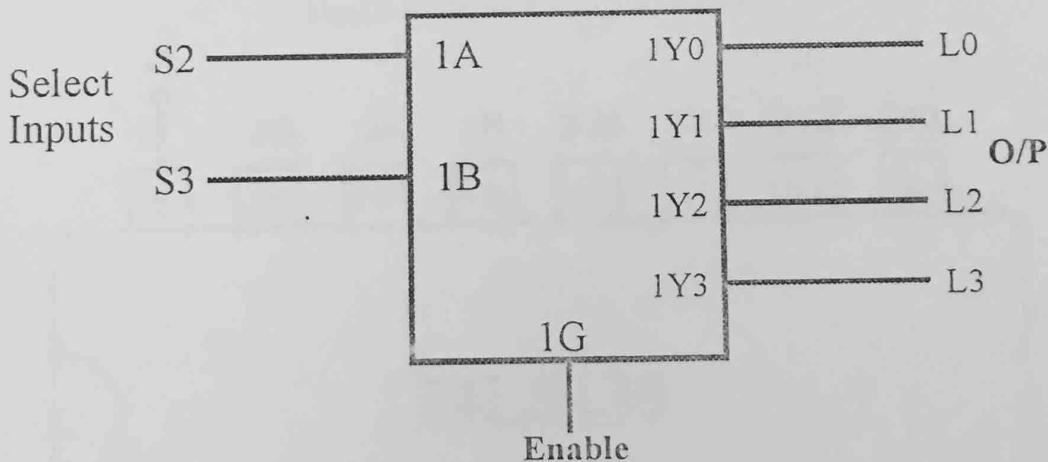


Figure 14.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the Multimeter. It should be +5V exactly.
3. Install the IC 74LS139 on trainer's breadboard.
4. IC 74LS139 is a dual 2 to 4 line decoders / demultiplexers. Wire one of such decoder according to the diagram in fig. 14.1 by consulting data sheet of the IC.

5. Use logic switches S2 & S3 for decoder inputs 1A and 1B respectively.
6. Connect outputs 1Y0, 1Y1, 1Y2 and 1Y3 to LED's L0, L1, L2 and L3 respectively.
7. Supply the VCC= +5V and GND to the pins 16 and 8 of the IC.
8. Test all the possible combination of inputs and verify the output according to the truth table of 74LS139.
9. Fill in the table given below according to the results.

Table 1. Truth Table For 2 to 4 lines Decoder

Inputs			Outputs			
Enable	Select		1Y0	1Y1	1Y2	1Y3
1G	1B	1A				
1	x	X				
0	0	0				
0	0	1				
0	1	0				
0	1	1				

Dual 2 – Line to 4 – Line Decoders

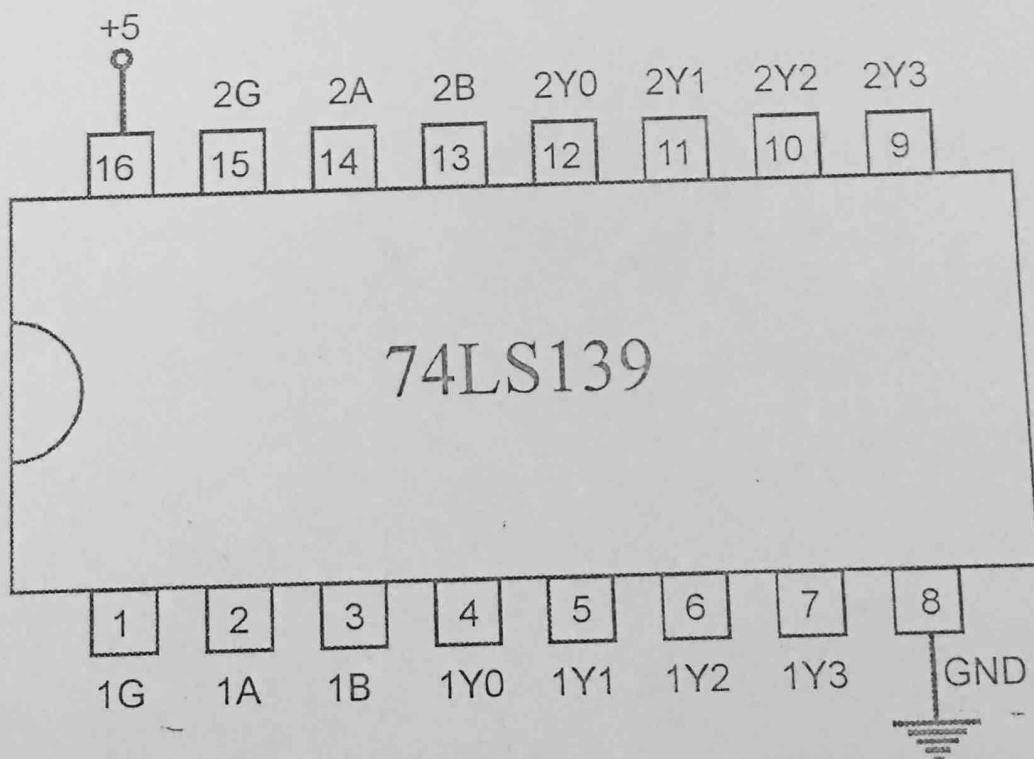
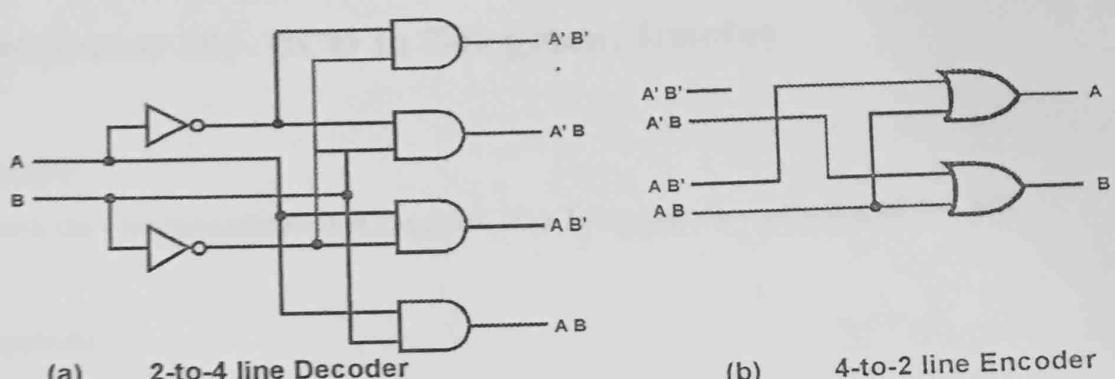


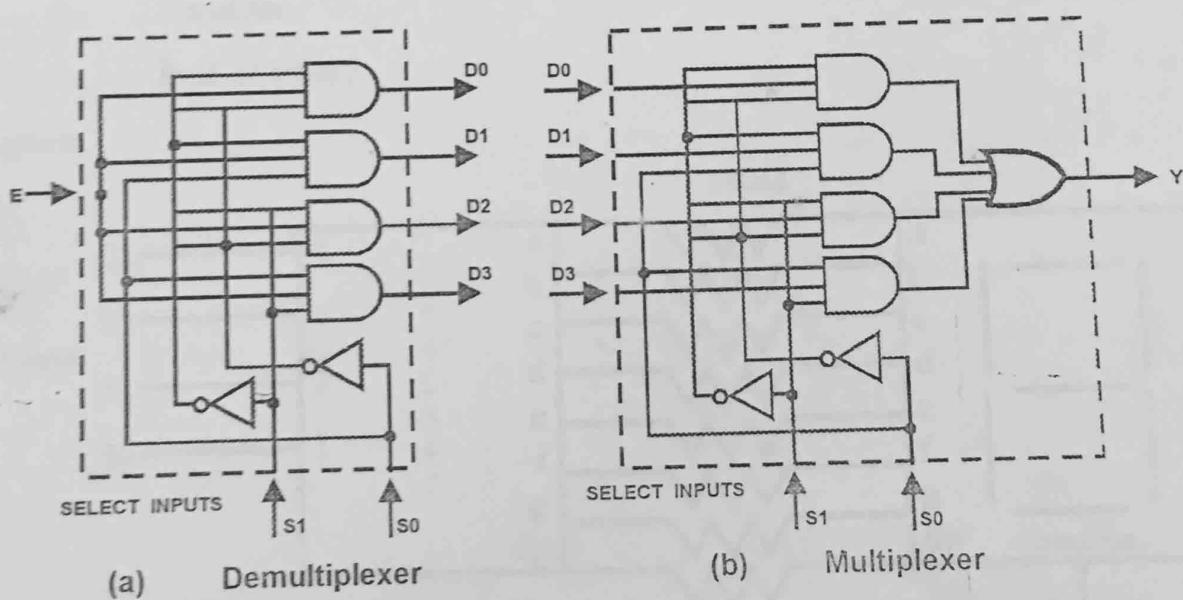
Figure 14.2

## **In Case of Trouble**

1. Check the power supply.
2. Check the VCC and GND at pins 16 and 8 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using its truth table.



Binary Encoder and Decoder Circuits



AND gate realization of Multiplexer and Demultiplexer

# Experiment 15:- BCD to 7-Segment Display

## Objective

To check the operation of common anode BCD to 7-Segment decoder using IC 74LS47.

## Equipment

### Components

1. 7-segment display (common anode) x 1.
2.  $180\Omega$  x 8.
3. IC 74LS47.

### Tools

1. AM-2000 Trainer
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

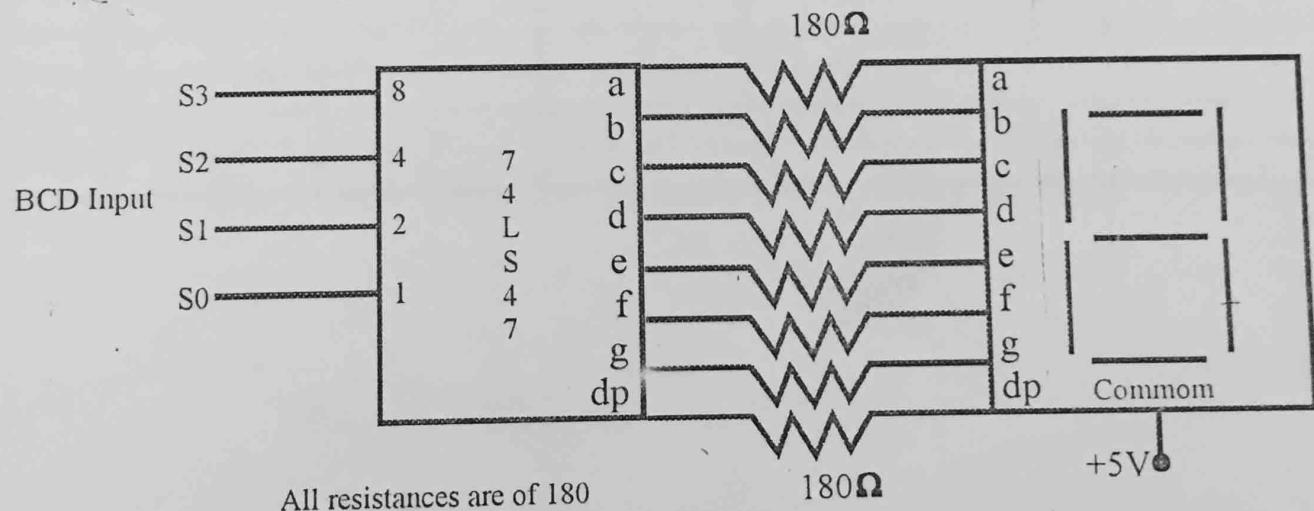


Figure 15.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the Multimeter. It should be +5V exactly.
3. Install the 7-segment display and IC 74LS47 on trainer's breadboard.
4. Wire the circuit according to the diagram shown above.
5. Use logic switches S2 through S5 for BCD inputs (1,2,4 and 8) to decoder.
6. Supply the VCC = +5V and GND to the pins 16 and 8 of the IC.
7. Connect the common pin of 7-segment display to +5V.
8. Enter BCD numbers from 0-9 using logic switches and see the result on to the display.
9. Fill the table given below according to the results.
10. The circuit in fig. 15.1 is also provided in AM-2000 Trainer. The BCD input is available on SBB-63 and as 8421.

Table 1. Truth table for BCD to 7-segment decoder

S5	S4	S3	S2	Display
B8	B4	B2	B1	Decimal digit
0	0	0	0	-
0	0	0	1	-
0	0	1	0	-
0	0	1	1	-
0	1	0	0	-
0	1	0	1	-
0	1	1	0	-
0	1	1	1	-
1	0	0	0	-
1	0	0	1	-

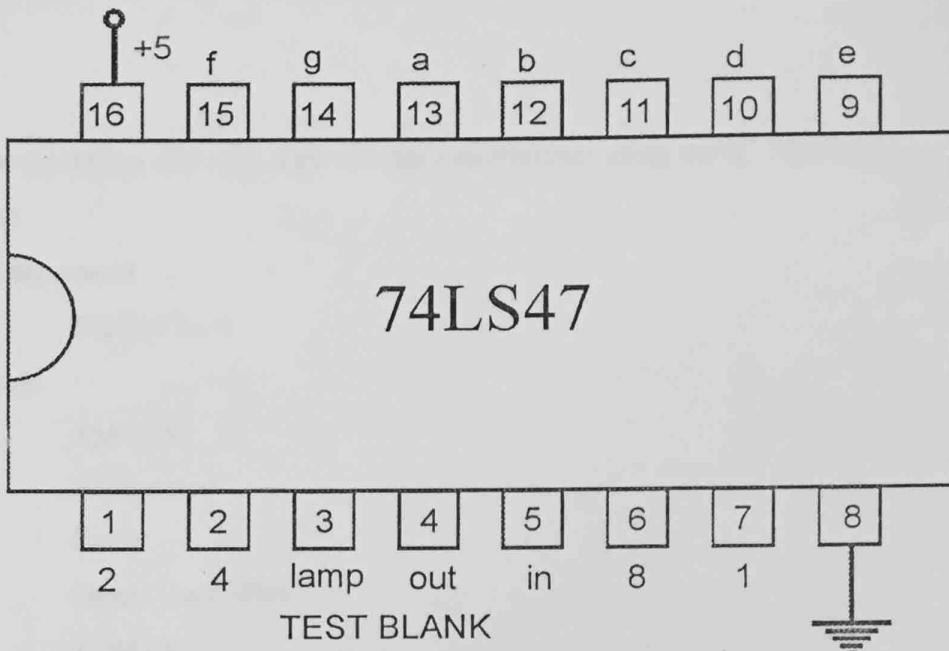


Figure 15.2

## Results

0-9 digits will be displayed in sequence.

## In Case of Trouble

1. Check the power supply.
2. Check +5V to common pin of 7-segment display.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the individual segments of 7-segment display by consulting its data sheet.

# Experience 16:- Multiplexer Operation

## Objective

To check the operation of 1 of 2 data selector / multiplexer using the IC 74LS157.

## Equipment

### Component

1. 74LS157 x 1

### Tools

1. AM-2000
2. Multimeter
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

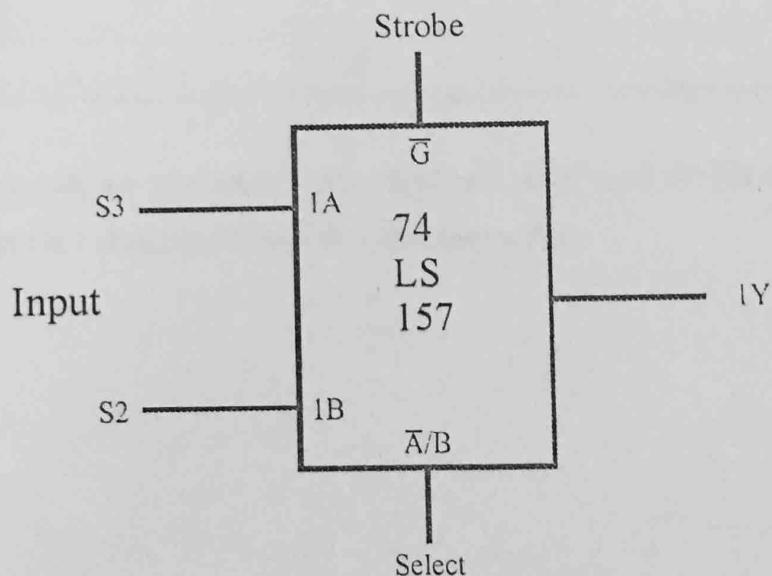


Figure 16.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the Multimeter. It should be +5V exactly.
3. Install the IC 74LS157 on trainer's breadboard.

4. IC 74LS157 is a quadruple 1 of 2 data selectors / multiplexers. Use one out of 4 such MUX and wire the circuit according to the diagram.
5. Use logic switch S3 for 1A and switch S2 for 1B respectively.
6. Connect output 1Y to LED L0.
7. Supply the VCC = +5V and GND to the pins 16 and 8 of the IC.
8. Test all the possible combinations of inputs and verify the output according to the truth table of 74LS157.
9. Fill in the table given below according to the results.

Table 1. Truth table for 1 of 2 data multiplexer.

Inputs			Output	
Strobe $\bar{G}$	Select $\bar{A} / B$	Date		1Y
		1A	1B	
1	X	X	X	
0	0	0	X	
0	0	1	X	
0	1	X	0	
0	1	X	1	

10. You will see that when select input is 0, then input A will be selected if select input is 1 then input B will be selected as output.

## Diagram

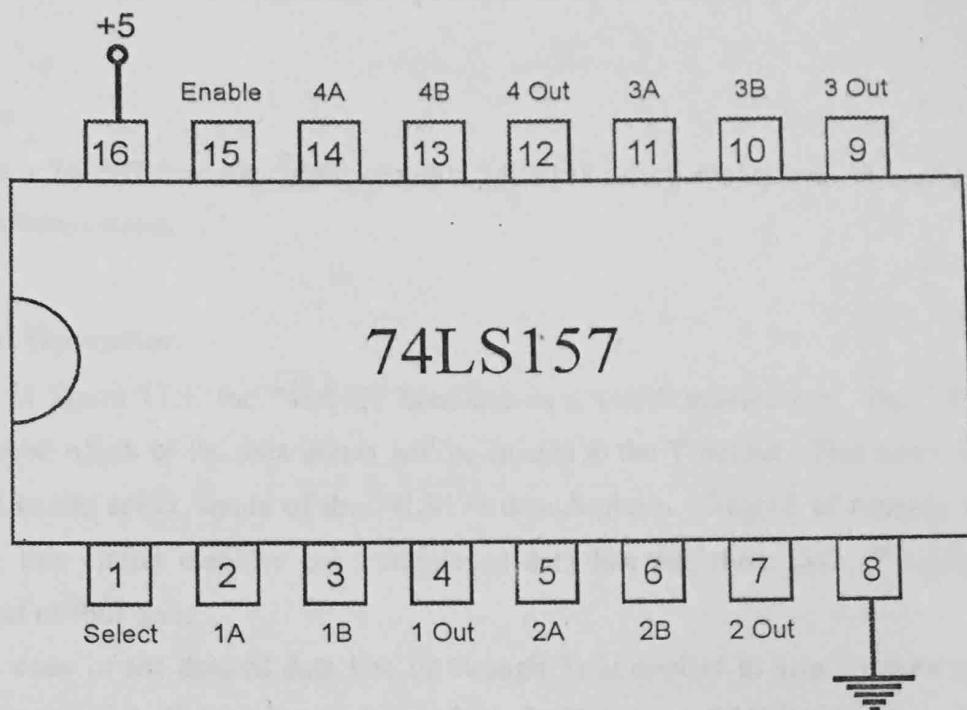


Figure 16.2

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 16 and 8 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using its truth table.

# **Experiment 17. Using Multiplexer and Demultiplexer / Decoder**

## **Objective**

To employ a 74LS151 as a multiplexer and a 74LS138 as a demultiplexer in a single-line digital communications circuit.

## **Theory of Operation**

As shown in figure 17.1, the 74LS151 functions as a 1-of-8 multiplexer. The 3-bit select code will command which of the data inputs will be steered to the Y output. This same 3-bit code will be applied to the select inputs of the 74LS138 demultiplexer. Instead of running eight separate data lines, this circuit employs one multiplexed data line and three lines of select code. This saves a total of four lines.

The select code of the desired data line (0 through 7) is applied to select inputs of both ICs as shown in figure 17-1. If the selected data is low, the Y output of 74LS151 will go low. This low is applied to the G2A enable input of 74LS138 which will enable the IC and the output that corresponds to the select code will go low and match the original data from 74LS151. If the selected data is high, the Y output of multiplexer will go high. When this high is applied to the active-low enable input of 74LS138, IC will become disabled. All outputs of demultiplexers will go high. The selected output will be high, matching the original data sent from 74LS151.

## **Equipment**

### **Components**

1. 74LS151 x 1
2. 74LS138 X 1

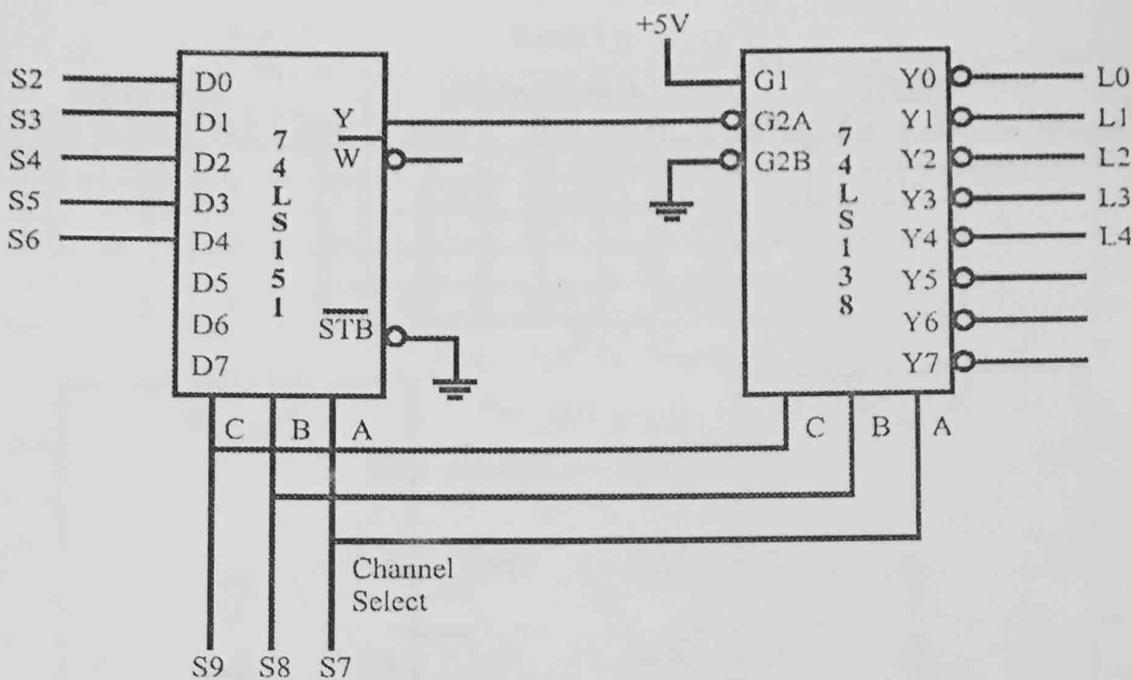


Figure 17.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of power supply using Multimeter, it should be +5V exactly.
3. Install the ICs 74LS151 and 74LS138 on trainer's bread board.
4. Wire the circuit according to the diagram in figure 17-1 by consulting data sheets in figure 17.2.
5. Maximum 8 switches are available on the trainer so for inputs D0 through D4 use logic switches S2 through S6 and for select lines A, B and C use switches S7, S8 and S9 respectively.
6. Connect outputs Y0 through Y4 of 74LS138 to LED's L0 through L4 respectively.
7. Supply the VCC=+5V and GND to the pins 16,8 of the ICs.
8. Apply the select code of the desired data line (0 through 4).
9. Observe the corresponding output match the original data.
10. Test all the select inputs (0 through 4) and verify the output matches the corresponding input.
11. Fill in the table-1 according to the results

Table I

Input data					Channel Select			Output Data				
D0	D1	D2	D3	D4	C	B	A	Y0	Y1	Y2	Y3	Y4
1	0	0	0	0	0	0	0					
0	1	0	0	0	0	0	0					
0	0	1	0	0	0	0	1					
0	0	0	1	0	0	1	0					
0	0	0	0	1	1	0	0					

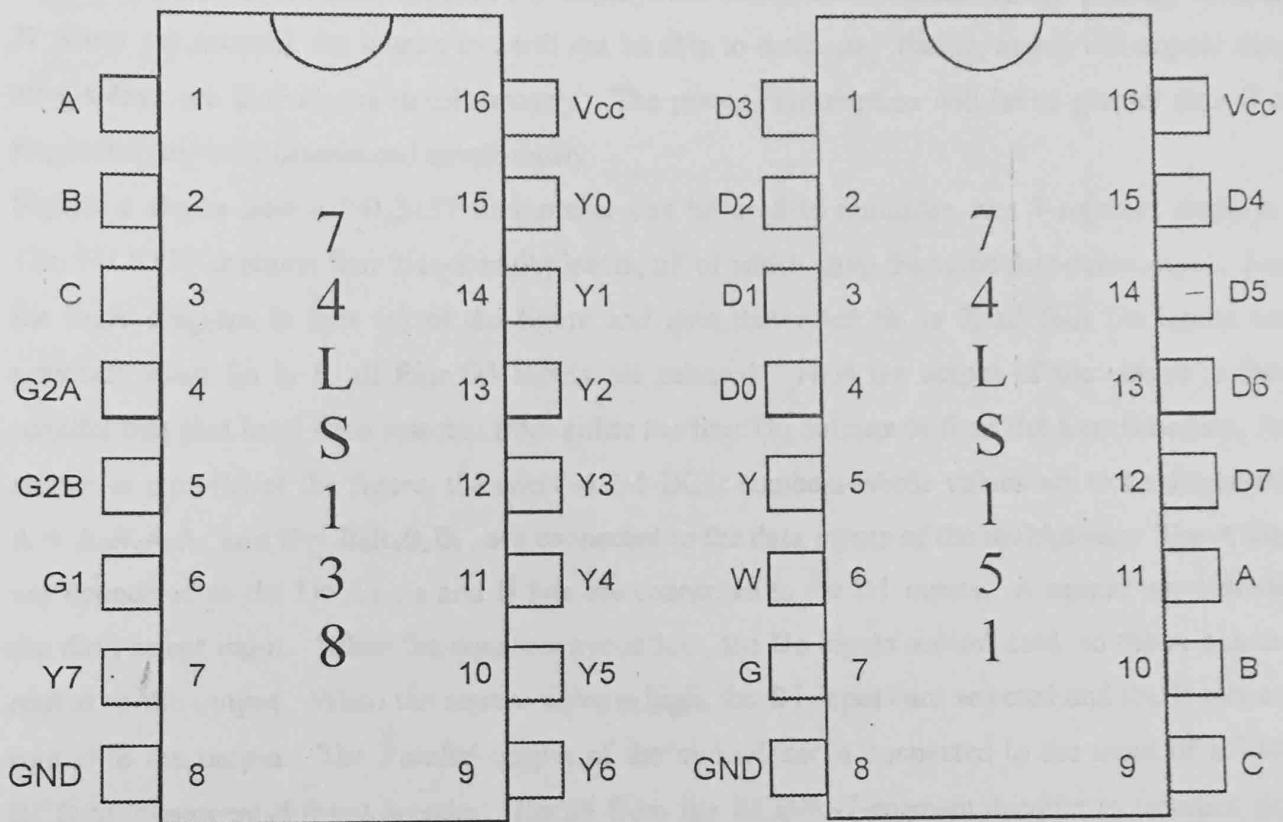


Figure 17.2

# Project 1: - Multiplexing 7-Segment Displays

## Theory of Operation

Optical output displays, such as 7-segment displays, typically consume considerable power. In applications where power consumption is a major concern, such as pocket calculators, and where several displays must be illuminated simultaneously, multiplexers are used to reduce power consumption. Instead of illuminating all displays simultaneously, a multiplexer selects each display in turn. If the rate at which the displays are illuminated is great enough (usually around 30 times per second), the human eye will not be able to detect any flicker, and it will appear that all displays are illuminated simultaneously. The power consumption will be no greater than if a single display were illuminated continuously.

Figure 1a shows how a 74LS157 multiplexer can be used to multiplex two 7-segment displays. The 74LS157 contains four 1-to-2 multiplexers, all of which have the same data-select input. See the logic diagram in part (a) of the figure and note that when  $S_0$  is 0, all four  $D_0$  inputs are selected; when  $S_0$  is 1, all four  $D_1$  inputs are selected. Thus the output of the circuit is four parallel bits that have been selected from either the four  $D_0$  outputs or from the four  $D_1$  inputs. As shown in part (b) of the figure, the two 8-4-2-1 BCD numbers whose values are to be displayed,  $A = A_8A_4A_2A_1$  and  $B = B_8B_4B_2B_1$ , are connected to the data inputs of the multiplexer. The  $A$  bits are connected to the  $D_0$  inputs and  $B$  bits are connected to the  $D_1$  inputs. A square wave drives the data-select input. When the square wave is low, the  $D_0$  inputs are selected, so the  $A$  bits are routed to the output. When the square wave is high, the  $D_1$  inputs are selected and the  $B$  bits are routed to the output. The Parallel output of the multiplexer is connected to the input of a 7449 BCD-to-7-segment-display decoder. Recall from the BCD-to-7-segment decoder experiment that this device provides the seven outputs needed to drive the segment that must be illuminated when its BCD input corresponds to any of the decimal digits from 0 through 9. We see that the multiplexer alternately supplies the decoder with  $A_8A_4A_2A_1$  and  $B_8B_4B_2B_1$  at the frequency of the square wave, so the decoder alternately activates the segments for the decimal digits corresponding to  $A_8A_4A_2A_1$  and  $B_8B_4B_2B_1$ . The output of the 7-segment decoder is connected in parallel to two common-cathode 7-segment displays. However, we want only one display,  $A$  or  $B$ , depending on which BCD input has been selected to be illuminated. The common-cathode 7-segment is activated when its common line is made low. The 74LS139 2-to-4 decoder is used to select the 7-segment display that is to be activated. Since input 1 of the decoder is connected to logical 0 and square wave is connected to input 0, active-low decoder output  $D_0$  is low when the square wave is low (input = 00) and output  $D_1$  is low when the square wave is high (input = 01). These active-low outputs enable the 7-segment displays in proper sequence.

## Diagram

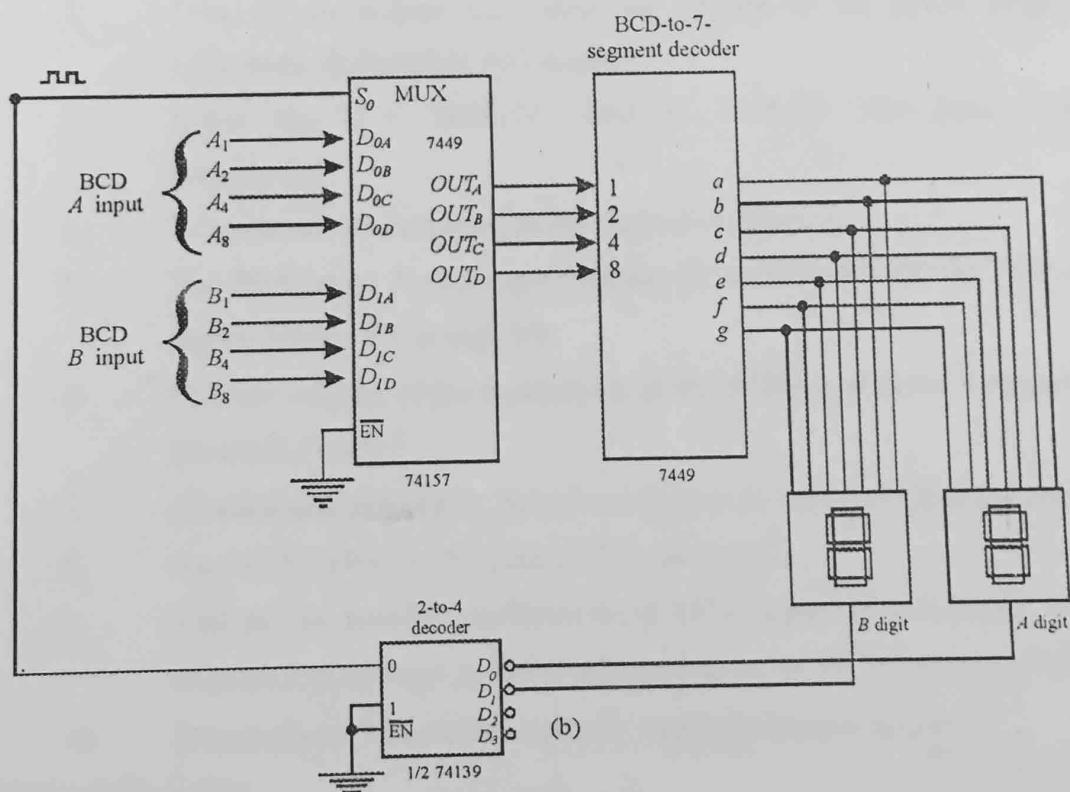
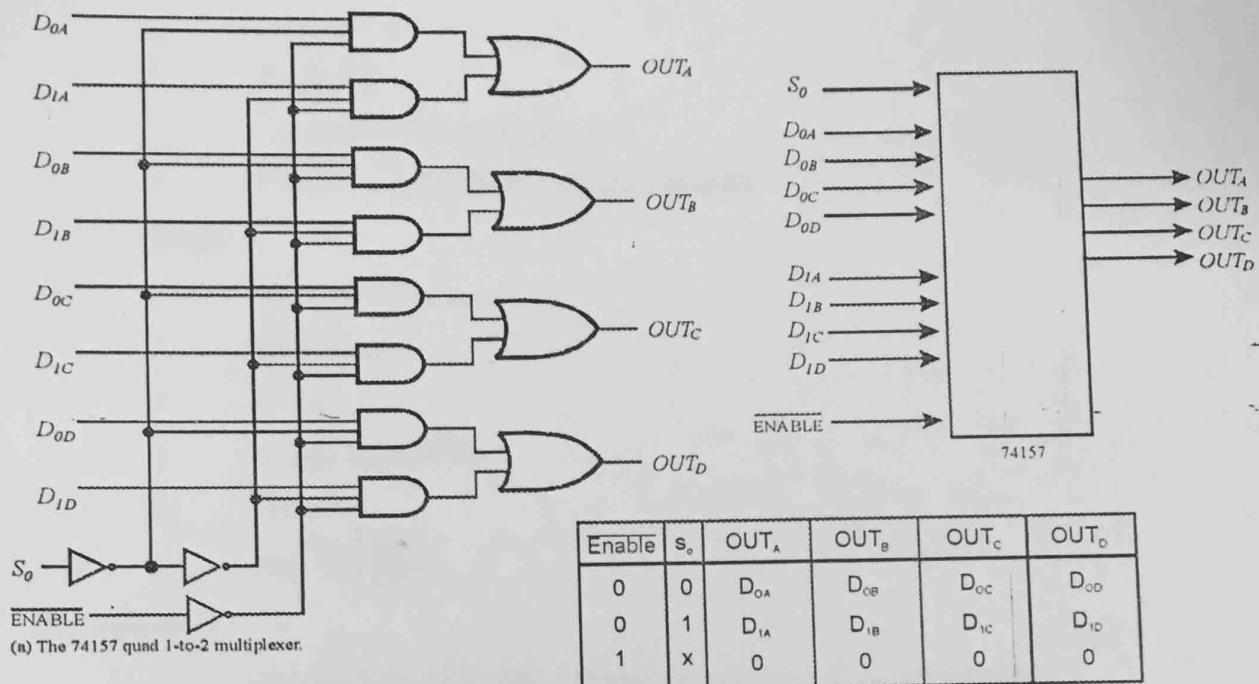


Figure 1

Multiplexing seven-segment displays.

## **Components**

1. 74LS 157 x 1
2. 74LS139 x 1
3. Common-Cathode Display x 2
4. 74LS49 x 1; BCD-to-7-segment decoder

## **Tools**

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## **Procedure**

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC's 74LS157, 74LS49, 74LS139 and displays on trainer's breadboard.
4. Wire the circuit according to the diagram in Figure 1.
5. For BCD input A, use logic switches S2 through S5 and for BCD input B, use logic switches S6 through S9.
6. Connect outputs of the multiplexer to the BCD input of the 7-segment decoder as shown in Figure 1.
7. Connect data select line (So) of multiplexer to the timer/clock output (CLK).
8. Supply the VCC = +5V and GND to all the ICs.
9. Test all the possible combination of BCD inputs A and B and verify the digits displayed at displays A & B are according to the BCD inputs A and B.
10. Observe how 7-Segment display is enabled in proper sequence.

## **In Case of Trouble**

1. Check the power supply.
2. Check the VCC and GND at pins 16 and 8 of the ICs.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.

# Experiment 18: - Comparator Operation

## Objective

To check the operation of 4-bit Magnitude Comparator using the IC 74LS85.

## Comparators

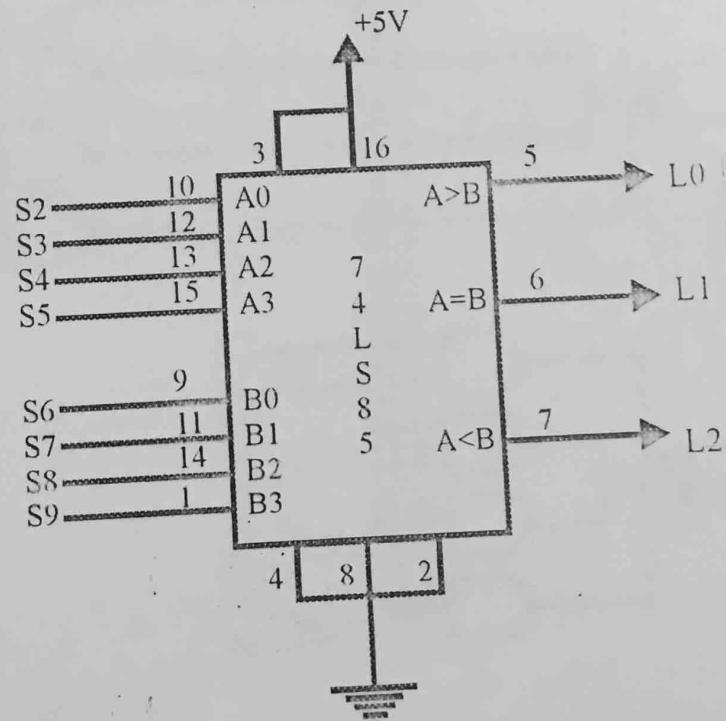
A comparator is a logic circuit used to compare the magnitude of two binary numbers. It may simply provide an output that is active (goes High) when the two numbers are equal, or it may additionally provide outputs that signify which of the number is larger when equality does not hold. 74LS85 is a 4-bit magnitude comparator. Figure 18.1 shows this IC, which accepts two four-bit words at its inputs and produces one of three outputs,  $A > B$ ,  $A = B$ , and  $A < B$ . Depending upon the status of the four-bit words at the inputs, the appropriate one of these outputs will be high and the other two will be low.  $A_0A_1A_2A_3$  and  $B_0B_1B_2B_3$  are two 4-bit numbers. Note from the Figure 18.2a that pins 4,5 and 6 are designated  $(A > B)$ in,  $(A < B)$ in and  $(A = B)$ in are used for cascading.

## Equipment

### Component

1. 74LS85 x 1

## Diagram

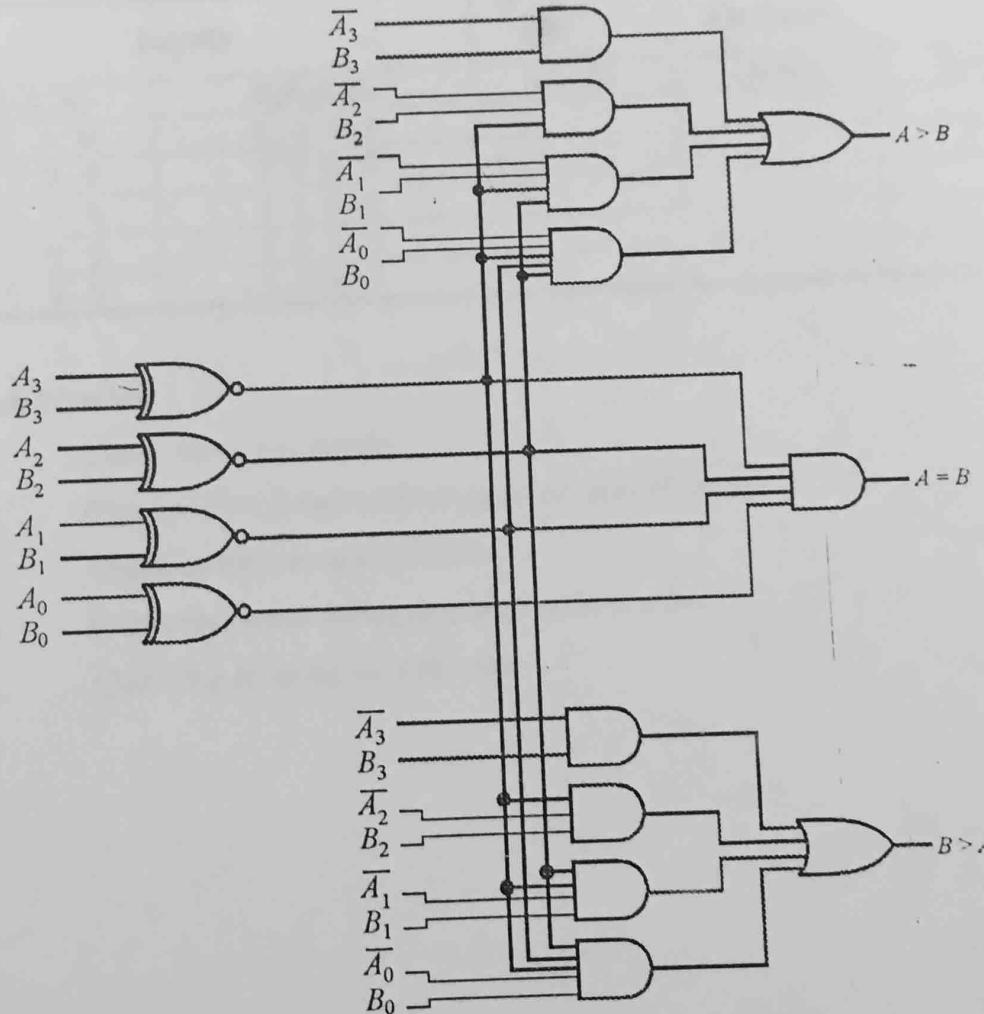


(Figure 18.1)

## Procedure

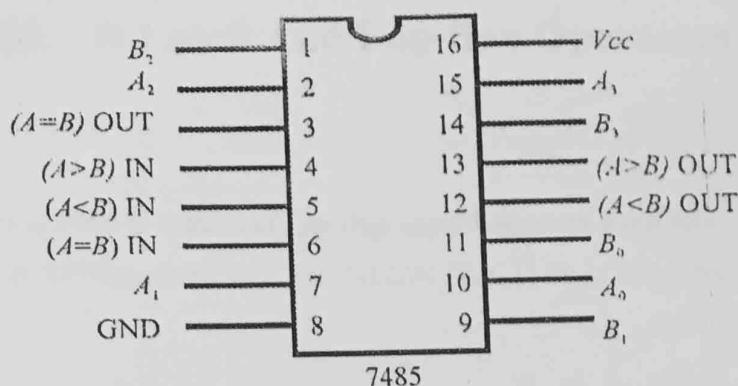
1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS85 on trainer's breadboard.
4. Wire the circuit by consulting the diagram in Figure 18.2.
5. Supply the VCC = +5V and GND to the pins 16 and 8 of the IC
6. For binary input A ( $A_3A_2A_1A_0$ ) use logic switches S5S4S3S2 and for B ( $B_3B_2B_1B_0$ ) use switches S9S8S7S6 respectively.
7. Use LED's L0, L1 and L2 for outputs ( $A < B$ )out ( $A = B$ )out and ( $A > B$ ) respectively.
8. For different settings of A and B, observe the outputs.
9. Fill in the table 1 according to the results.

## Diagram



(Figure 1)

A 4-bit magnitude comparator used to determine which of inputs  $A=A_3A_2A_1A_0$  and  $B=B_3B_2B_1B_0$  is larger or if they are equal



(a) Pin diagram

Figure 18.2.  
The 7485 4-bit comparator.

Table 1. 4-bit magnitude Comparator

Inputs		Outputs		
$A_3 A_2 A_1 A_0$	$B_3 B_2 B_1 B_0$	$(A < B)$	$(A = B)$	$(A > B)$
0 0 1 0	0 0 0 0			
0 1 0 0	1 0 0 0			
1 1 0 0	1 1 0 0			
1 1 0 0	0 0 1 1			
1 0 0 0	1 0 0 1			

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 16 and 8 of the IC.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using its truth table.

# Experiment 19: - D Latch And Flip flop Operation

## **Objective**

The experiment is to use the D latch and flip flop according to its truth table and to learn how it works by using IC 74LS75 Quad D Latch and 74LS74 Dual D Edge Triggered Flip-Flops.

## **Equipment**

### **Components**

1. 74LS75 x 1
2. 74LS74 x 1

### **Tools**

1. AM-2000
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## **Diagram**

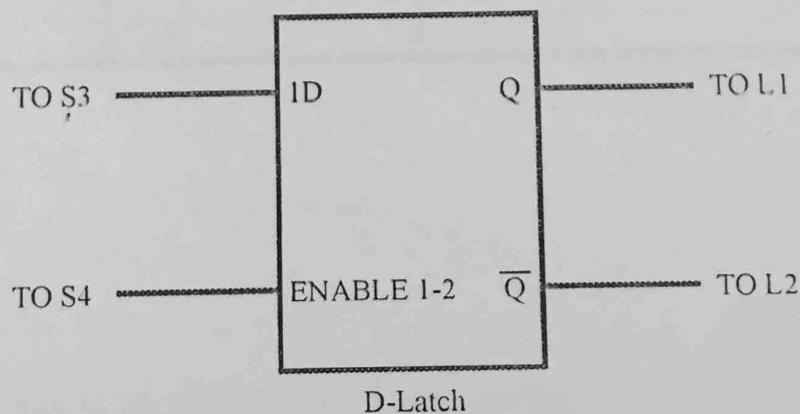


Figure 19.1

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS75 on trainer's breadboard.
4. Wire the circuit according to the diagram in Figure 19.1 by consulting IC's data sheet in Figure 19.2
5. Supply the VCC=+5 and GND to the pins 5 and 12 of the IC.
6. Connect Enable 1-2 to switch S4.
7. Change the setting of switch S3 and make switch S4 (Enable) High.
8. Observe the output is latched. That is, the output retains the data that was present at the input when the enable is made High.
9. Also observe that when Enable is high output is continually updated. The output follows any change in input when Enable is High. Thus this latch has an enable that requires a High level.
10. Fill the truth table given below according to the results.

Table 1.      Truth Table For D Latch

Enable	Input	Output
E1-2	D	Q
0	1	
0	0	
1	1	
1	0	

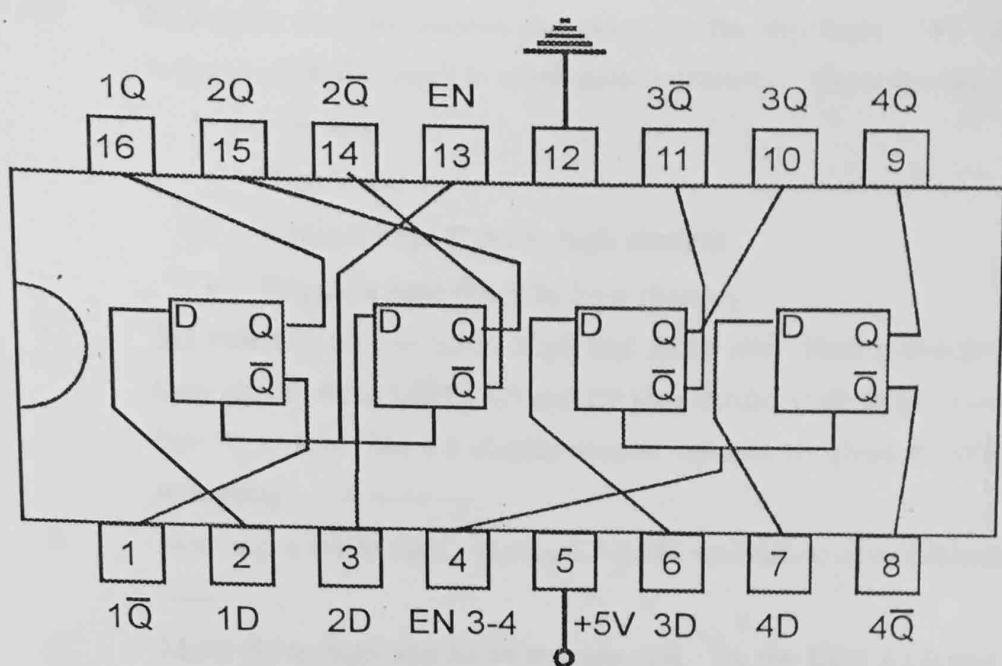


Figure 19.2

**74LS75 Quad D Latch**

### Diagram

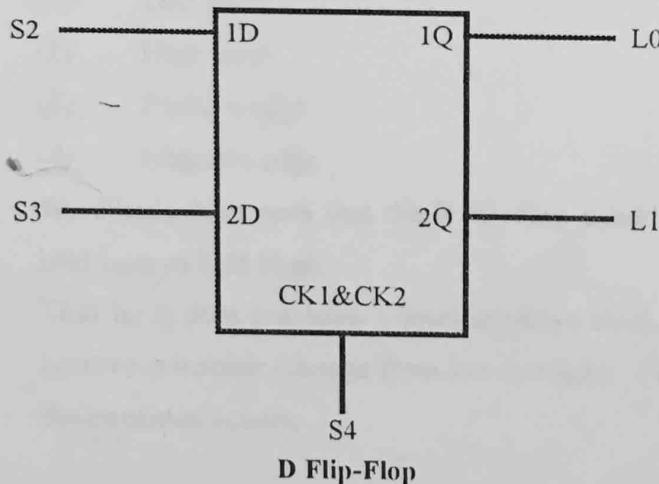
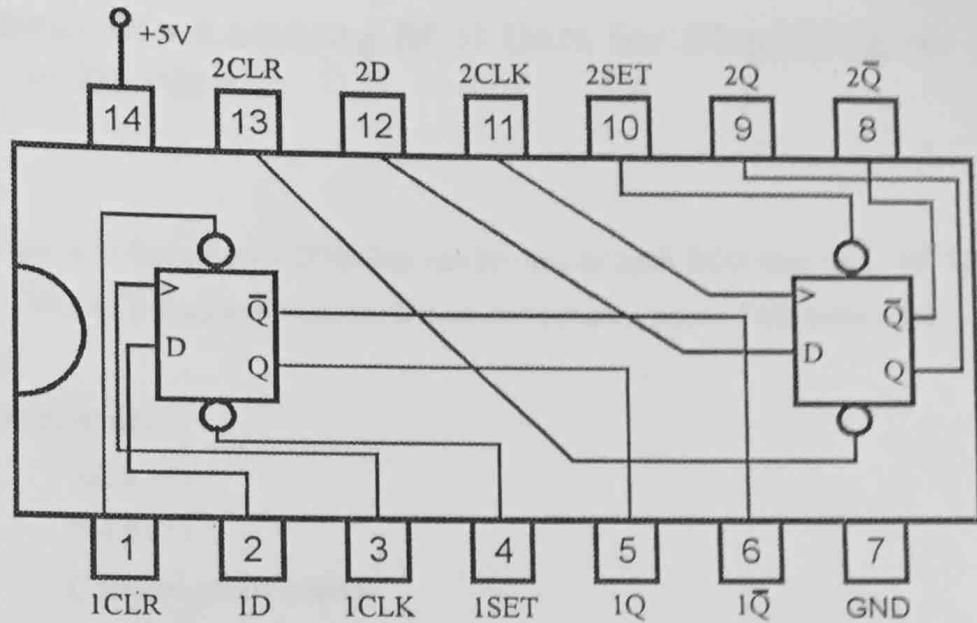


Figure 19.3

### Procedure

1. Install the IC 74LS74 on the trainer's breadboard.
2. Connect switches S2 and S3 to inputs 1D and 2D respectively.
3. Connect LED's L0 and L1 to outputs 1Q and 2Q respectively.
4. Connect S4 to CK1 and CK2 pins of the IC.

5. Recognize that S4 controls the clock for the flip-flops. We will determine what is required on the clock to allow data to transfer. There are four possibilities:
- Low level
  - High level
  - Positive Edge (Low to high change)
  - Negative edge (High to Low change)
6. Set switches S2 and S3 to High and S4 to low. Now move S4 to High and back Low again. Both LED's L0 and L1 should read 1: do they? -----
7. Set S2 to low. The L0 display should indicate 1. Does it? What is the L1 LED indicating? -----
8. Now move S4 to high. Do the L0 LED updated to new information? -----  
-----
9. Move S2 to high and S3 to low position. Do the LED's L0 and L1 update to the new data? -----
10. Move S4 to low. Any change in the LED's? -----
11. Now move S4 to high. Any change now? -----
12. Therefore, what is required to the output? -----  
(1) Low level  
(2) High level  
(3) Positive edge  
(4) Negative edge
13. We should have seen that the D flip-flop would not transfer data if the clock is held Low or held High.
14. That is, it does not have a level sensitive clock. The clock responds only to a positive transition (change from low to High). The output follows the input when the transition occurs.



74LS74 Dual D Edge Triggered Flip-Flops

Figure 19.4

### In Case of Trouble:

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections
4. Check the circuit wiring and remove the breaks.
5. Check the IC using its truth table.

# Experiment 20:- Latching BCD Data for Displaying on 7-Segment Display

## Objective

The experiment is to learn how a D latches can be used to latch BCD data using IC 74LS75 Quad D Latch, IC 74LS47 7-Segment Decoder/Driver and common anode 7-segment display.

## Equipment

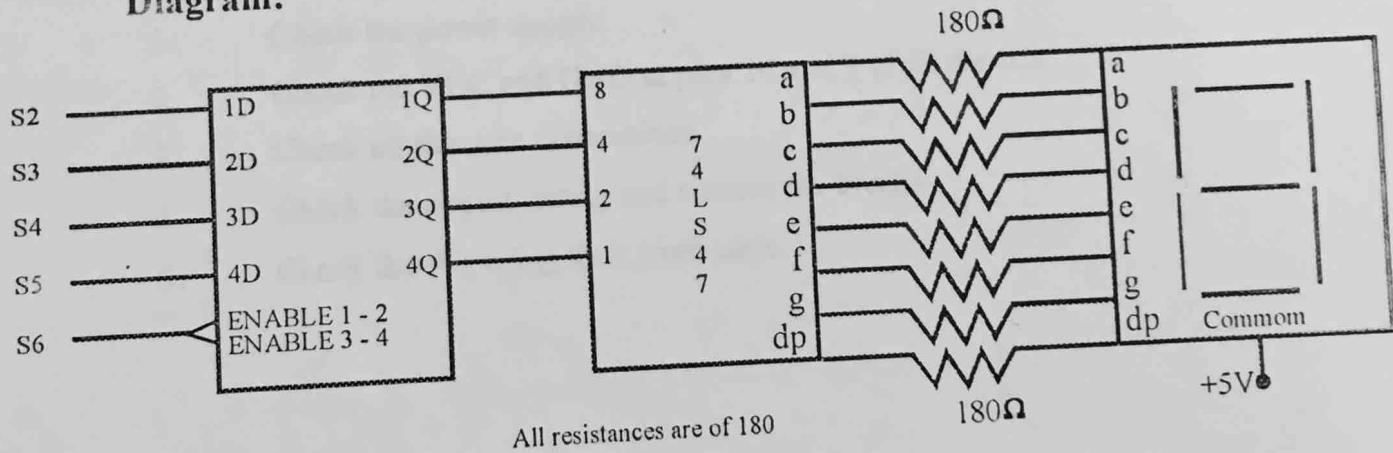
### Components

1. 74LS75 x 1
2. 74LS47 x 1
3. Common anode display

### Tools

1. AM-2000 Trainer
2. Multimeter
3. Cutter
4. Single Core Wire
5. Tweezer
6. Pair of Pliers

### Diagram:



(Figure: 20.1)

## **Procedure**

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS75 on trainer's breadboard.
4. Supply the VCC = +5v and GND to the pins 5 to 12 of the IC.
5. Wire the circuit according to the diagram using IC's data sheet.
6. Use logic switches S2 through S5 for inputs 1D through 4D.
7. Connect the enable signals coming out of each flip-flop (Enable 1-2 and Enable 3-4) to S6. Connect the outputs 1Q through 4Q 74 LS 54 to BCD input 8421 of 7447 respected available on SBB-63.
8. Input different BCD words using switches S2 through S5 and than set S6 to High.
9. Observe that the output is latched and corresponding digit is displayed on 7-segment display. That is, the output retains the data that was present when the enable is high.
10. Also observe that when enable is High, the output follows any change in input.

## **In Case of Trouble:**

1. Check the power supply
2. Check the VCC and GND at pins 14 and 7 of all the ICs
3. Check all the wire connections
4. Check the circuit wiring and remove the breaks
5. Check the ICs using their truth table

# Experiment 21: - Recirculating Data

## Objective

This experiment is to examine the concept of shifting data around in a circular shift register. By presetting the flip-flop, any desired output pattern can be generated.

## Equipment

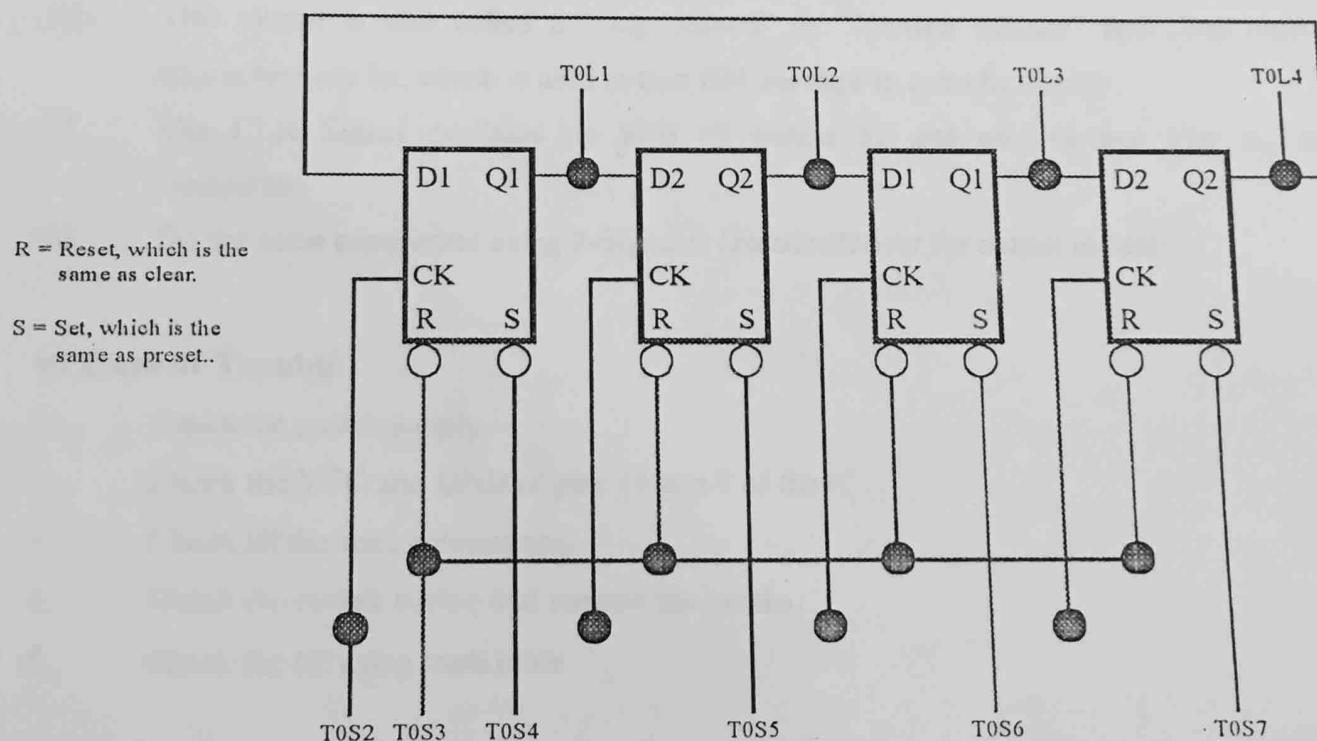
### Components

1. 74LS74 x 2

### Tools

1. AM-2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers

## Diagram



(Figure 21.1)

## **Procedure**

1. Install the Two 74LS74 ICs on the trainer's breadboard.
2. Wire the circuit according to the diagram in figure in 21.1.
3. Set S2 to Low. Set S4, S5, S6 and S7 to High.
4. Set S3 to Low and than back to high. This resets all flip-flops. All four LED's should be OFF.
5. Move S4 to Low and then back High. This has set (preset) the first flip-flop; its Q output should be High and L1 should be lit.
6. Now cycle the data through the ring of flip-flops by supplying a clock signal. Move S2 to High and then back Low again. Note that the High has moved to L2.
7. Again cycle S2 High and then Low. The data again should have shifted one position.
8. Continue to cycle S2, observing that four clock are needed to get the data completely around the loop.
9. Set S2 Low. Set S3 to Low and then High.
10. Set S6 and S7 both Low and then High again. Observe that L3 and L4 are lit.
11. Cycle S2. Observe that the data recirculates.
12. This circuit is also called a "ring counter" or "Johnson counter" and often used to recirculate one bit, which is used to turn ON one digit in a strobe display.
13. Use CLK Signal available on SBB 63 instate S2 and observe that how the data recirculate.
14. Do the same experiment using 7-Segment Decoder/Driver for output indication.

## **In Case of Trouble**

1. Check the power supply.
2. Check the VCC and GND at pins 14 and 7 of the IC.
3. Check all the wire connections
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table

# Experiment 22: - J-K Flip Flop Operation

## Objective

The experiment is to use the J-K flip-flop according to its truth table and to learn how it works by using IC 74LS76 Dual J-K Flip-Flops.

## Equipment

### Component

1. 74LS76 x 1

### Tools

1. AM-2000.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Diagram

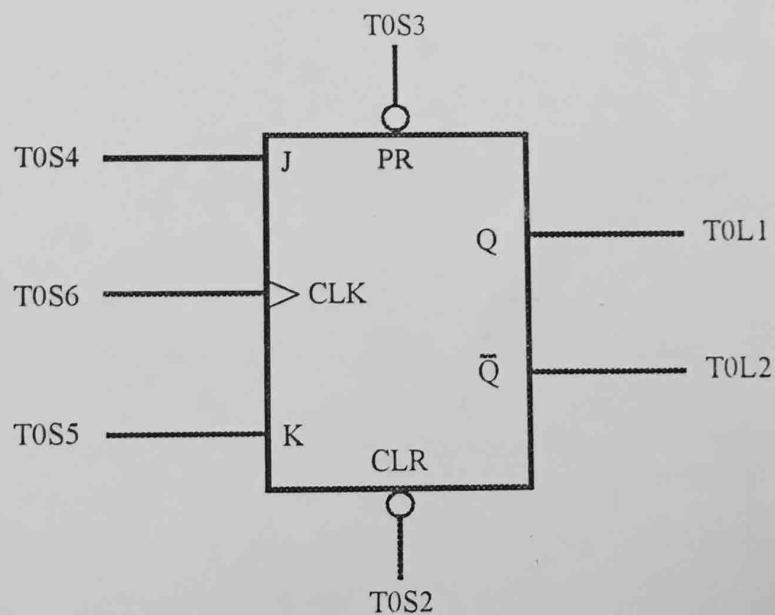


Figure 22.1.

## **Procedure**

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the multimeter. It should be +5V exactly.
3. Install the IC 74LS76 on trainer's breadboard.
4. Wire the circuit according to the diagram using IC's data sheet.
5. Supply the VCC = +5V and GND to the pins 14 and 7 of the IC.
6. Set the switches as shown in table – 1 and record the indications of L1 and L2.
7. Analyze your results to determine some conclusions about the JK.
8. When Clear and Preset is both High, does the output respond to the J, K and clock inputs? -----
9. When Clear is Low, does Q get held Low or High? -----
10. When preset is Low, does Q get held Low or High? -----
11. With Highs on Preset, Clear, J and K what happens to the output with each successive clock pulse?
12. Test all possible combinations of inputs, verify the output and fill the Table 2.

Table 1.

Inputs					Outputs	
S2 = CLR	S3 = PRE	S4 = J	S5 = K	S6 = CLK	L1 = Q	L2 = $\bar{Q}$
1	1	1	0	0-1-0	1	0
1	1	0	0		1	0
1	1	0	1		0	1
1	1	0	0			
1	1	1	0			
1	1	0	1			
1	1	1	0			
0	1	1	0			
0	1	0	0			
0	1	0	0			
0	1	0	0			
1	0	0	0			
1	0	1	0			
1	0	0	0			
1	0	0	1			
1	1	1	1			
1	1	1	1			
1	1	1	1	0-1-0		

CLR = Clear  
Which is the same as reset

1  
RESPOND  
TO J & K

2  
HELD IN  
CLEAR

3  
HELD IN  
PRESET

4  
TOGGLE

Table 2. Truth Table of JK Flip Flop

Mode	Inputs		Outputs			Effect on Q
	J	K	Q	$\bar{Q}$		
Hold	0	0				
Reset	0	1				
Set	1	0				
Toggle	1	1				

## In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND at pins 5 and 13 of the IC.
3. Check all the wire connections
4. Check the circuit wiring and remove the breaks.
5. Check the IC using its truth table.

# Experiment 23: - Random Access Memories

## Objective

To check the Read / Write operation of a RAM

## Equipment

### Component

1. 74LS47 x 1
2. 74LS93 x 1
3. 74LS170 x 1

### Tools

1. AM2000 Trainer.
2. Multimeter.
3. Cutter.
4. Single Core Wire.
5. Tweezer.
6. Pair of Pliers.

## Theory

A memory is an important part to store information. Computer memories include tapes, punched cards, magnetic disks and semiconductor devices.

Random Access Memory or RAM is a semiconductor memory wherein any location is accessible to retrieve (read) or store (write) information regard to any other location. In a Figure 16.1 a basic cell of Read / Write RAM which consists select, data input, output and Read / Write lines. The select input enables the cell for writing or reading. The Read / Write input determines the operation on the selected cell.

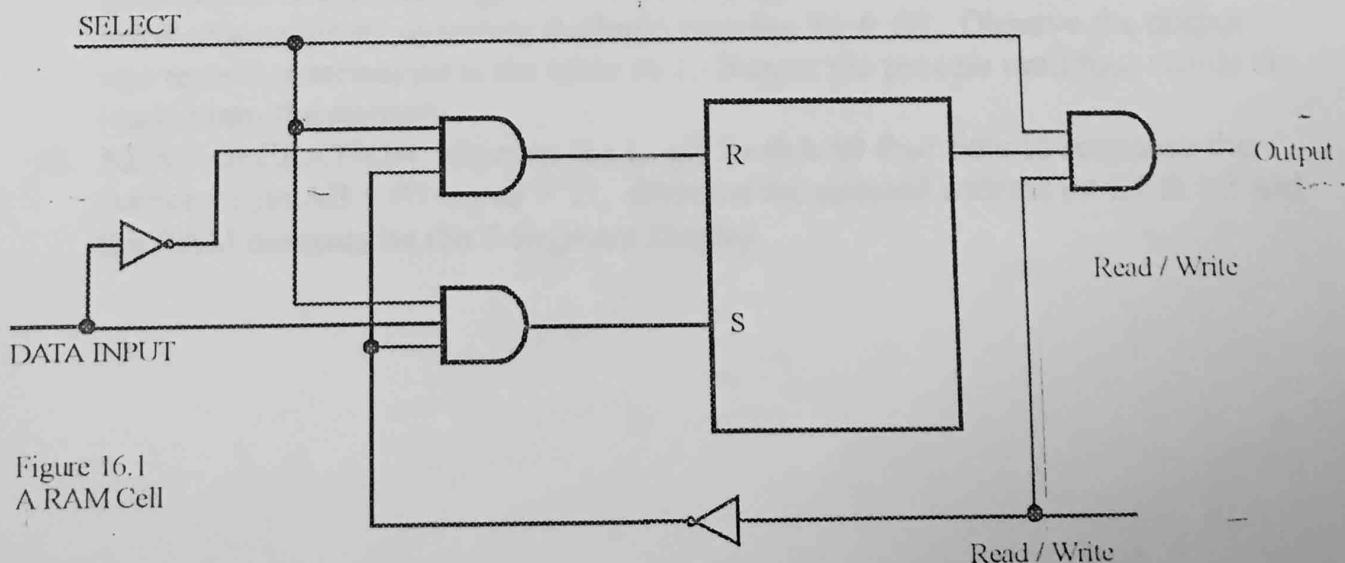


Figure 16.1  
A RAM Cell

## Procedure

1. Connect the AM2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of the power supply using the Multimeter. It should be +5 V exactly.
3. **WRITE OPERATION:** Install the 4 x 4 RAM chip 74LS170 and the binary counter 74LS93 on the trainer's breadboard.
4. Wire the circuit as shown in the Figure 16.2.
5. Use logic switches S2 through S5 for data inputs A through D.
6. For read and write enable inputs, i.e., pin # 11 and # 12, use logic switches S6 and S7 respectively. It normally places the memory in read mode.
7. Use LED L1 and L2 for outputs A and B of the counter.
8. The outputs of the A & B of Binary Counter 7493 are connected to the read / write select inputs of the RAM whereby the address from AB = 00 to AB = 11 is selected. Use logic switch S8 for setting the counter in state AB = 00.
9. Set Logic switches S2 through S5 in state 0000, use Logic switches S6 & S7 to load the binary word into the memory.
10. Observe the output and record your observation in table T 16.1.

Address		Binary Word Loaded					Output Display
A	B	S2	S3	S4	S5		
0	0						
0	1						
1	0						
1	1						

TABLE T 16.1

11. Use the Logic Switch S8 to select the next memory address. The display goes Blank. Reset the Logic Switch S2 through S5 to 0101 and load it into selected location by operating the logic switches S6 & S7. Observe the output and record observations in the table 16.1. Repeat the process until four words are loaded into the memory.
12. **READ OPERATION:** Operate the Logic Switch S8 four time to sequence the counter from AB = 00 to AB = 11. Observe the selected address on L1 & L2 and the RAM contents on the 7-Segment Display.

Circuit Diagram

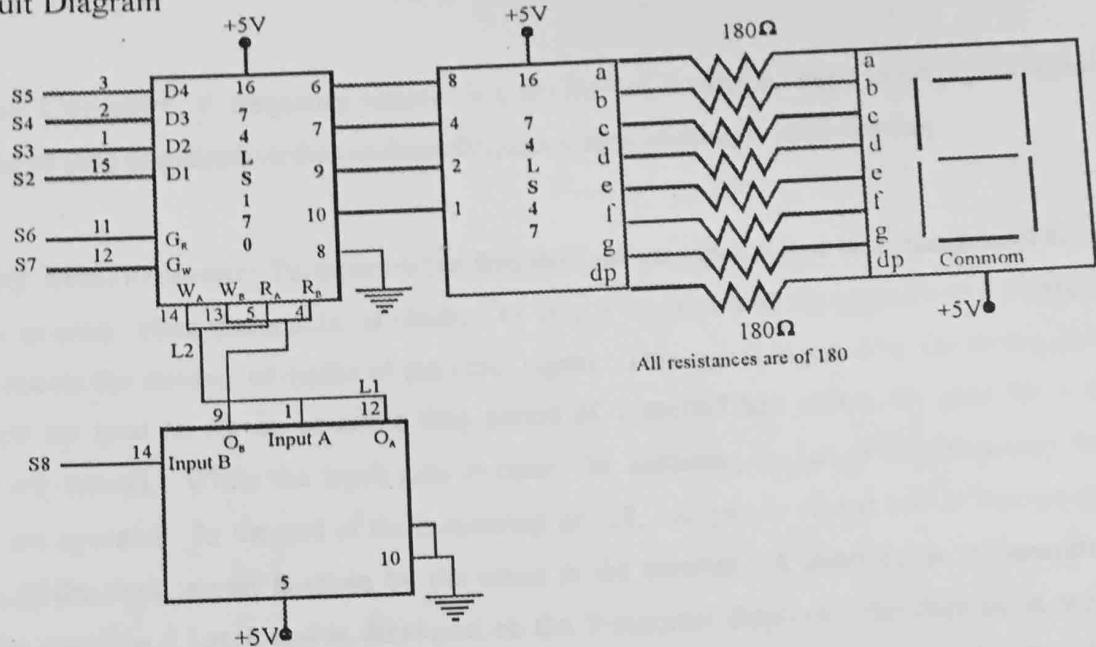


Figure 16.2  
Circuit Diagram for RAM Read And Write Operations.

### In Case of Trouble

1. Check the power supply.
2. Check the VCC and GND of the IC's.
3. Check all the wire connections.
4. Check the circuit wiring and remove the breaks.
5. Check the IC using truth table.

**Frequency Counter:** A frequency counter is a device that counts selected input signal form a fixed period of time and displays the resultant frequency on a multidigit LED display.

**Frequency Measurement:** To measure the frequency of an input signal an arrangement shown in figure 1 is used. Here the counter is clocked by 0 to 1 transition of the signal being measured. So that it counts the number of cycles of the input signal. This signal is gated by the timing pulse, which turns the gate on for an accurate time period of 1 second and closes the gate for a time period of 0.2 second. While the input gate is open, the incoming cycles of the frequency being measured are counted. At the end of the measuring period, the gate is closed and at this point the frequency of the input signal is given by the count in the counter. A short pulse is generated to transfer the count to a Latch and is displayed on the 7-segment displays. Another short pulse is generated for counter, which reset the counters so that the new count starts from zero. The Latch enable pulse and counter reset pulse are much shorter than the period of the timing clock for the counter and are generated during the time when gate is closed. The reset action must be carried out after the count has been transferred to Latch, other wise the count value would be lost by the reset action.

### Subsystems of the counter:

As shown in figure 1, the frequency counter comprises of the following subsystems.

- Timing System
- Counter
- Latch
- BCD to 7-Segment Decoder/Driver
- Display

## Block Diagram

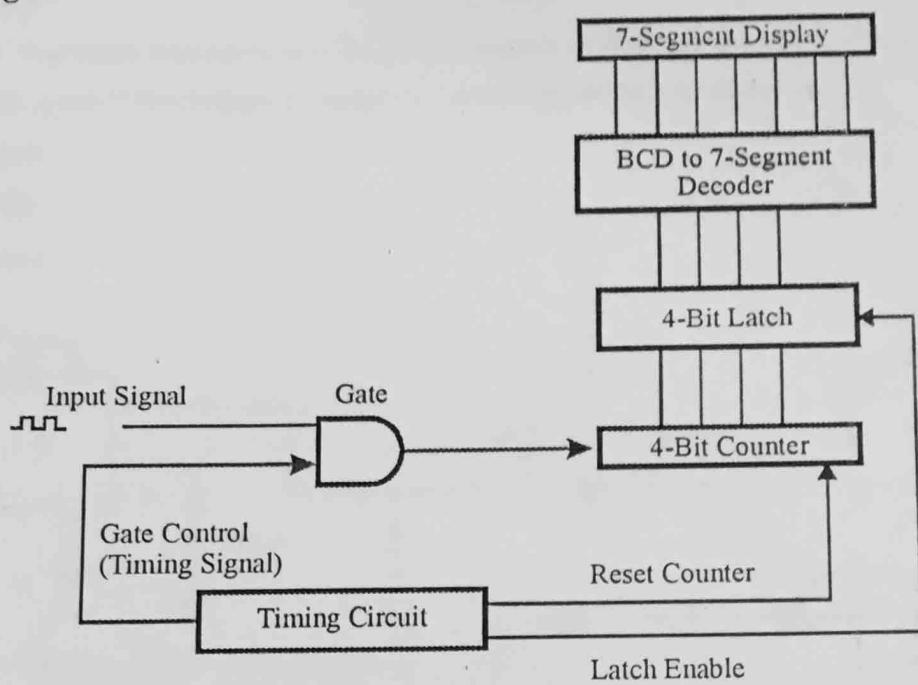


Figure 1

## Timing System

This is a most important subsystem in a frequency counter system. It controls and synchronizes the different operation of the frequency counter by generating the following pulses:

- Timing Signal
- Latch Enable
- Counter Reset

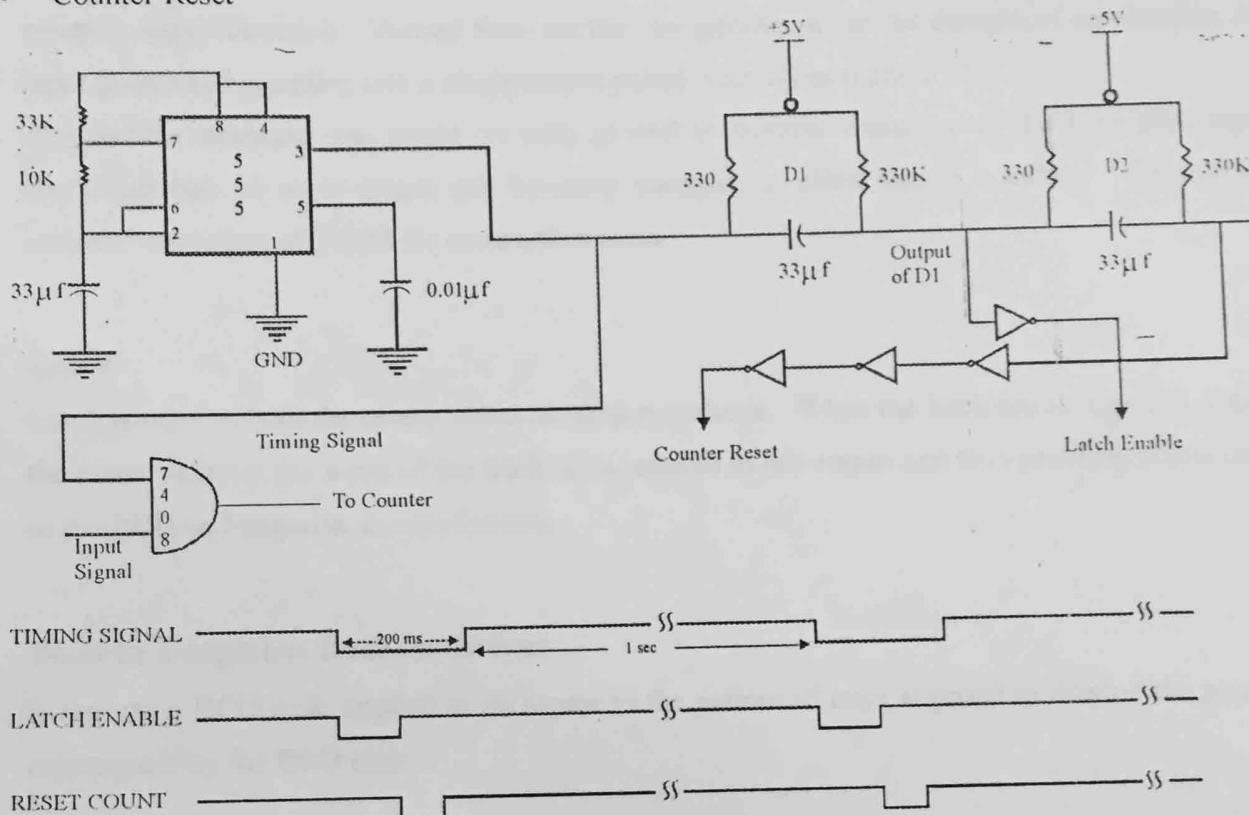


Figure 2

These signals are shown in the schematic diagram along with the timing diagram in fig 2. Timing pulse signal is generated by the 555 timer configured as an astable multivibrator that puts out a fixed time width pulse which is used to turn the gate ON for an accurate time period of 1 second and closes the gate for a time period of 0.2 second. During ON time, the input signal pulses clock the counter, which counts the incoming signal frequency. At the end of this (ON) period, the gate is closed and a short latch enable pulse is generated to transfer the count to a latch. Falling edge of the timing pulse is detected by the differentiator D1 and it produces a negative-going pulse of 2ms duration. This pulse is passed through an inverter to get a well-shaped pulse of 2ms duration to enable the latch. Another differentiator D2 is used to detect the falling edge of the signal at the

output of the D1. It generates the negative-going pulse (counter reset signal) of 2 ms, which is then passed through three inverters to get an appropriate delay. This signal is used to reset the counter to zero.

## **Counter**

4-bit synchronous decade counter (74192) is used which divide the input frequency by 10 and can count in either direction. Viewed from another perspective, it can be thought of as counting the input pulses and signaling (via a single output pulse) when it has reached 10.

The counter advances one count on each ground to positive transition of the Up-Count input clock and two or more stages can be carry cascaded to allow higher counting. Consult the attached data sheet of 74192 for more information.

## **Latch**

Latch is used to hold the counts value on temporary basis. When the latch enable signal is active, the count value at the input of the latch is transferred at the output and thus provides stable input to the BCD to 7-segment decoder/drivers.

## **BCD to 7-segment Decoder/Driver**

It converts a BCD code applied to its inputs to the pattern of lows required to display the number represented by the BCD code.

## **7-Segment LED Display**

It is used to display the frequency of the input signal. Common anode type display is used and its 8-segments is labeled as 'a' through 'g'.

# Frequency Counter

## Objective

To design a frequency measuring circuit to count from 0-999Hz.

## Components and Tools:

- 74192 x 3 Decade UP/DOWN Counter
- 7408 Quad 2-input AND Gate
- 74175 x 3 Quad D +ve Edge-Clocked Latch
- 555 Timer
- 7447 x 3 BCD to 7-segment Decoder/Driver
- Common Anode LED Display x 3
- Resistances: 180 x 24, 330 x 2, 3.3Kx3, 33K, 10K.
- Capacitors: 33uFx3, 0.01uF
- AM-2000 Trainer

## Procedure

1. Connect the AM-2000 trainer to the 220V AC power supply.
2. Turn on the trainer and verify the voltage of power supply using multimeter, it should be +5V exactly.
3. Wire the circuit according to the diagram in fig. 3 by consulting the data sheets of the ICs.
4. Use BCD to 7-Segment decoder/driver provided on the AM-2000 trainer.
5. It is to be noted that only one stage is shown here, construct the rest of two stages in the same fashion and cascade them by connecting the carry out (pin# 12 of 74192) of the least stage of the counter to the input UP COUNT (pin#5 of the counter) of the next stage and so on.
6. Connect CLEAR and LATCH ENABLE inputs of the three stages to the counter reset and latch enable signals respectively as shown in figure 3.
7. Supply the VCC = +5V and GND to the circuit.
8. Test the circuit by inputting different frequencies in the range of 0-999Hz.

