The KELVIN® L.D.T.™

Laptop Digital Trainer

TABLE OF CONTENTS

INTRODUCTION

About the KELVIN® Laptop Digital Trainer™

The phenomenal growth of the Digital Electronics Industry has provided electronics engineers and technicians countless "black boxes" (or integrated circuits) to use in the design of complex circuits. These complex circuits var from calculators to super computers. These circuits use basic logic theory to operate. This theory is that a digital l system uses only two different voltage levels. They are called "HIGH" and "LOW" or, "ON and OFF" or, "0" and "1".

This manual explains how to use and test different types of integrated circuits (IC's). All of the ICs in the labs ar classified as "TTL" or transistor - transistor - logic. Most of these are LS (Low Power Schottky).

Each lab contains related definitions, symbols, circuit diagrams, Truth Tables, a quiz and more. No previous experience in electronics is needed to understand the functions of digital circuits. After completion of the labs in thi manual you will have an understanding of basic digital electronics. At the end of each lab, there are quiz questions answers and the definitions for all terms used can be found in the back of this manual.

In order to perform the labs in this manual, you will need to use the KELVIN® Laptop Digital Trainer™ and a fe components (listed below), mainly TTL IC's. Although not mandatory, you can use an oscilloscope in two of the la

List of Components

- ICs: 74LS00, 74LS02, 74LS04, 74LS08, 74LS14, 74LS32, 74LS74, 74LS76A, 74LS86, 74LS93
- [2] 1k Ohm Resistors
- [1] 100 Microfarad Capacitor
- [20] Hook-up Wires

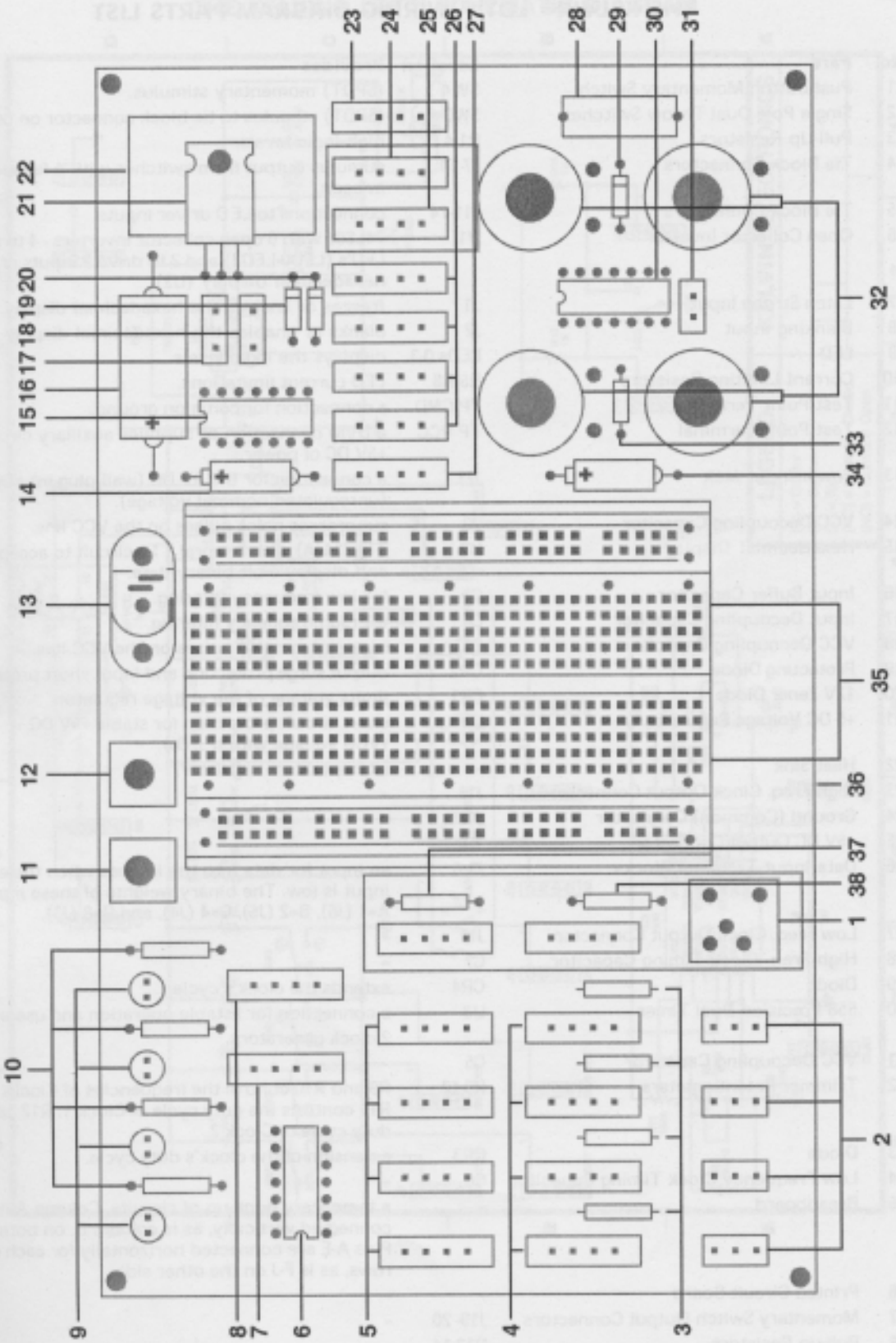
The trainer contains five inputs: four toggle switches and one pushbutton switch. It also includes two outputs: t light emitting diode (LED) and a hexadecimal display. The 9V power supply is a plug-in wall unit with unregulated output voltage. It is connected to the input of the voltage regulator and provides +5V regulated DC voltage.

Two astable multivibrators are operated from the IC 556. The mounting board (a breadboard) is located in the center. All the IC's being tested must be inserted into the breadboard. Connections under the holes complete the cir Rows connect the IC and component's leads while the columns connect the ground (GND) and power supply (VCC).

General Safety Instructions

1. Avoid any liquids or metallic objects in your work area. They can cause electrical shorts and damage to yo the circuit.
2. Always disconnect the power supply before constructing a circuit. Turn on the power supply only when yo ready for testing and turn it right off when you are finished.
3. When you turn on the power supply, the LED's with unused inputs is ON. If you want them OFF, then groun (GND) them by connecting them to J16 (GND).
4. Handle all IC's with care. Use a conductive wrist grounding strap with a built-in current limiting resistor (s as KELVIN's® Stock No. 470057) to avoid electrostatic charge which could damage the IC's.
5. When you insert or remove IC's, use an extractor to avoid bending the Pins.
6. Do not insert any wire or component into the breadboard with leads greater than 0.8 mm in diameter (AWG because they could damage the contacts. Also, do not use any wire or component leads with a diameter sm than 0.3 mm (AWG 29) because you will not get a reliable connection.
7. The test equipment and tools should be set out on the workbench in a neat and orderly manner.
8. If there is anything in doubt about your circuit construction or testing, don't proceed. Call you instructor ov assistance.

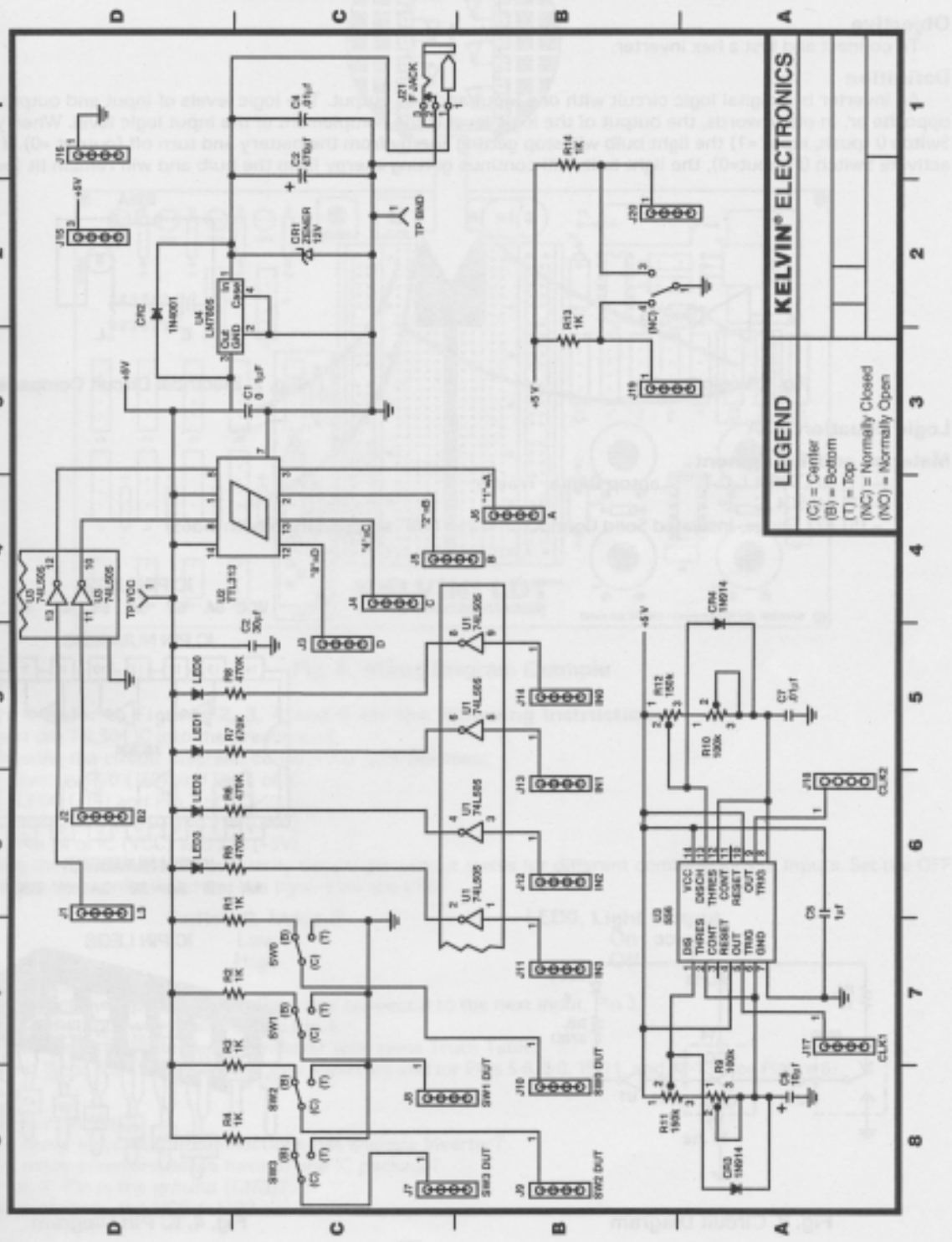
THE KELVIN® LDT™ WIRING DIAGRAM



THE KELVIN® LDT™ WIRING DIAGRAM PARTS LIST

No.	Part	Location	Provides
1	Pushbutton Momentary Switch	SW4	(SPDT) momentary stimulus.
2	Single Pole Dual Throw Switches	SW0-4	(SPDT) stimulus to tie block connector on breadboard
3	Pull-Up Resistors	R1-4	high logic levels.
4	Tie Block Connectors	J7-10	stimulus output from switches with 4 female contact in each.
5	Tie Block Connectors	J11-14	connections to LED driver inputs.
6	Open Collector Inverter	U1	74LS05 with 6 open collector inverters - 4 to drive the LED's (LED0-LED3) and 2 to drive 2 inputs of the hexadecimal display (U2)
7	Latch Strobe Input	J1	freezes or enables the hexadecimal display.
8	Blanking Input	J2	blanks or enables the hexadecimal display
9	LED	LEDs 0-3	displays the logic levels.
10	Current Limiting Resistors	R5-R8	LED current limitations.
11	Test Point Terminal	TP GND	a connection for common ground.
12	Test Point Terminal	TP VCC	a DVM connection or supplies auxiliary circuits with +5V DC of power.
13	Power Input Jack	J21	a connection for the 9V DC (wall plug-in) power supp (unregulated nominal voltage).
14	VCC Decoupling Capacitor	C2	suppresses noise pulses on the VCC line.
15	Hexadecimal Display	U2	TTL311(A) with integral TTL circuit to accept, store, and display 4-bit binary data.
16	Input Buffer Capacitor	C3	for low frequency filtering.
17	Input Decoupling Capacitor	C4	for high frequency filtering.
18	VCC Decoupling Capacitor	C1	suppresses noise pulses on the VCC line.
19	Protecting Diode	CR2	output surge protection and input short protection.
20	12V Zener Diode	CR1	limits voltage of the voltage regulator.
21	+5 DC Voltage Regulator	U4	short circuit protection for stable +5V DC (VCC voltage within ±5%).
22	Heat Sink	-	a temperature regulator.
23	High Freq. Clock Output Connector	J18	-
24	Ground (Common) Connector	J16	-
25	+5V DC Output Connector	J15	-
26	Data Input Terminal Blocks	J3-6	an input for data into the latches when the enable input is low. The binary weights of these inputs are A=1 (J6), B=2 (J5), C=4 (J4), and D=8 (J3).
27	Low Freq. Clock Output Connector	J17	-
28	High Freq. Clock Timing Capacitor	C7	-
29	Diode	CR4	extends the clock's cycle.
30	556 Precision Dual Timer	U3	a connection for astable operation and use as the 2-clock generators.
31	VCC Decoupling Capacitor	C5	-
32	Trimmer Potentiometers	R9-12	R9 and R10 control the frequencies of Clocks 1 and 2 R11 controls the duty cycle of Clock 1. R12 controls t duty cycle of Clock 2.
33	Diode	CR3	extension of the clock's duty cycle.
34	Low Frequency Clock Timing Capacitor	C6	-
35	Breadboard	-	a temporary hook-up of circuits. Column A is connected vertically, as is column B, on both sides. Pins A-E are connected horizontally for each of the 3 rows, as is F-J on the other side.
36	Printed Circuit Board	-	-
37	Momentary Switch Output Connectors	J19-20	-
38	Pull-up Resistors	R13-14	-

THE KELVIN® LDT™ SCHEMATIC DIAGRAM



LAB 1 • 74LS04 Hex Inverter

Objective

To connect and test a hex inverter.

Definition

An Inverter is a digital logic circuit with one input and one output. The logic levels of input and output are alw
opposite or, in other words, the output of the logic level is the complement of the input logic level. When you acti
Switch 0 (push, input =1) the light bulb will stop getting energy from the battery and turn off (output =0). If you do
activate Switch 0 (input=0), the light bulb will continue getting energy from the bulb and will remain lit (output=0)

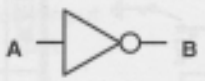


Fig. 1, Logic Symbol

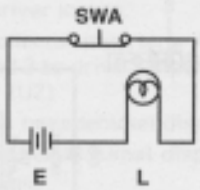


Fig. 2, Electrical Circuit Comparison

Logic Equation: Y=A

Material and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS04 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

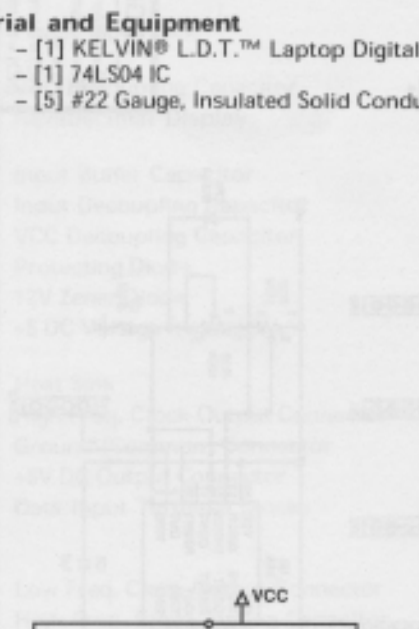
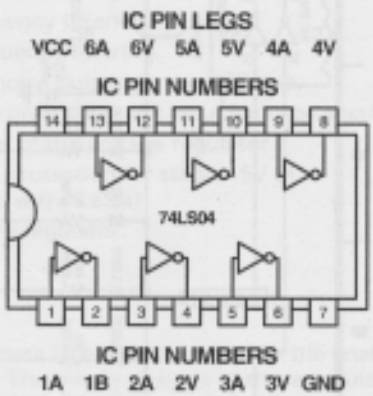


Fig. 3, Circuit Diagram



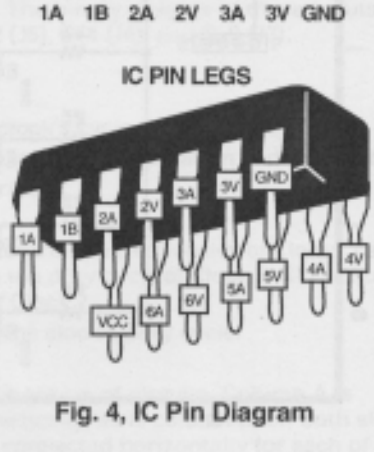


Fig. 4, IC Pin Diagram

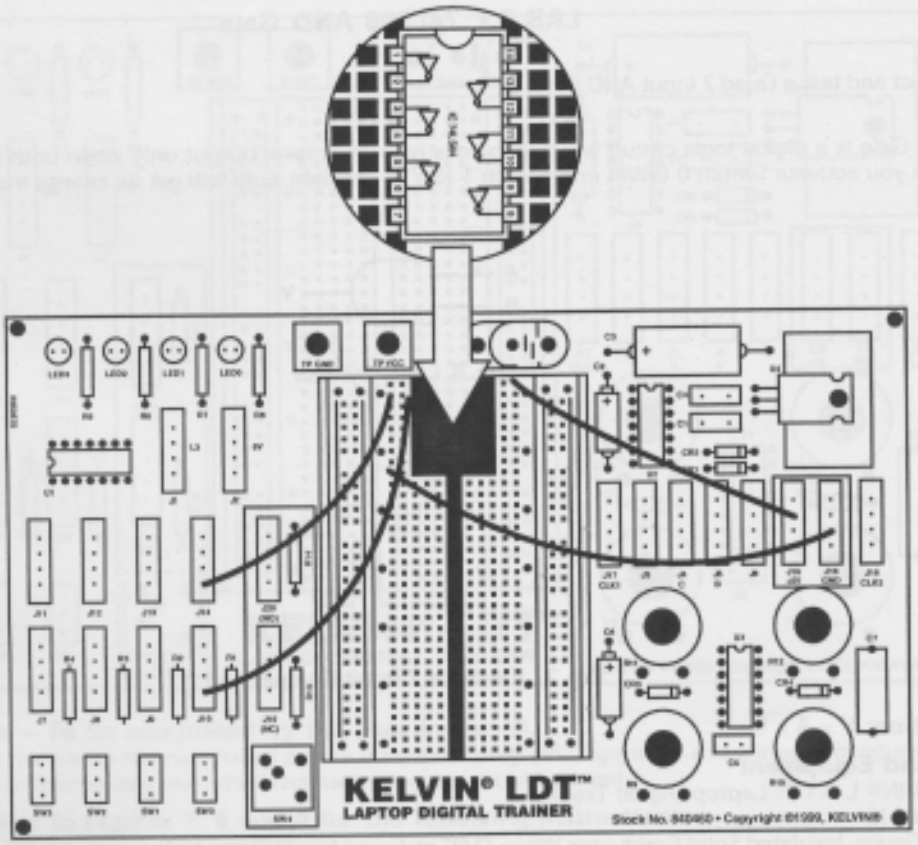


Fig. 5, Wiring Diagram Example

Procedure – Refer to Figures 2, 3, 4 and 5 for the following instructions.

1. Insert the 74LS04 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. Switch SW0 (J10) and Pin 1 of IC.
   b. LED0 (J14) and Pin 2 of IC.
   c. Pin 7 of IC (GND) and J16 (GND).
   d. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output states for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

Switch 0, Input A	LED0, Light Output
Low	On
High	Off

4. Disconnect the input wire from Pin 1 and connect it to the next input, Pin 3.
5. Move the output wire from Pin 2 to Pin 4.
6. Repeat Step 3. Test the second inverter with same Truth Table.
7. Repeat Steps 4 and 5 for the next four inverters and for Pins 5-6, 8-9, 10-11, and 12-13 (see Figure 6).

Quiz 1

1. Define an inverter.
2. How many input/output connections has a single inverter?
3. How many inverters do we have in one IC package?
4. Which IC Pin is the ground (GND)?
5. Which IC Pin is the VCC (+5V)?

LAB 2 • 74LS08 AND Gate

Objective

To connect and test a Quad 2 Input AND Gate.

Definition

The AND Gate is a digital logic circuit which provides high logic level output only when both inputs have high levels. When you activate Switch 0 (SW0) and Switch 1 (SW1), the light bulb will get its energy from the battery and light up.

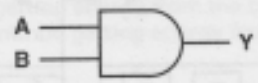


Fig. 6, Logic Symbol

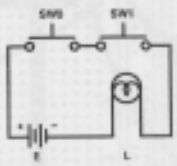


Fig. 7, Electrical Circuit Comparison

Logic Equation: Y = A x B

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS08 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

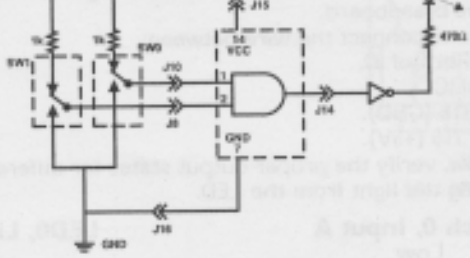


Fig. 8, Circuit Diagram

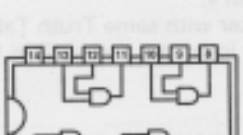
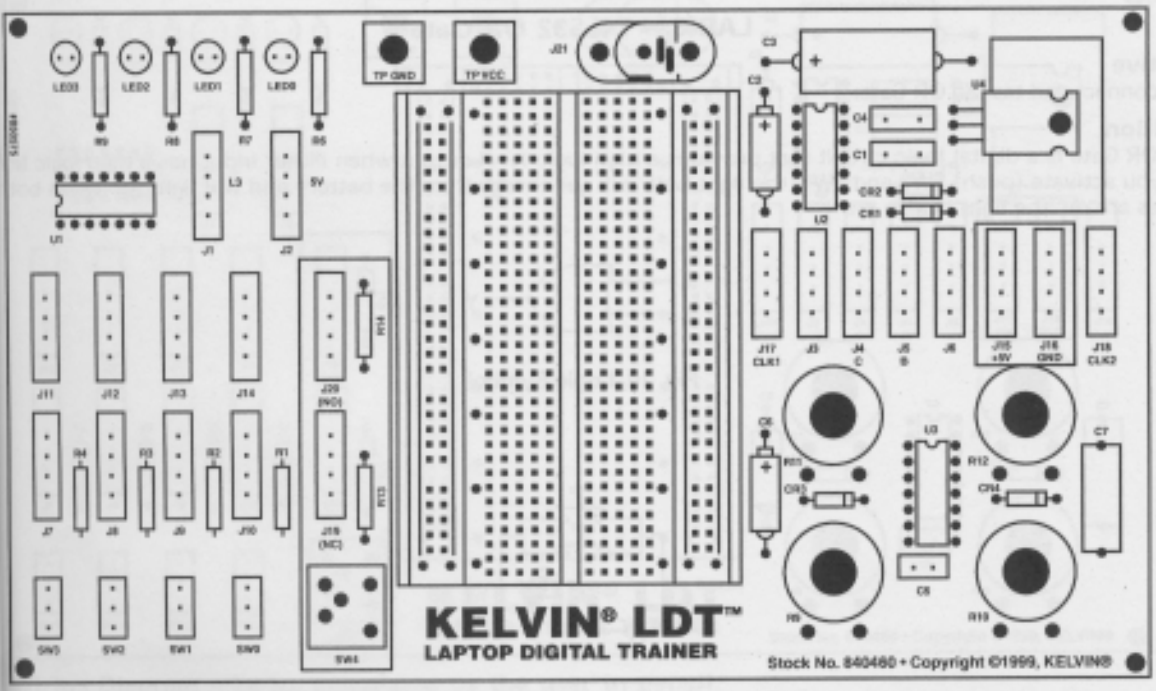


Fig. 9, IC Pin Diagram

puts have high l
the battery and



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram (Figure 10) and wiring procedure.
2. If there is a discrepancy then the schematic diagram should prevail.

Procedure – Refer to Figures 7, 8 and 9 for the following instructions.

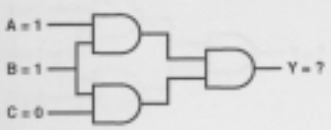
1. Insert the 74LS08 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. SW0 (J10) and Pin 1 of IC.
   b. SW1 (J8) and Pin 2 of IC.
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
- Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	SW1, Input B	LED0, Light Output
Low	Low	Off
Low	High	Off
High	Low	Off
High	High	On

4. Disconnect the input wires from Pins 1 and 2, connect them to the next input Pins pair 4 and 5.
5. Move the output wire from Pin 3 to Pin 6.
6. Repeat Step 3. Test the second AND Gate with same Truth Table.
7. Repeat Steps 4 and 5 for the next two AND Gates and for Pins 8-9, 10-11, and 12-13 (see Figure 11).

Quiz 2

1. Define an AND Gate
2. What is the logic level output if the inputs are at opposite logic levels?
3. What is the logic level output in the circuit below:



LAB 3 • 74LS32 OR Gate

Objective

To connect and test an OR Gate.

Definition

An OR Gate is a digital logic circuit that provides a high logic level output when either input has a high logic level. When you activate (push) SW0 and SW1, the light bulb will get energy from the battery and will light up. When both switches are on, the light is also on.

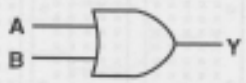


Fig. 10, Logic Symbol

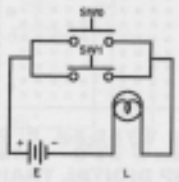


Fig. 11, Electrical Circuit Comparison

Logic Equation: Y = A + B

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS32 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

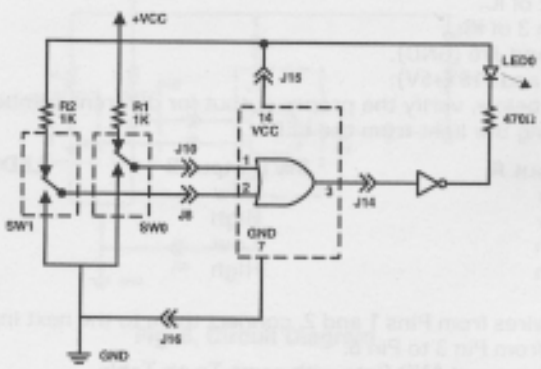


Fig. 12, Circuit Diagram

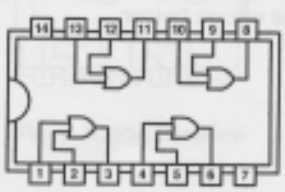
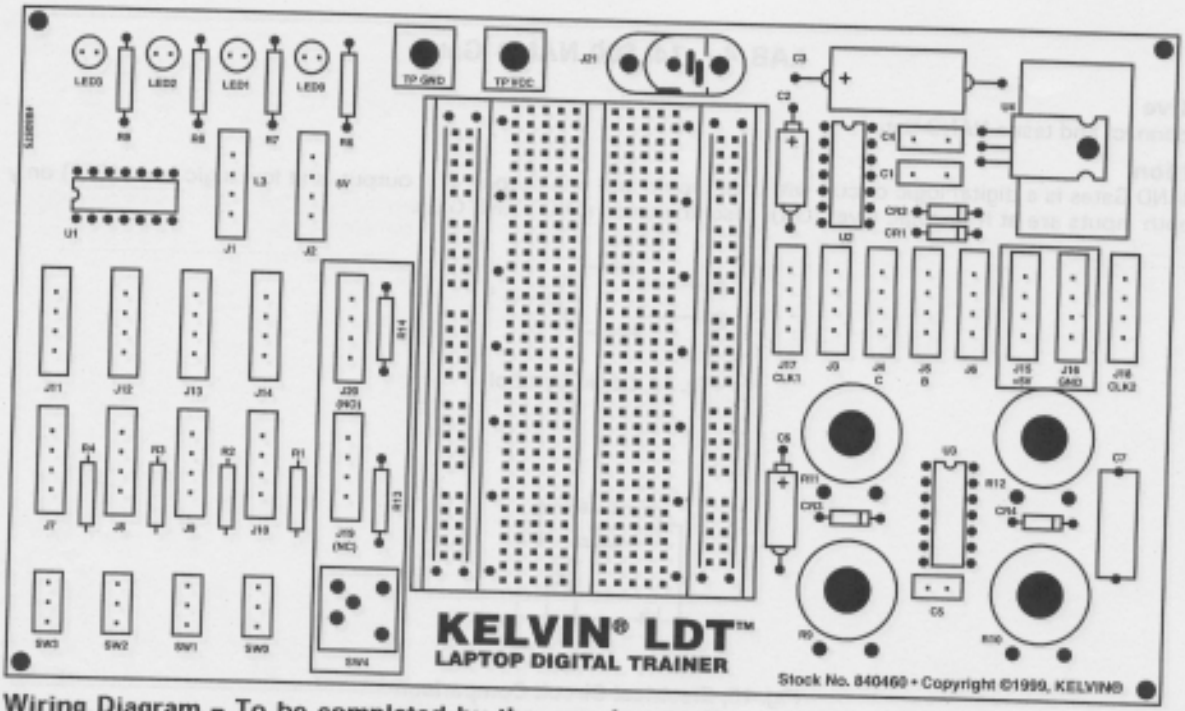


Fig. 13, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – Refer to Figures 11, 12 and 13 for the following instructions.

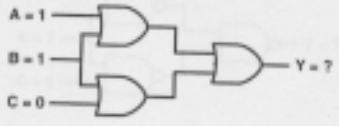
1. Insert the 74LS32 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. SW0 (J10) and Pin 1 of IC.
   b. SW1 (J8) and Pin 2 of IC.
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON switches while watching the light from the LED.

SW0, Input A	SW1, Input B	LED0, Light Output
Low	Low	Off
Low	High	On
High	Low	On
High	High	On

4. Disconnect the input wires from Pins 1 and 2 and connect them to Pins 4 and 5.
5. Move the output wire from Pin 3 to Pin 6.
6. Repeat Step 3. Test the second OR Gate with same Truth Table.
7. Repeat Steps 4 and 5 for the next two OR Gates and for Pins 8-9, 10-11, and 12-13 (see Figure 16).

Quiz 3

1. Give an example of application which you would use an OR Gate.
2. If the inputs are connected to high logic levels, what will happen to the logic level output when one of the wires is cut off?
3. What is the output of the circuit below?



LAB 4 • 74LS00 NAND Gate

Objective

To connect and test a NAND Gate.

Definition

A NAND Gates is a digital logic circuit with two inputs and one output. The output is at low logic level (OFF) only when both inputs are at high logic level (ON). Also known as a NOT-AND Gate.

Fig. 14, Logic Symbol

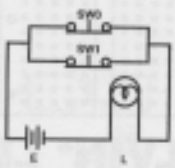


Fig. 15, Electrical Circuit Comparison

Logic Equation: $Y = \overline{A \times B}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

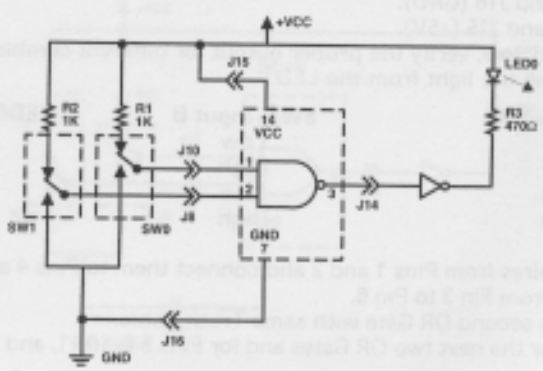


Fig. 16, Circuit Diagram

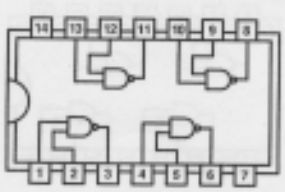
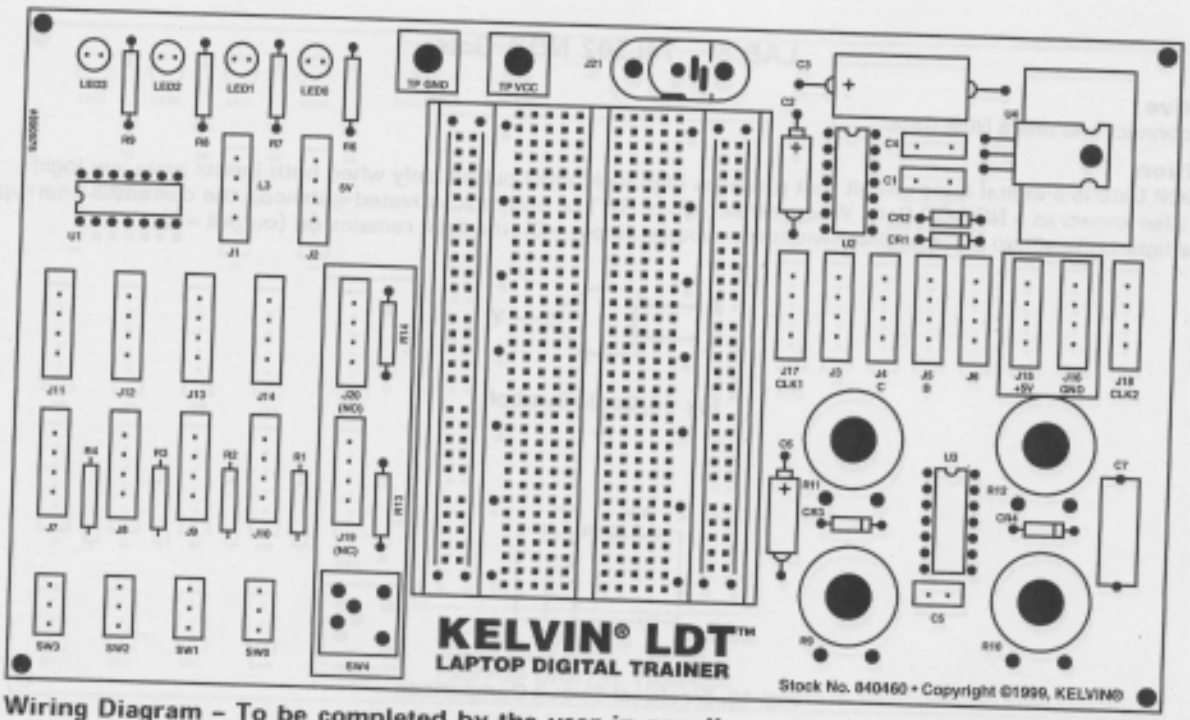


Fig. 17, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – Refer to Figures 15, 16, and 17 for the following instructions.

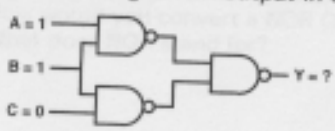
1. Insert the 74LS00 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. SW0 (J10) and Pin 1 of IC.
   b. SW1 (J8) and Pin 2 of IC.
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	SW1, Input B	LED0, Light Output
Low	Low	On
Low	High	On
High	Low	On
High	High	Off

4. Disconnect the input wires from Pins 1 and 2 and connect them to Pins 4 and 5.
5. Move the output wire from Pin 3 to Pin 6.
6. Repeat Step 3, Test the second NAND Gate with same Truth Table.
7. Repeat Steps 4 and 5 for the next two OR Gates and for Pins 8-9, 10-11, and 12-13 (see Figure 21).

Quiz 4

1. What is the output of a NAND Gate if both inputs at "0" level?
2. The word NAND is a combination of what words?
3. What is the logic level output in the following circuit diagram?



LAB 5 • 74LS02 NOR Gate

Objective

To connect and test a NOR Gate.

Definition

A NOR Gate is a digital logic circuit that provides high logic level output only when both inputs have low logic levels. Also known as a NOT-OR Gate. When either SW0 or SW1 or both are activated (pushed), the current is interrupted and the light bulb will go off. If neither switch is activated (input = 0), the light remains on (output = 1).

Fig. 18, Logic Symbol

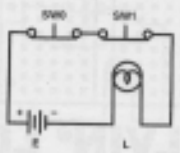


Fig. 19, Electrical Circuit Comparison

Logic Equation: $Y = \overline{A + B}$

Materials and Equipment:

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS02 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

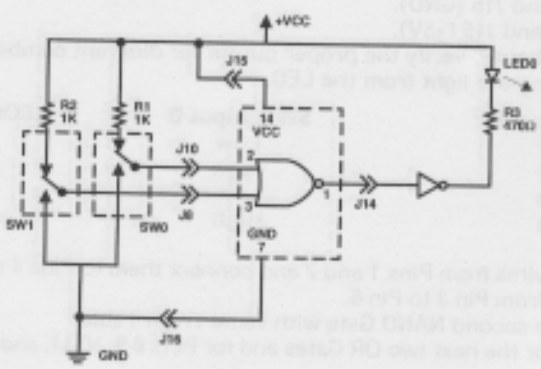


Fig. 20, Circuit Diagram

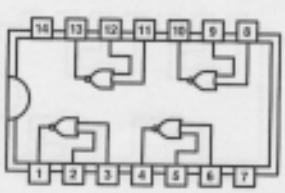
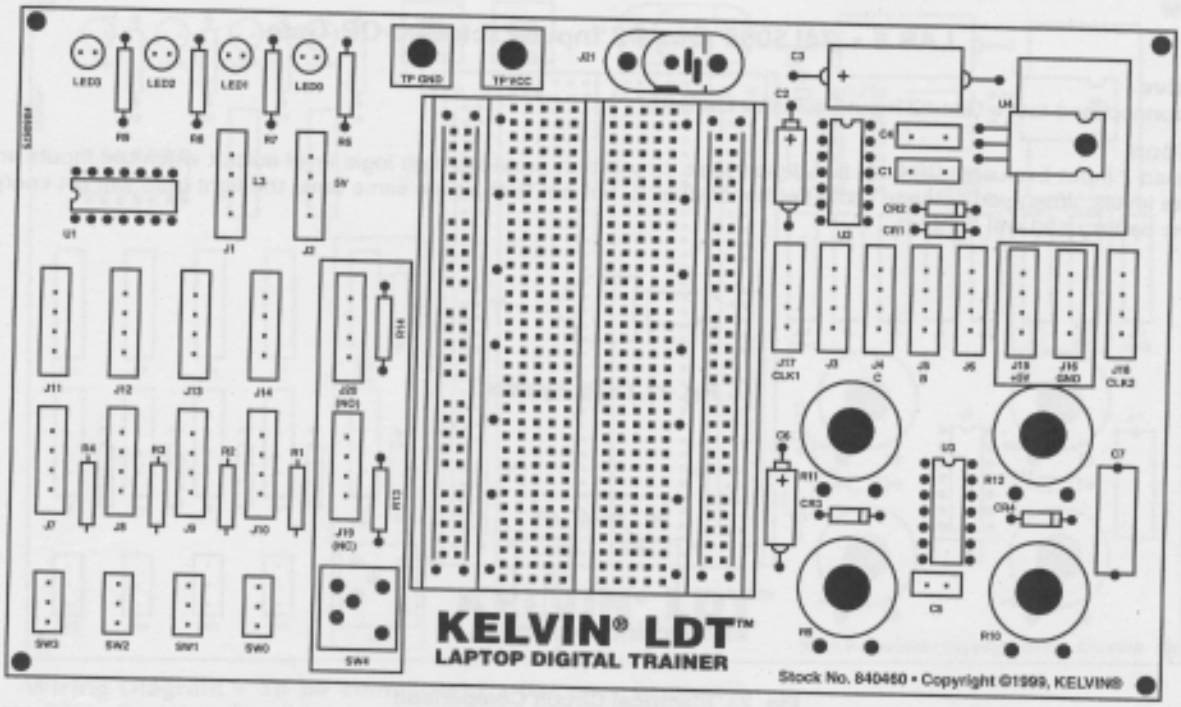


Fig. 21, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – Refer to Figures 19, 20 and 21 for the following instructions.

1. Insert the 74LS02 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. SW0 (J10) and Pin 1 of IC.
   b. SW1 (J8) and Pin 2 of IC.
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	SW1, Input B	LED0, Light Output
Low	Low	On
Low	High	Off
High	Low	Off
High	High	Off

4. Disconnect the input wires from Pins 1 and 2, connect them to the next input Pins pair 5 and 6.
5. Move the output wire from Pin 1 to Pin 4.
6. Repeat Step 3. Test the second NOR Gate with same Truth Table).
7. Repeat Steps 4 and 5 for the next two NOR Gates and for Pins 8-9, 10-11, and 12-13 (see Figure 26).

Quiz 5

1. What is the logic level output of a NOR Gate if both inputs are at opposite logic levels?
2. Explain your answer for Question 1.
3. How would you convert a NOR Gate into an OR Gate?
4. What does NOR stand for?

LAB 6 • 74LS086 Quad 2 Input Exclusive-OR Gate

Objective

To connect and test a Quad 2 Input Exclusive-OR Gate.

Definition

A Quad 2 Input Exclusive-OR Gate is a digital logic circuit that provides high logic level output when the inputs are at opposite levels. When you activate (push) either SW0 or B, but not both at the same time, the light bulb will get energy from the battery and will light up.

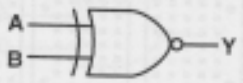


Fig. 22, Logic Symbol

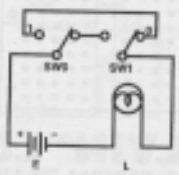


Fig. 23, Electrical Circuit Comparison

Logic Equation: $Y = A \oplus B$ or $Y = \overline{A} \times B + \overline{B} \times A$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS86 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

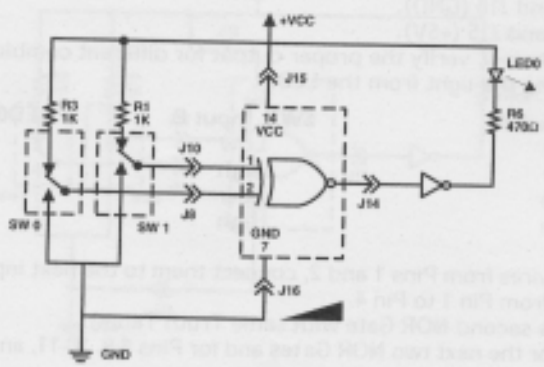


Fig. 24, Circuit Diagram

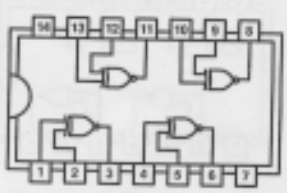
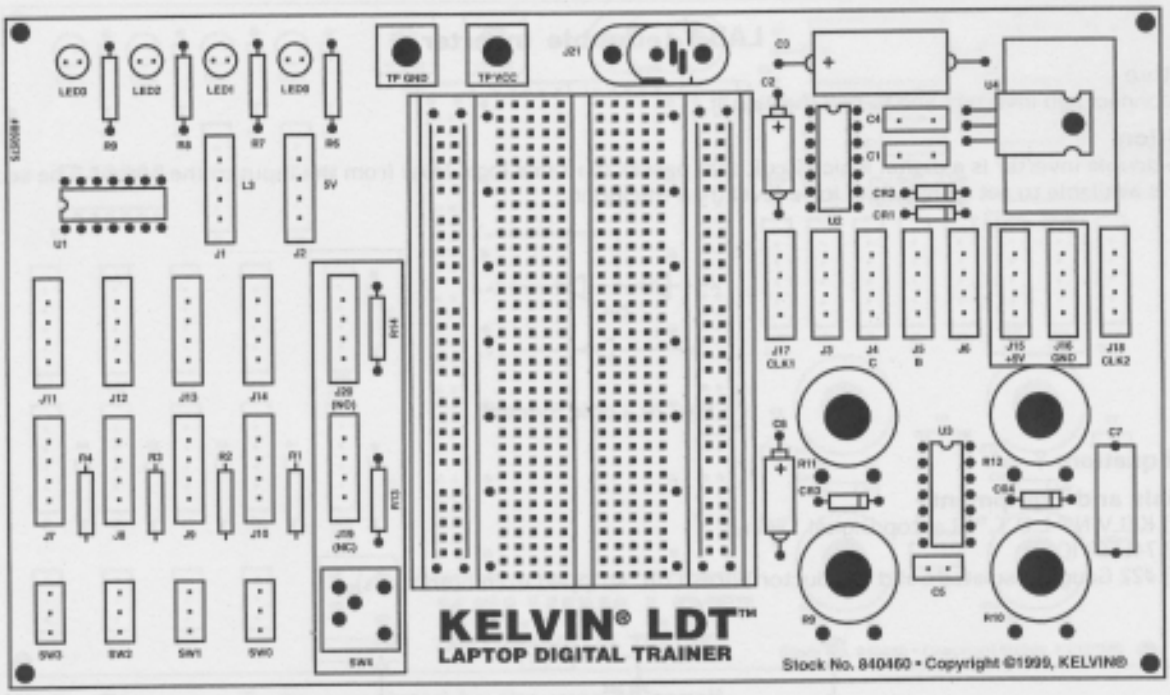


Fig. 25, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – Refer to Figures 23, 24 and 25 for the following instructions.

1. Insert the 74LS86 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. SW0 (J10) and Pin 1 of IC.
   b. SW1 (J8) and Pin 2 of IC.
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	SW1, Input B	LED0, Light Output
Low	Low	Off
Low	High	On
High	Low	On
High	High	~~On~~ Off

4. Disconnect the input wires from Pins 1 and 2 and connect them to Pins 4 and 5.
5. Move the output wire from Pin 3 to Pin 6.
6. Repeat Step 3. Test the second AND Gate with same Truth Table.
7. Repeat Steps 4 and 5 for the next two XOR Gates and for Pins 8-9, 10-11, and 12-13 (see Figure 31).

Quiz 6

1. The Exclusive-OR Gate is different from the OR Gate in one state (or position). Which one is it?
2. One of the logic equations of the XOR Gate is A/x B + B/x A. It means that the function is created from a combination of several gates. What gates are they and how many are needed?
3. Try to draw the circuit diagram for the logic equation in Question 2.

LAB 7 • Double Inverter

Objective

To connect two inverters and to test the circuit.

Definition

The double inverter is a digital logic circuit that passes the same logic level from the input to the output. The second output is available to get an opposite logic level than the input.

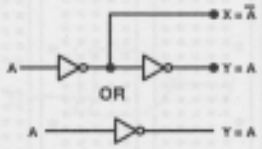


Fig. 26, Logic Symbol

Logic Equation: $Y = \overline{A}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS04 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

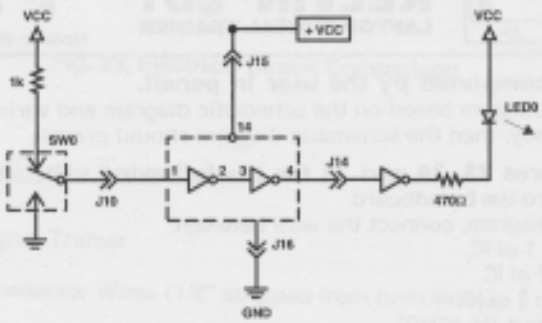


Fig. 27, Circuit Diagram

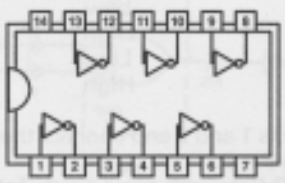
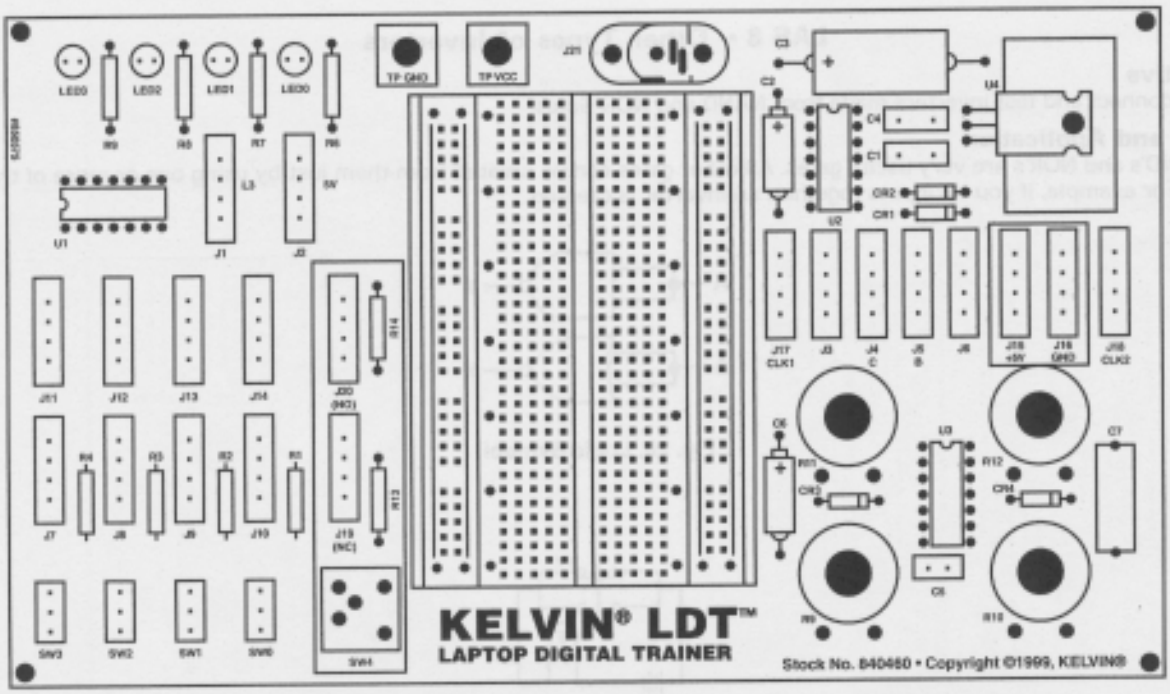


Fig. 28, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – Refer to Figures 27 and 28 for the following instructions.

1. Insert the 74LS04 IC into the breadboard.
2. Following the circuit diagram, connect the wire between:
   a. Pin 2 of IC and Pin 3 of IC.
   b. Pin 4 of IC and J14 (LED0)
   c. LED0 (J14) and Pin 3 of IC.
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	LED0, Light Output
Low	On
High	On

Quiz 7

1. You have seven inverters to be used in two circuits. Draw two circuits; one showing a circuit that is functioning as an inverter and the other showing a circuit that is functioning as non-inverting buffer.

LAB 8 • Other Types of Inverters

Objective

To connect and test inverters made from NAND and NOR Gates.

Usage and Application

NAND's and NOR's are very useful gates. All other gates can be created from them just by using one or more of these gates. For example, if you tie inputs together, an inverter is created.

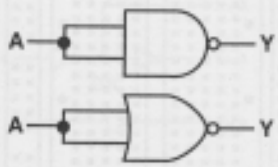


Fig. 29, Logic Symbol

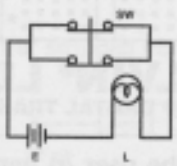


Fig. 30, Electrical Circuit Comparisons

Logic Equation: $Y = \overline{A \times A} = \overline{A}$, $Y = \overline{A + A} = \overline{A}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [1] 74LS02 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

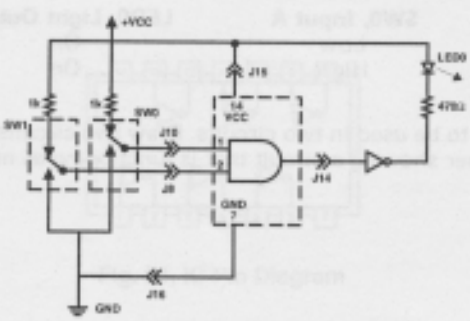


Fig. 31, Circuit Diagram

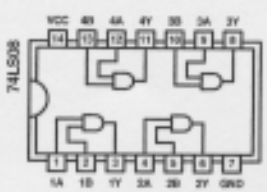
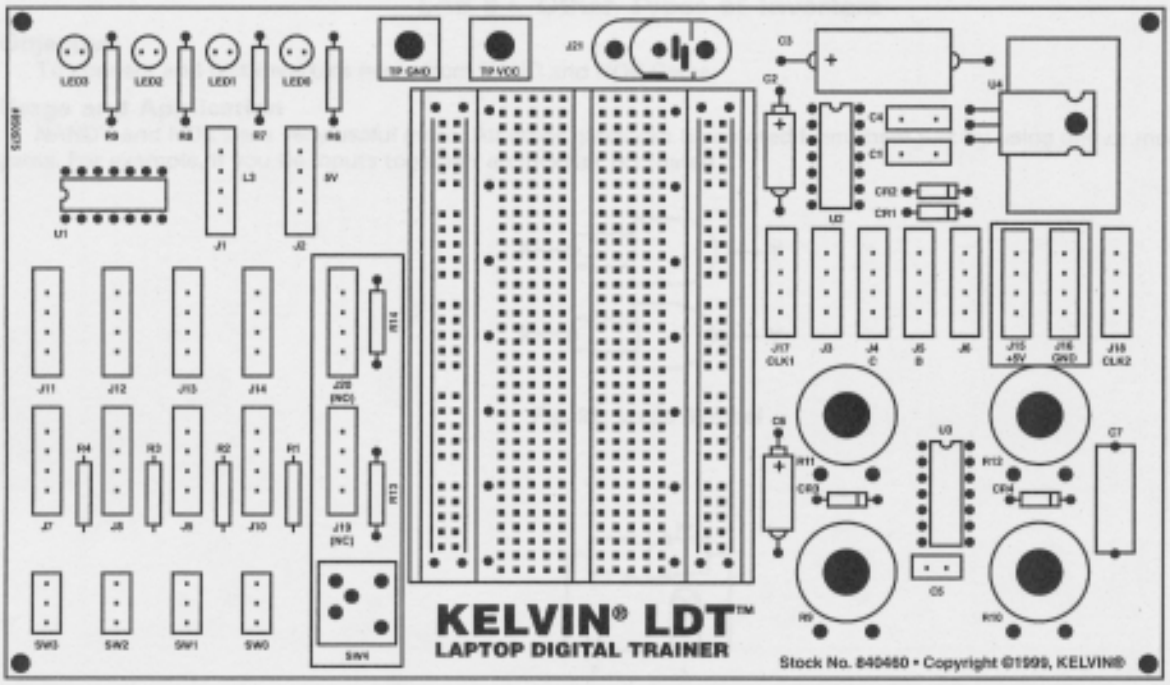


Fig. 32, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure – For a NAND with shorted inputs.

1. Insert the 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. Pin 1 and Pin 2 of IC.
   b. SW0 (J10) and Pin 2 of IC.
   c. Pin 3 of IC and LED0 (J14).
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	LED0, Light Output
Low	On
High	Off

4. Remove IC 74LS00 from the breadboard.

Procedure – For a NOR with shorted inputs.

5. Insert the 74LS02 IC into the breadboard.
6. Connect the following wires between:
   a. Pin 2 and Pin 3 of IC.
   b. Switch SW0 (J10) and Pin 2 of IC.
   c. Pin 1 of IC and LED0 (J14).
   d. Pin 7 of IC (GND) and J16 (GND).
   e. Pin 14 of IC (VCC) and J15 (+5V).
7. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	LED0, Light Output
Low	On
High	Off

Quiz 8

1. Draw the Truth Table for a NAND Gate being used as an inverter.
2. Draw the Truth Table for a NOR Gate being used as an inverter.

LAB 9 • Creating AND Functions by using NAND Gates

Objective

To connect and test a combination circuit made of 74LS00 ICs (two NAND Gates) and to create an AND Gate similar to an 74LS08 IC.

Logic Equation: $\overline{(A \times B)} = A \times B$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [7] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

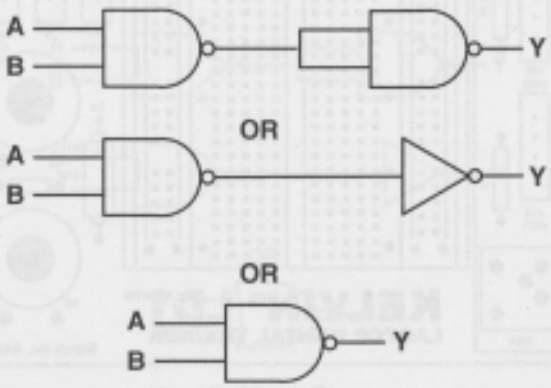


Fig. 33, Circuit Diagram

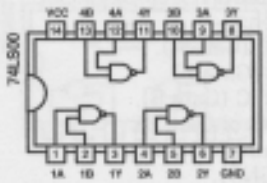
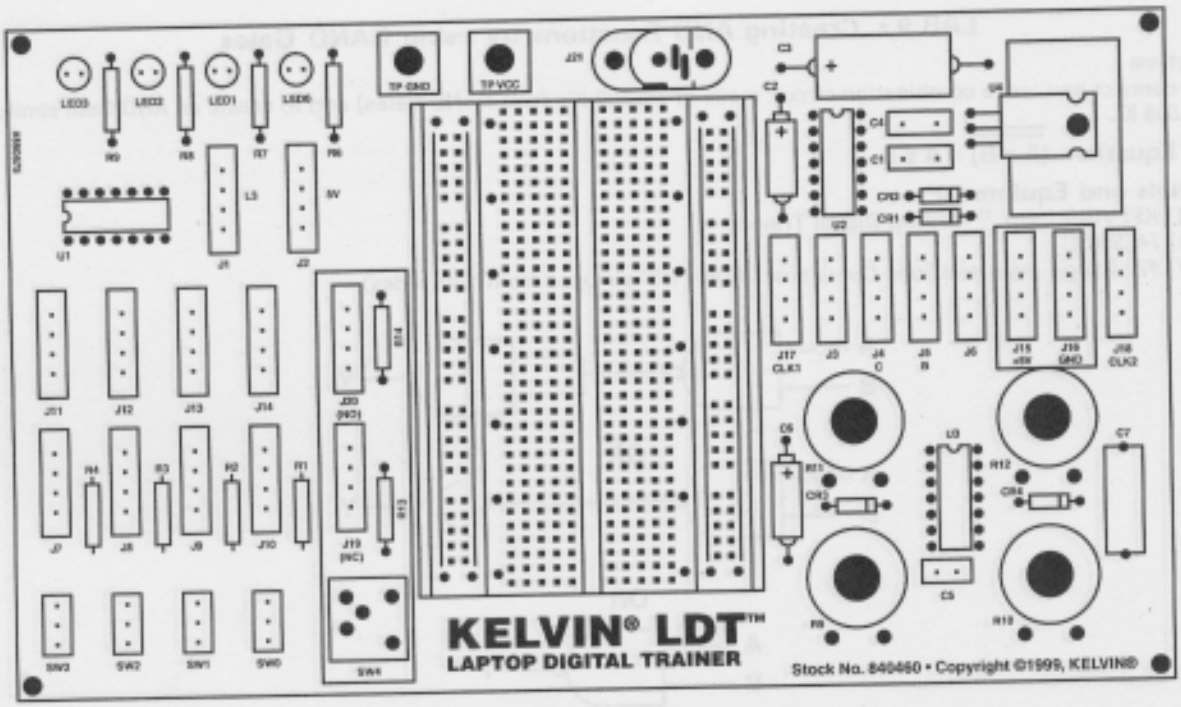


Fig. 34, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 1 of IC (Gate A).
   b. Switch SW1 (J8) and Pin 2 of IC (Gate B).
   c. Pin 3 of IC (Gate A) and Pin 4 of IC (Gate B).
   d. Pin 4 of IC and Pin 5 of IC (inputs of Gate B).
   e. Pin 6 of IC (output of Gate B) and LED0 (J14).
   f. Pin 7 (GND) of the IC and J16 (GND).
   g. Pin 14 (VCC) of the IC and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

3. Set up switches SW0 and SW1 according to the Truth Table.
4. Write the output indication of the LED for each input combination.
5. Compare the Truth Table that you just filled out to the Truth Table in Lab 2 (AND Gates).

Quiz 9

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 10 • Creating OR Functions by using NOR Gates

Objective

To connect and test a combination circuit made of an 74LS02 IC (two NOR Gates) and to create an OR Gate similar to an 74LS32 IC.

Logic Equation: $\overline{(A + B)} = A + B$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS02 IC
- [7] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

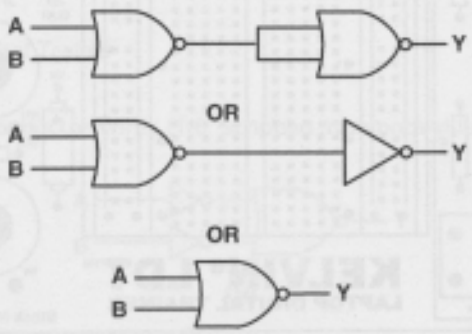


Fig. 35, Circuit Diagram

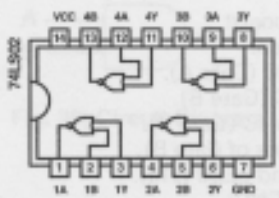
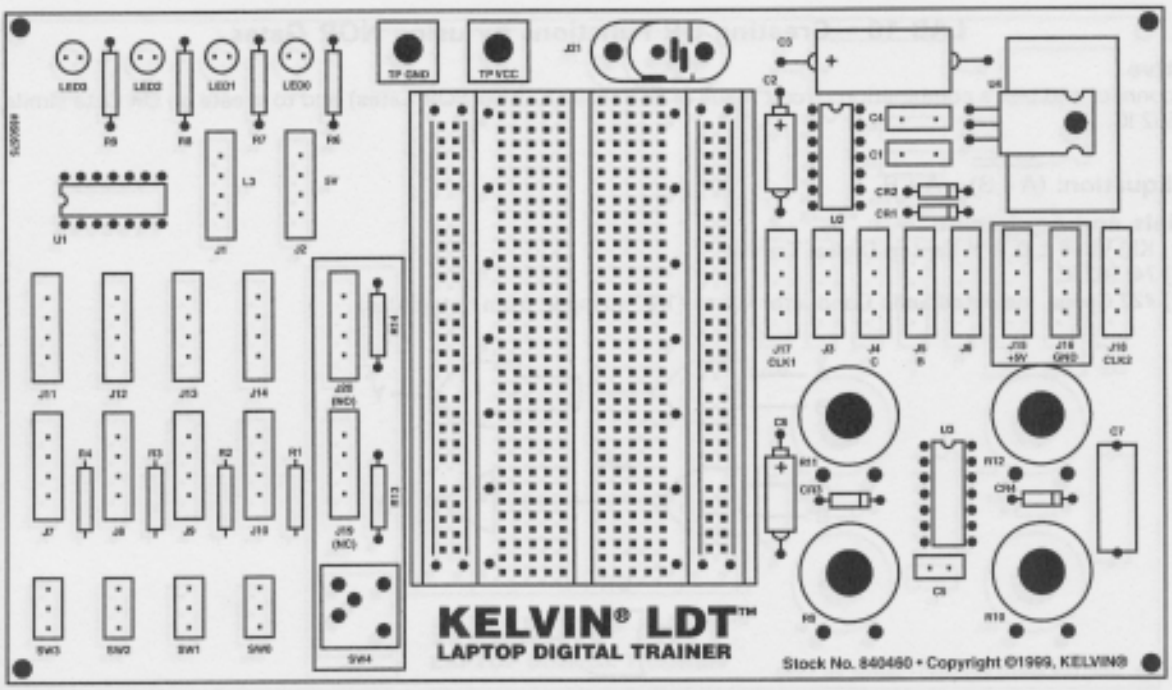


Fig. 36, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS02 IC into the breadboard.
2. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 2 of IC (Gate A).
   b. Switch SW1 (J8) and Pin 3 of IC (Gate B).
   c. Pin 1 of IC (Gate A) and Pin 5 of IC (Gate B).
   d. Pin 5 of IC to Pin 6 and IC (inputs of Gate B).
   e. Pin 4 of IC (output of Gate B) and LED0 (J14).
   f. Pin 7 (GND) of the IC and J16 (GND).
   g. Pin 14 (VCC) of the IC and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

3. Set up switches SW0 and SW1 according to the Truth Table.
4. Write the output indication of the LED for each input combination.
5. Compare the Truth Table that you just filled out to the Truth Table in Lab 3 (OR Gates).

Quiz 10

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 11 • Creating NAND Function with an OR Gate and Inverters

Objective

To connect and test a combination circuit made of an 74LS04 IC (inverter) and an 74LS32 IC (OR Gate) and to create an NAND Gate similar to an 74LS00 IC.

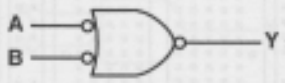


Fig. 37, Logic Symbol

Logic Equation: $\overline{A} + \overline{B} = \overline{A \times B}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS04 IC
- [1] 74LS32 IC
- [10] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

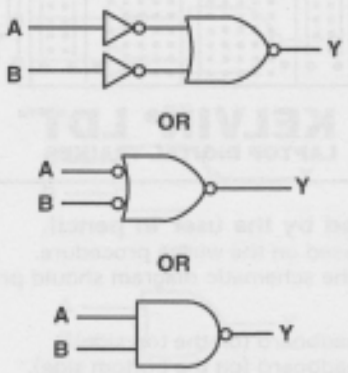


Fig. 38, Circuit Diagram

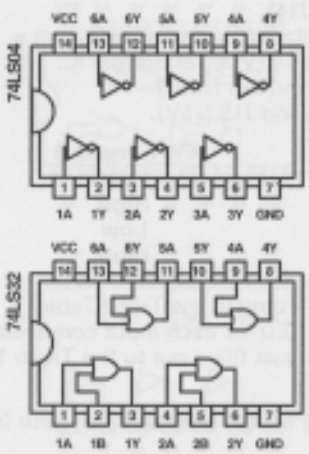
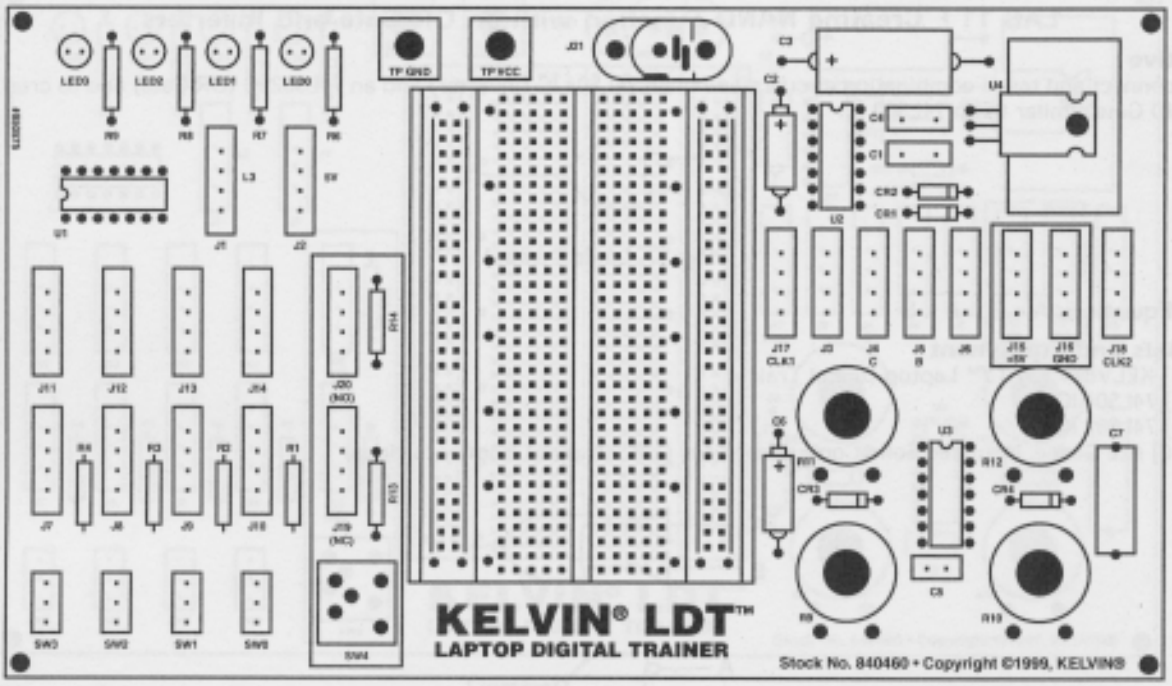


Fig. 39, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS04 IC into the breadboard (on the top side).
2. Insert the 74LS32 IC into the breadboard (on the bottom side).
3. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 1 of top IC.
   b. Switch SW1 (J8) and Pin 3 of top IC.
   c. Pin 2 of top IC and Pin 2 of bottom IC.
   d. Pin 4 of top IC and Pin 3 of bottom IC.
   e. Pin 1 of bottom IC and LED0 (J14).
   f. Pin 7 (GND) of top IC and Pin 7 (GND) of bottom IC.
   g. Pin 14 (VCC) of top IC and Pin 14 (VCC) of bottom IC.
   h. Pin 7 (GND) of any of the ICs and J16 (GND).
   i. Pin 14 (VCC) of any of the ICs and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

4. Set up switches SW0 and SW1 according to the Truth Table.
5. Write the output indication of the LED for each input combination.
6. Compare the Truth Table that you just filled out to the Truth Table in Lab 4 (NAND Gates).

Quiz 11

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 12 • Creating NOR Function using an AND GATE and Inverters

Objective

To connect and test a combination circuit made of an 74LS04 IC (inverter) and an 74LS08 IC (AND Gate) and to create a NOR Gate similar to an 74LS02 IC.

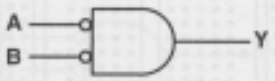
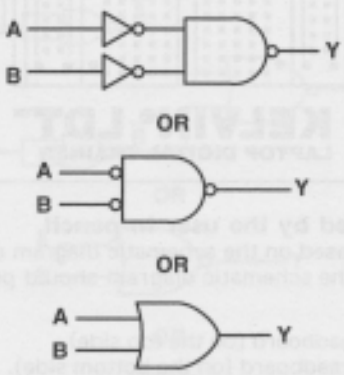


Fig. 40, Logic Symbol

Logic Equation: $\overline{A} \times \overline{B} = \overline{A + B}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS04 IC
- [1] 74LS08 IC
- [10] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)



\Fig. 41, Circuit Diagram

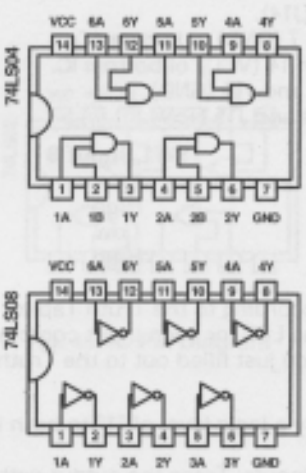
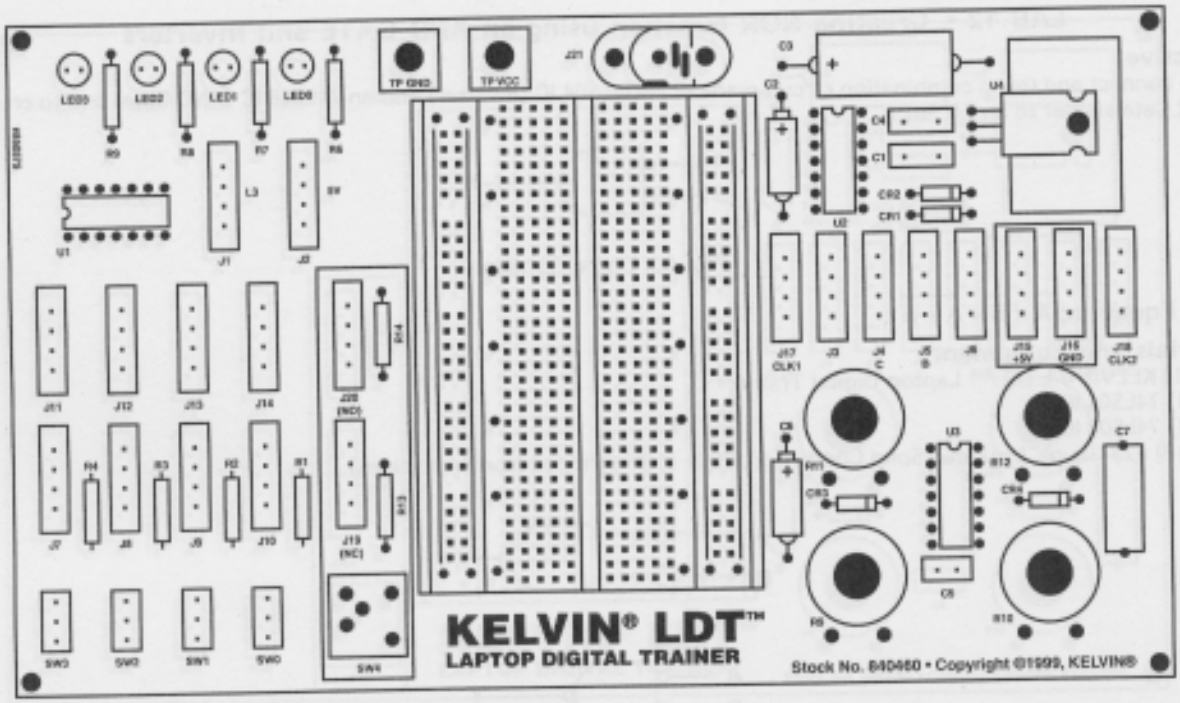


Fig. 42, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS04 IC into the breadboard (on the top side).
2. Insert the 74LS038 IC into the breadboard (on the bottom side).
3. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 1 of top IC.
   b. Switch SW1 (J8) and Pin 3 of top IC.
   c. Pin 2 of top IC and Pin 1 of bottom IC.
   d. Pin 4 of top IC and Pin 2 of bottom IC.
   e. Pin 3 of bottom IC and LED0 (J14).
   f. Pin 7 (GND) of top IC and Pin 7 (GND) of bottom IC.
   g. Pin 14 (VCC) of top IC and Pin 14 (VCC) of bottom IC.
   h. Pin 7 (GND) of any of the ICs and J16 (GND).
   h. Pin 14 (VCC) of any of the ICs and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

4. Set up switches SW0 and SW1 according to the Truth Table.
5. Write the output indication of the LED for each input combination.
6. Compare the Truth Table that you just filled out to the Truth Table in Lab 5 (NOR Gates).

Quiz 12

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 13 • Creating an AND Function using NOR Gates

Objective

To connect and test a combination circuit made of 74LS02 IC's (three NOR Gates) and to create an AND Gate similar to an 74LS08 IC.

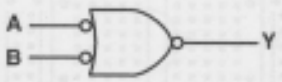


Fig. 43, Logic Symbol

Logic Equation: $A \times B = \overline{(\overline{A} \times \overline{B})} = \overline{\overline{A} + \overline{B}}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS02 IC
- [10] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

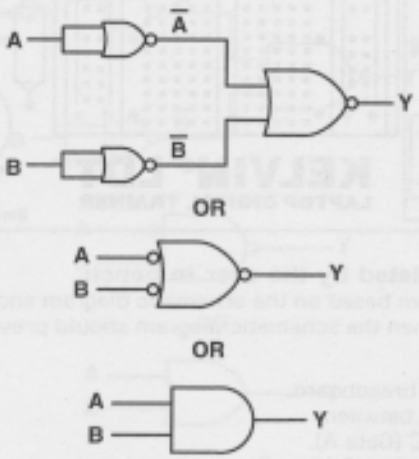


Fig. 44, Circuit Diagram

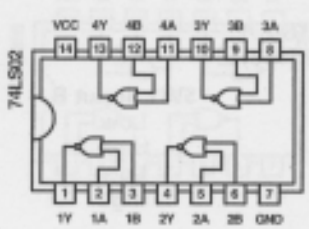
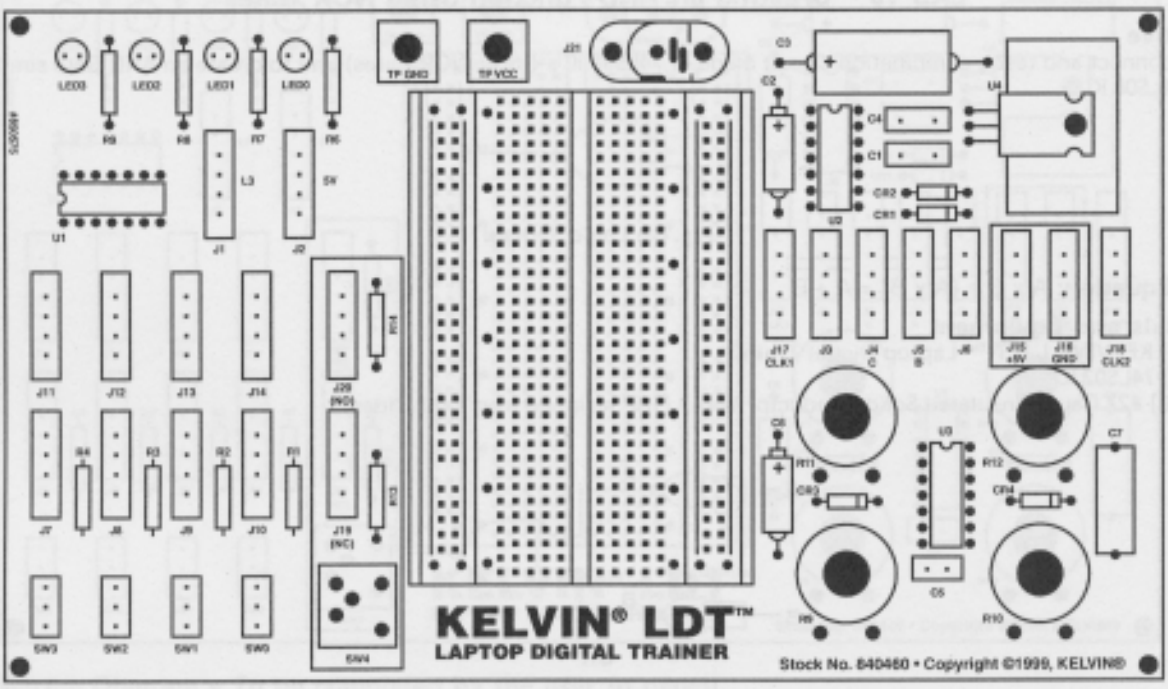


Fig. 45, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS02 IC into the breadboard.
2. Connect the following wires between:
   a. SW0 (J10) and Pin 3 of IC (Gate A).
   b. Switch SW1 (J8) and Pin 5 of IC (Gate B).
   c. Pin 1 of IC (Gate A) and Pin 8 of IC (Gate C).
   d. Pin 2 of IC and Pin 3 of IC (inputs of Gate A).
   e. Pin 4 of IC (Gate B) and Pin 9 of IC (Gate C).
   f. Pin 5 of IC and Pin 6 of IC (inputs of Gate B).
   g. Pin 10 of IC and LED0 (J14).
   h. Pin 7 (GND) of the IC and J16 (GND).
   i. Pin 14 (VCC) of the IC and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

3. Set up switches SW0 and SW1 according to the Truth Table.
4. Write the output indication of the LED for each input combination.
5. Compare the Truth Table that you just filled out to the Truth Table in Lab 2 (AND Gates).

Quiz 13

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 14 • Creating OR Functions using NAND Gates

Objective

To connect and test a combination circuit made of 74LS00 IC's (three NAND Gates) and to create an OR Gate similar to an 74LS32 IC.

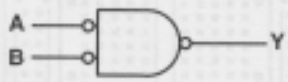


Fig. 46, Logic Symbol

Logic Equation: $A + B = (\overline{A} + \overline{B}) = \overline{\overline{A} \times \overline{B}}$

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

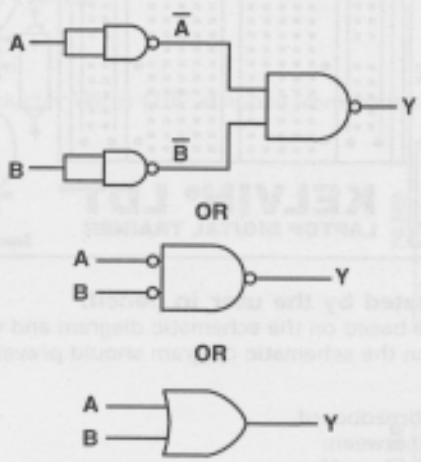


Fig. 47, Circuit Diagrams

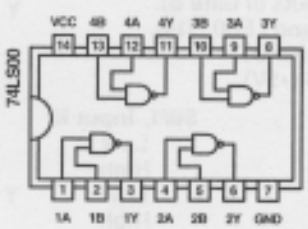
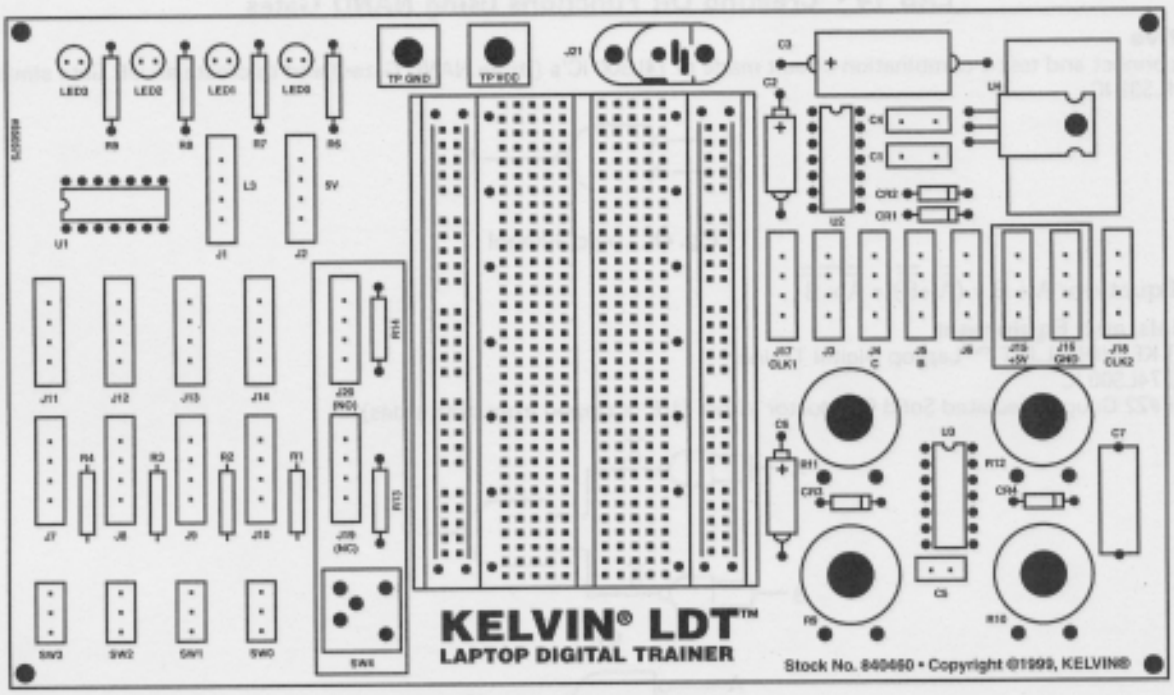


Fig. 48, IC Pin Diagrams



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. SW0 (J10) and Pin 1 of IC (Gate A).
   b. SW1 (J8) and Pin 4 of IC (Gate B).
   c. Pin 3 of IC (Gate A) and Pin 9 of IC (Gate C).
   d. Pin 1 of IC and Pin 2 of IC (inputs of Gate A).
   e. Pin 6 of IC (Gate B) and Pin 10 of IC (Gate C).
   f. Pin 4 of IC and Pin 5 of IC (inputs of Gate B).
   g. Pin 8 of IC (output of Gate C) and LED0 (J14).
   h. Pin 7 (GND) of the IC and J16 (GND).
   i. Pin 14 (VCC) of the IC and J15 (+5V).

SW0, Input A	SW1, Input B	LED0, Output
Low	Low	
Low	High	
High	Low	
High	High	

3. Set up switches SW0 and SW1 according to the Truth Table.
4. Write the output indication of the LED for each input combination.
5. Compare the Truth Table that you just filled out to the Truth Table in Lab 5 (NOR Gates).

Quiz 14

1. Redraw the circuit diagram. Apply a logic level of "1" to both inputs. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to both inputs. Trace the output path with a pencil and indicate the output of each gate.

LAB 15 • Logic Combination Circuits

Objective

To connect and test two logic circuits with the same outputs made of different gates. In one circuit, there should be three inputs using a combination of AND-OR Gates. In the other circuit, there should also be three inputs using a combination of NAND Gates.

Logic Equations

For AND-OR Gate combinations: $Y = A \times B + C$

Using DeMorgan Law's: $Y = A \times B + C = \overline{\overline{A \times B} + \overline{C}} = \overline{\overline{A \times B} \times \overline{C}}$

Arithmetic Example

The inputs are given as: A = 1, B = 0, C = 1.
Let's calculate the output "Y" using the Boolean expression: $Y = A \times B + C = 1 \times 0 + 1 = 0 + 1 = 1$.
Remember 0 + 0 = 0, 0 + 1 = 1, 1 + 1 = 1.

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS08 IC
- [1] 74LS32 IC
- [1] 74LS00 IC
- [10] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

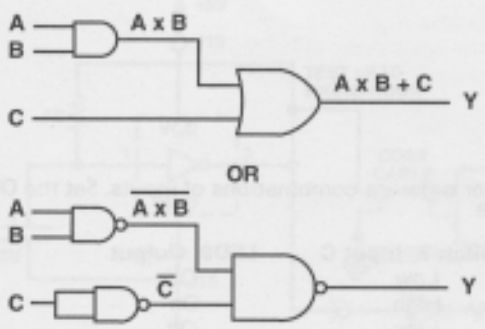


Fig. 49, Circuit Diagram

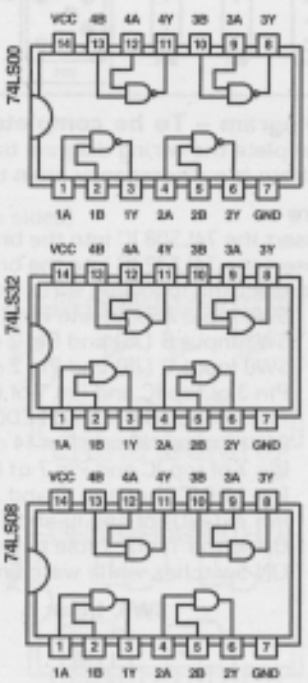
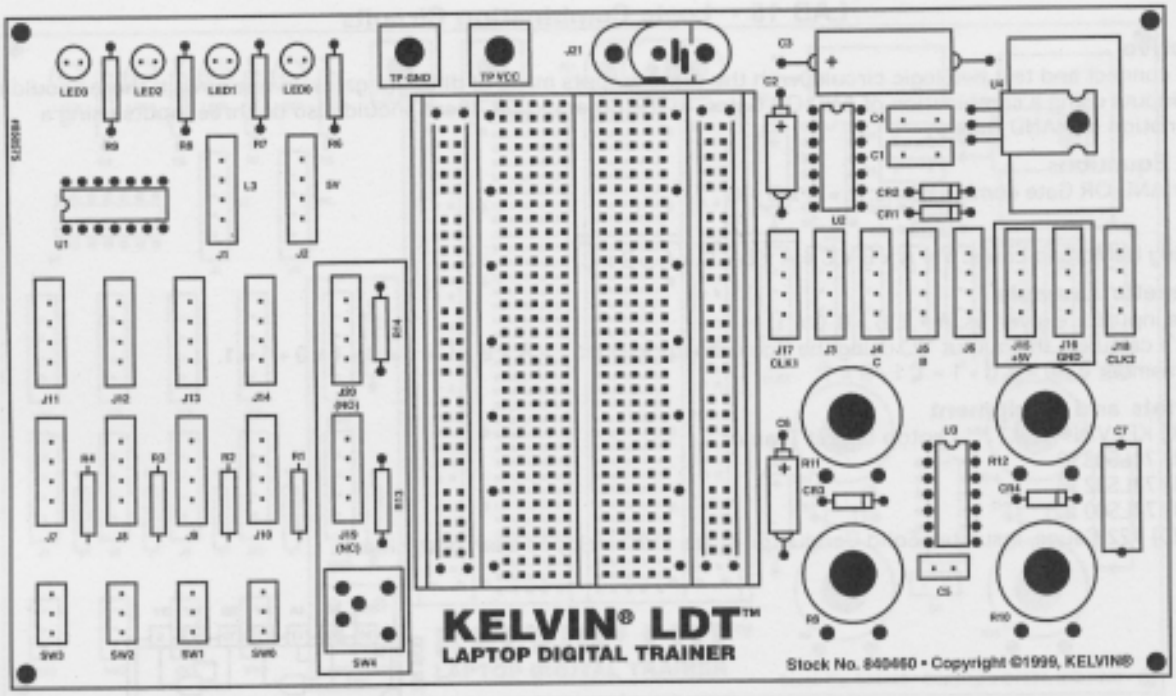


Fig. 50, Alternate Circuit Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS08 IC into the breadboard (on top).
2. Insert the 74LS32 IC into the breadboard (on bottom).
3. Connect the following wires between:
   a. SW0 Input A (J10) and Pin 1 of top IC.
   b. SW1 Input B (J8) and Pin 2 of bottom IC.
   c. SW0 Input C (J9) and Pin 2 of top IC.
   d. Pin 3 of top IC and Pin 1 of bottom IC.
   e. Pin 3 of bottom IC and LED0 (J14).
   f. Pin 14 of top IC and Pin 14 of bottom IC.
   g. Pin 7 of top IC and Pin 7 of bottom IC.
   h. Pin 14 (VCC) of any IC and J15 (+5V).
   i. Pin 7 (GND) of any IC and J16 (GND).
   j. Using the Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Input A	SW1, Input B	Switch 2, Input C	LED0, Output
Low	Low	Low	Off
Low	Low	High	On
Low	High	Low	Off
Low	High	High	On
High	Low	Low	Off
High	Low	High	On
High	High	Low	On
High	High	High	On

4. Remove the ICs and all wires from the mounting board.
5. Insert the 74LS00 IC into the mounting board and connect the wires following Figures 21 and 76.
6. Draw your own wiring diagram and show it your instructor for approval.
7. Construct the circuit according to your diagram and repeat Step 4. Verify correct outputs.

Quiz 15

1. Check the Truth Table by substituting numbers for letters in the equation: Y = A x B + C. Show each step.
2. Use NORs and INVERTERs to construct a new circuit that provides the same output as this experiment.
3. Write the Boolean equation for the circuit in Question 2 (it should represent the existing gates).
4. Using DeMorgan's Law's, try to get the original expression (A x B) + C.

LAB 16 • Free Running Oscillation and Gated Control

Objective

To connect and test a free running oscillator and a gated, free running oscillator.

Definition

A gated, free running oscillator is an astable logic circuit that provides square wave oscillations on its output just by turning on the power (no input is needed). The square wave is implemented by switching logic levels from high to low and back and forth. The frequency is determined by the values of the capacitor and the resistor.

Usage

Free running oscillators are used as basic clocks for timers, counters, and for reference frequency. When a high rate of accuracy is needed, a quartz crystal is used as a timing element. For this oscillator, will be using a Schmitt Trigger input inverter. A Schmitt Trigger input is a logic gate having input(s) that will produce a clean sharp output pulse even when the input voltage level is changing slowly. They are usually found in oscilloscopes and digital multimeters.

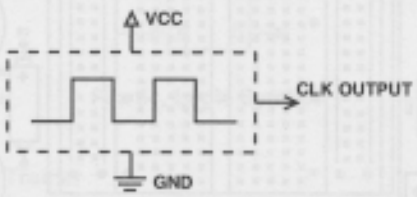


Fig. 51, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS14 IC
- [1] 74LS08 IC
- [1] Capacitor 100 Microfarad
- [1] Resistor 1k ohm
- [8] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

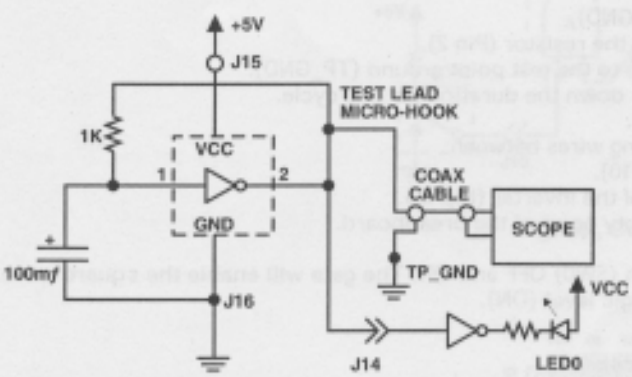


Fig. 52, Circuit Diagram

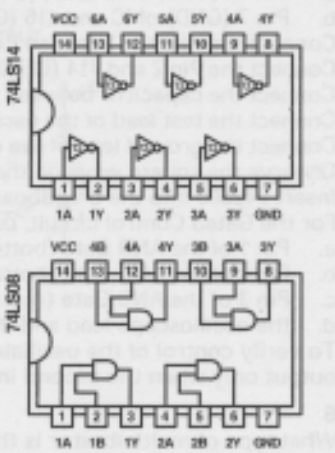
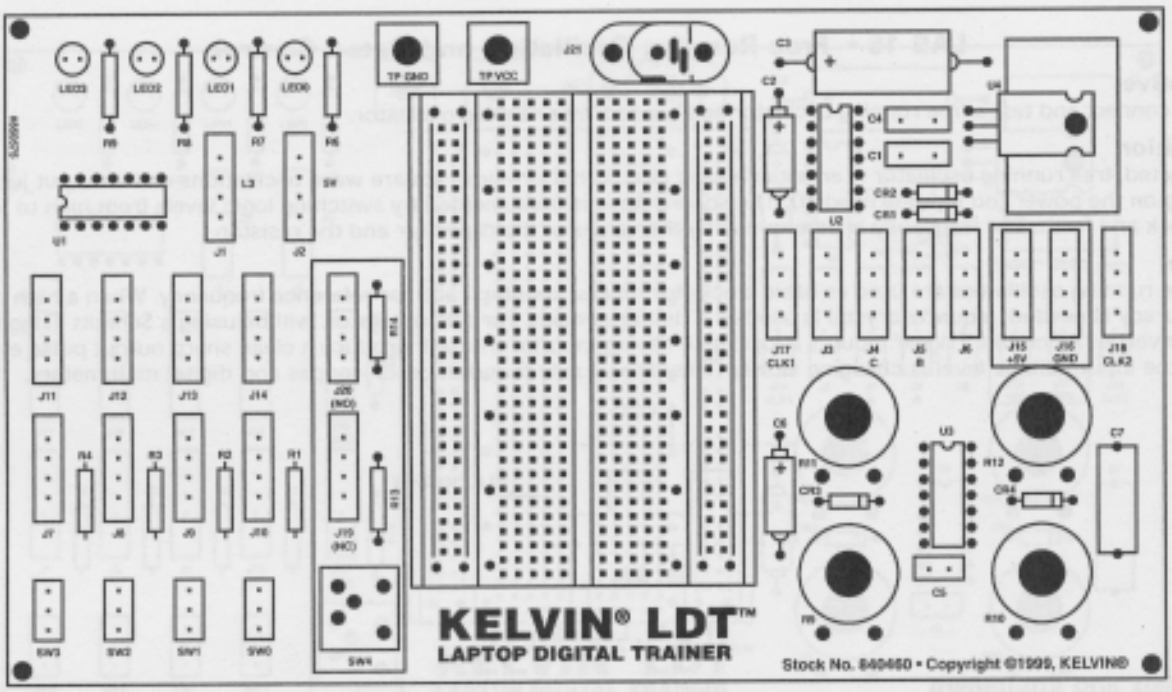


Fig. 53, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS14 IC into the breadboard.
2. Connect the following wires between:
   a. Pin 14 (VCC) of IC and J15 (+5V).
   b. Pin 7 (GND) of IC and J16 (GND).
3. Connect the resistor between Pins 1 and 2 of the IC.
4. Connect the Pin 2 and J14 (LED0).
5. Connect the capacitor between Pin 1 of IC to J16 (GND).
6. Connect the test lead of the oscilloscope probe to the resistor (Pin 2).
7. Connect the ground lead of the oscilloscope probe to the test point ground (TP_GND).
8. Observe the square wave on the screen and write down the duration for one cycle.
9. Insert 74LS08 into the breadboard (at the bottom).
10. For the Gated Control circuit, connect the following wires between:
    a. Pin 1 of the AND Gate (bottom IC) and SW0 (J10).
    b. Pin 2 of the AND Gate (bottom IC) and Pin 2 of the inverter (top IC).
    c. Pin 3 of the AND Gate (bottom IC) and an empty point of the breadboard.
    d. the oscilloscope lead and the AND output.
11. To verify control of the oscillator, turn the switch (SW0) OFF and ON. The gate will enable the square wave output only when the second input is at a high logic level (ON).

Quiz 16

1. What type of multivibrator is the free running oscillator?
2. How can you change the frequency of the output wave?
3. If the AND Gate in the gated oscillator is replaced by a NAND Gate, what is the new condition to enable the clock output?
4. Which built-in IC in the KELVIN® L.D.T.™ Laptop Digital Trainer is functioning as a multivibrator?

LAB 17 • Reset-Set Flip-Flop

Objective

To connect and test a RS Flip-Flop using two NAND Gates.

Definition

A Flip-Flop is a bistable logic circuit with two inputs and two outputs. The two outputs are always the opposite of each other except when "0" is applied at both inputs, in which case both outputs is "1". One is at logic level of "0" or, a reset state, and the other is at a logic level of "1" or, a set state. They can stay in this position as a memory device or they can be changed to a momentary (or permanent) "0" logic level state at the input that did not receive active low input stimulus at the previous state change.

If you change both inputs simultaneously from Low to High, the outputs will complement each other. However, we cannot predict whether the output will be Low or High. The outcome is a random event.

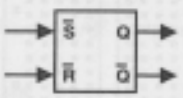


Fig. 54, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [8] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

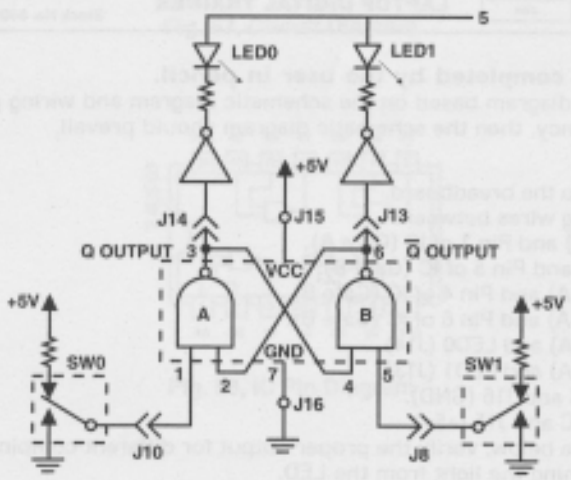


Fig. 55 , Circuit Diagram

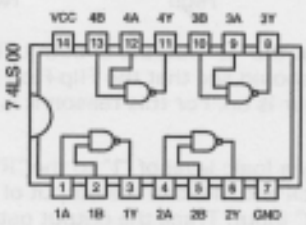
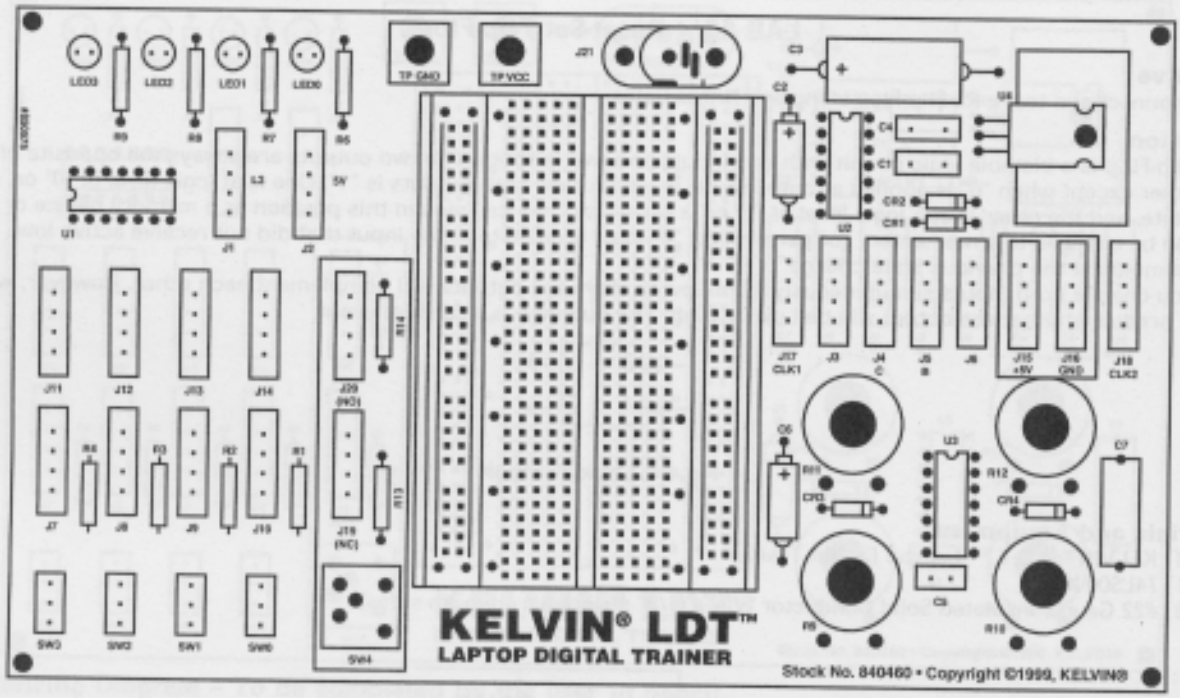


Fig. 56, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert a 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 1 of IC (Gate A).
   b. Switch SW1 (J8) and Pin 5 of IC (Gate B).
   c. Pin 3 of IC (Gate A) and Pin 4 of IC (Gate B).
   d. Pin 2 of IC (Gate A) and Pin 6 of IC (Gate B).
   e. Pin 3 of IC (Gate A) and LED0 (J14).
   f. Pin 6 of IC (Gate A) and LED1 (J13).
   g. Pin 7 (GND) of IC and J16 (GND).
   h. Pin 14 (VCC) of IC and J15 (+5v).
3. Using the Truth Table below, verify the proper output for different combinations of Inputs. Set the OFF and ON Switches while watching the light from the LED.

SW0, Set Input	SW1, Reset Input	LED0, Q Output	LED1, Q Output
Low	Low	On*	On*
Low	High	On	Off
High	Low	Off	On
High	High	No change	No change

4. Check to see if there is a change at the "Q" outputs of both LEDs while transferring the second or third line of the Truth Table to the last line. You should see that the Flip-Flop is a memory device, that is, it will preserve its previous state as long as the power is on. For this reason it is also called a LATCH.

Quiz 17

1. Redraw the circuit diagram. Apply a logic level of "1" to the "R" input and a logic level of "0" to the "S" input. Trace the output path with a pencil and indicate the output of each gate.
2. Apply a logic level of "0" to the "R" input. Trace the output path with a pencil and indicate the output of each gate. (HINT – Use the NAND Gate Truth Table.)
3. Did you see any change at the output after Question 1? Explain why or why not.

LAB 18 • Debounced Switch

Objective

To connect and test a debouncing circuit made of a momentary pushbutton switch, two resistors, and two gates of an 74LS00 IC.

Definition

A Debounced Switch is a circuit that eliminates the spike (electronic noise/pulses) that is generated while switching any type of mechanical switch. A pushbutton switch is used as the input of a RS Flip-Flop with two resistors. This provides two different outputs: positive and negative pulse.

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [1] Dual Trace Oscilloscope
- [8] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

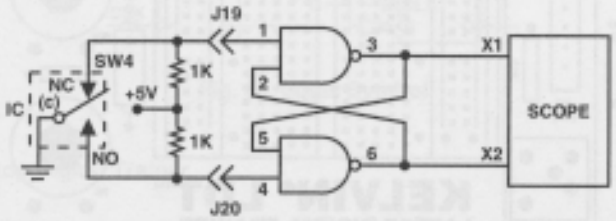


Fig. 57, Circuit Diagram

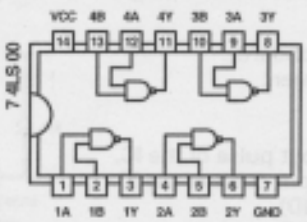
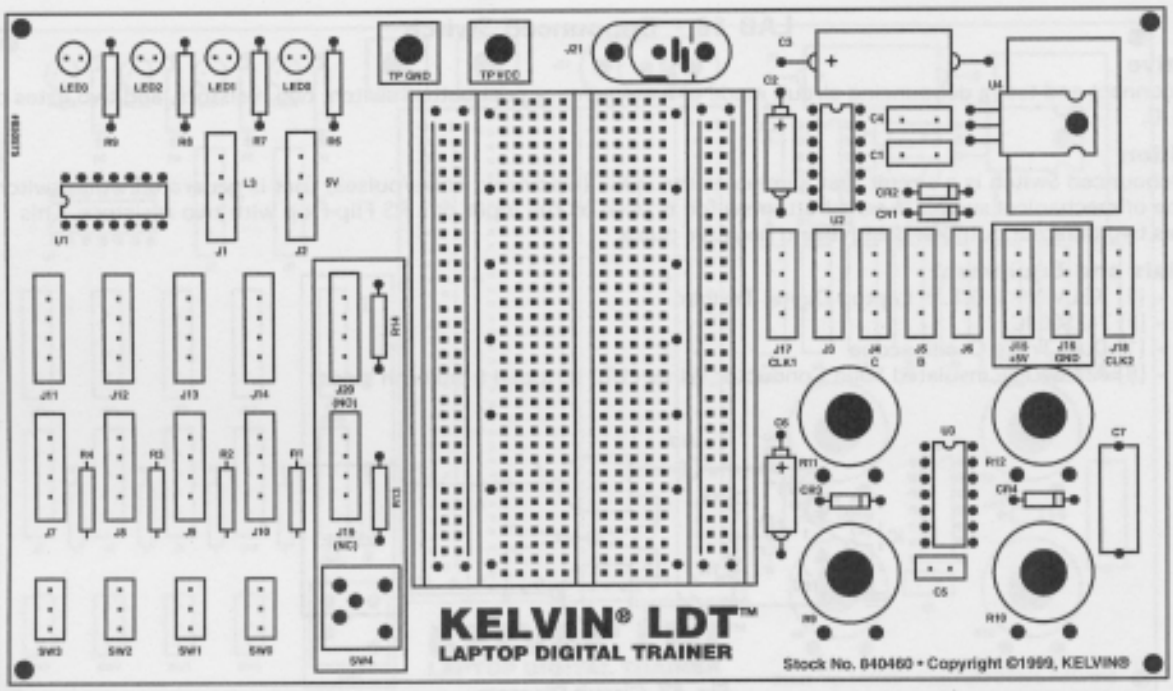


Fig. 58, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. Pin 1 of IC and J20.
   b. Pin 4 of IC and J19.
   c. Pins 2-6 and the positive output pulse of the IC.
   d. Pins 5-3 and the negative output pulse of the IC.
   e. Pin 7 (GND) of IC and J16 (GND).
   f. Pin 14 (VCC) of IC and J15 (+5V).
3. Use the dual trace oscilloscope to observe the output pulses. Connect the positive lead of "X1" from the oscilloscope to Pin 3 of the IC. Connect the positive lead of "X2" from the oscilloscope to Pin 6 of the IC. Connect the Ground lead of the oscilloscope to J16 (GND).
4. Push Switch SW4 and release it immediately. The waves shown below should appear on your oscilloscope screen.

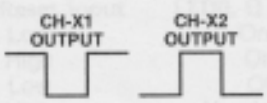


Fig. 59, Pulse Waves

5. For future labs with the Flip-Flops you will need an accurate square wave. Practice it by getting it from Pin 3 or Pin 6, depending on what type of pulse is needed, negative or positive respectively.

Quiz 18

1. Why use a debounced switch circuit in digital electronics?
2. Multivibrators are classified into these types: Astable, Monostable, and Bistable. What type is your debouncing circuit?

LAB 19 • Delay or Data (D-Type) Flip-Flop

Objective

To connect and test a Delay or Data (or D-type) Flip-Flop using IC 74LS74 using the two operating modes (synchronous and asynchronous).

Definition

A D Flip-Flop is bistable logic circuit with clock and date inputs. The outputs are "Q" (normal) and "Q/" (complementary). When operating the Flip-Flop in synchronous mode the output "Q" will follow the input "D" at the occurrence of the positive edge of the clock input, and will save that output state until the next positive clock input (and so on). The asynchronous mode is used to set or to reset the output regardless of the clock pulse.

Usage and Application

D Flip-Flops are wired together to form shift registers and storage registers. they are widely used in digital electronics.

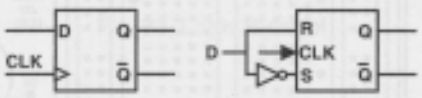


Fig. 60, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS74 IC
- [1] 74LS00 IC
- [9] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

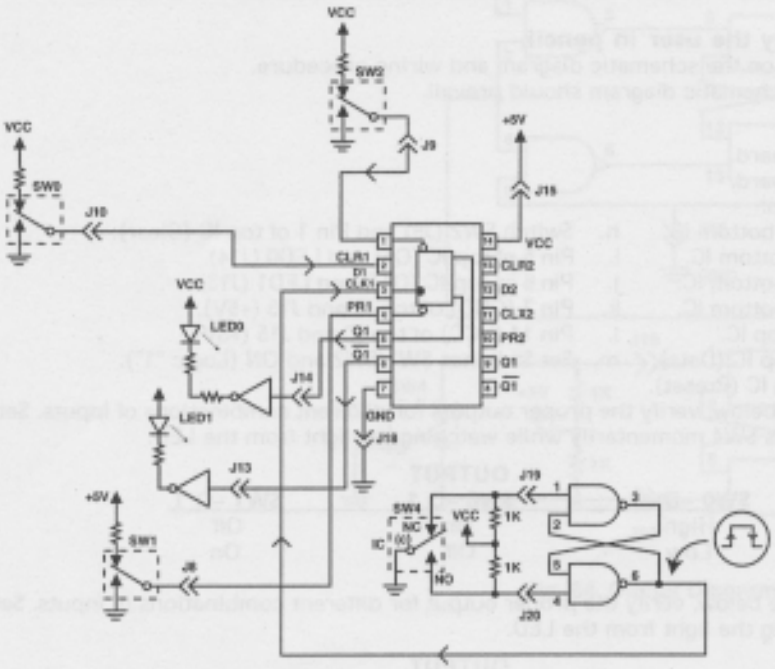


Fig. 61, Circuit Diagram

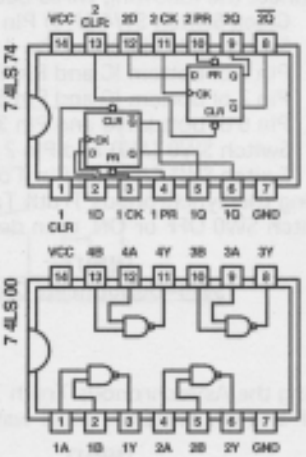
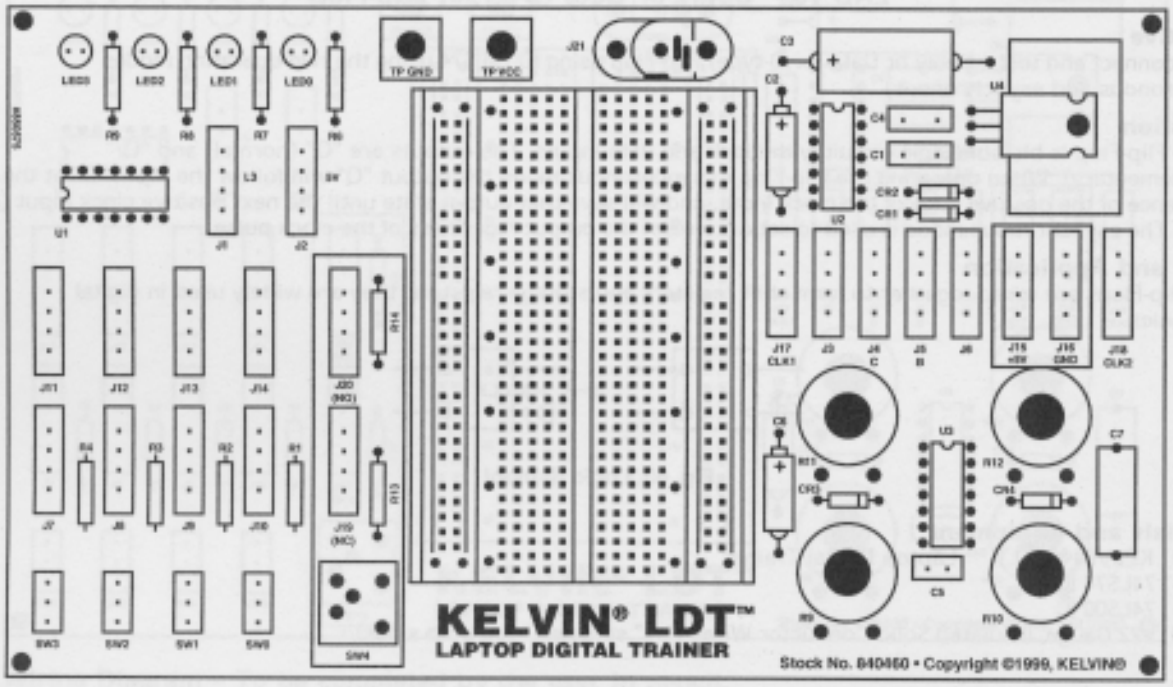


Fig. 62, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS74 IC into the breadboard.
2. Insert the 74LS00 IC into the breadboard.
3. Connect the following wires between:
   a. Clock Switch SW4 (J19) Pin 1 of bottom IC.
   b. Switch SW4 (J20) and Pin 4 of bottom IC.
   c. Pin 3 of bottom IC and Pin 5 of bottom IC.
   d. Pin 2 of bottom IC and Pin 6 of bottom IC.
   e. Pin 6 of bottom IC and Pin 3 of top IC.
   f. Switch SW0 (J10) and Pin 2 of top IC (Data).
   g. Switch SW1 (J8) and Pin 4 of top IC (Preset).
   h. Switch SW2 (J9) and Pin 1 of top IC (Clear).
   i. Pin 5 of top IC (Q1) and LED0 (J14).
   j. Pin 6 of top IC (Q1/) and LED1 (J13).
   k. Pin 7 (GND) of top IC and J15 (+5V).
   l. Pin 14 (VCC) of top IC and J15 (+5V).
   m. Set Switches SW1/SW2 and ON (Logic "1").
4. Using the Synchronous Truth Table below, verify the proper outputs for different combinations of Inputs. Set the Switch SW0 OFF or ON, then depress SW4 momentarily while watching the light from the LED.

INPUT		OUTPUT	
SW4–Debounced Clock	SW0 –Data	SW0 –Q 1	SW1 –Q 1
	High	On	Off
	Low	Off	On

5. Using the Asynchronous Truth Table below, verify the proper output for different combinations of inputs. Set the OFF and ON Switches while watching the light from the LED.

INPUT		OUTPUT	
SW1 –Preset	SW02 –Clear	LED0 –Q 1	LED1 –Q 1
Low	Low	On	On
Low	High	Off	On
High	High	See Synchronous Mode Truth Table	

Quiz 19

1. Explain the difference between the terms: Asynchronous mode and synchronous mode.
2. What is the logic levels at Q and Q/ of a D flip-flop with the following conditions:
   a. Preset = 1 Clear = 1 Data = 0 and a positive clock pulse is just received.
   b. Preset = 0 Clear = 1 Data = 1 and a positive clock pulse is just received

LAB 20 • Toggle (T-Type) Flip-Flop

Objective

To connect and test a Toggle Flip-Flop using an 74LS00 IC (four NAND Gates).

Definition

A Toggle (T) Flip-Flop is a bistable logic circuit with one input (T) and two outputs (Q and Q/). The outputs are always different. The T Flip-Flop is also known as a complementary flip-flop. The outputs will also toggle (reverse logic states) only when a positive transition, a change from Low to High, appears at the input. Otherwise the output "remembers" the last state and remain the same.

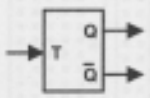


Fig. 63, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS00 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

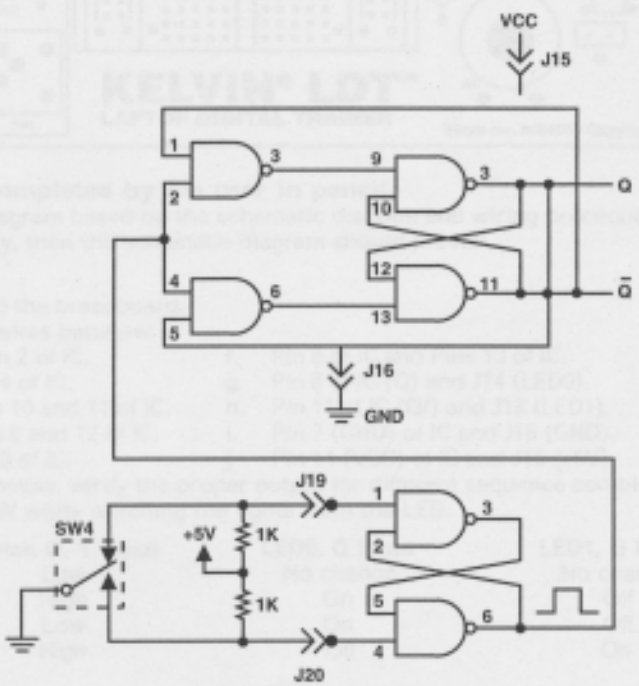


Fig. 64, Circuit Diagram

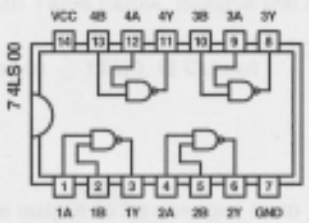
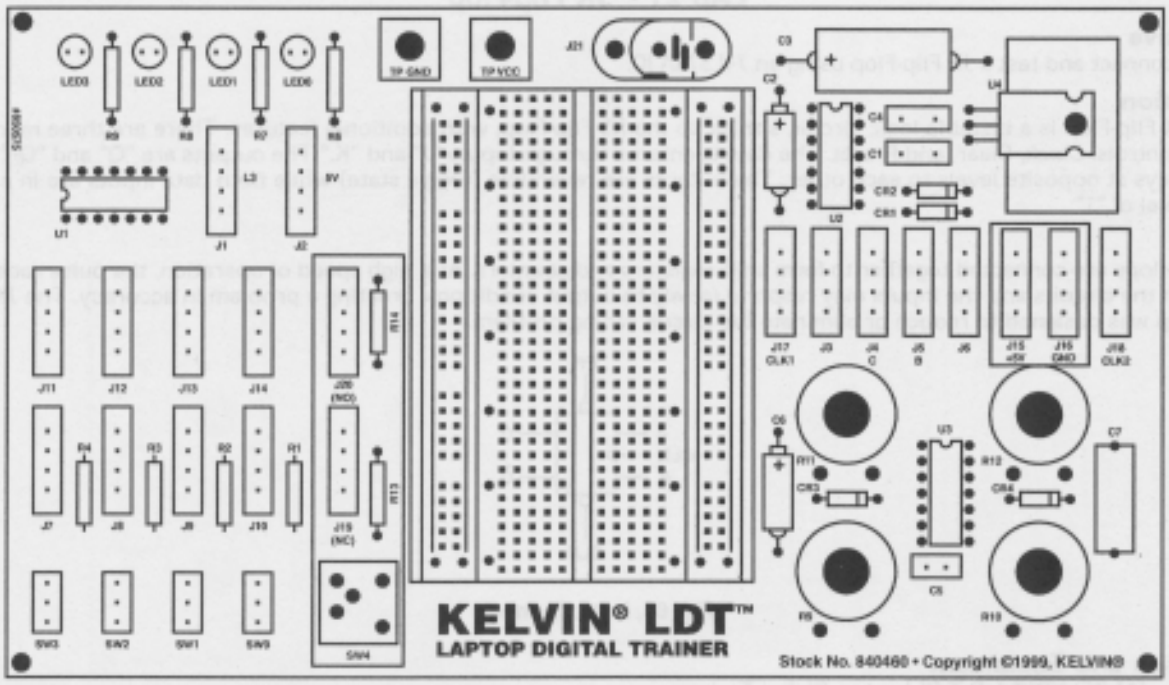


Fig. 65, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS00 IC into the breadboard.
2. Connect the following wires between:
   a. Switch SW0 and Pin 2 of IC.
   b. Pin 2 of IC and Pin 4 of IC.
   c. Pin 1 of IC and Pins 10 and 11 of IC.
   d. Pin 5 of IC and Pins 8 and 12 of IC.
   e. Pin 3 of IC and Pin 9 of IC.
   f. Pin 6 of IC and Pins 13 of IC.
   g. Pin 8 of IC (Q) and J14 (LED0).
   h. Pin 11 of IC (Q/) and J13 (LED1).
   i. Pin 7 (GND) of IC and J16 (GND).
   j Pin 14 (VCC) of IC and J15 (+5V).
3. Using the Truth Table below, verify the proper output for different sequence combinations of input. Set the switches HIGH and LOW while watching the lights from the LED.

Switch O, T Input	LED0, Q Input	LED1, Q Input
Low	No change	No change
High	On	Off
Low	On	Off
High	Off	On

4. Verify that there is no change at the "Q" and "Q/" outputs while you transfer from ON to OFF at the input. Also verify that the outputs are toggled (changing positions) when you change the input from OFF to ON.
5. Disconnect Pin 2 of the IC from Switch SW0 (J10) and connect it to the Pushbutton Switch SW4 (J19).
6. Hold Switch SW4 in the "pushed" position (T input = ON).
7. Push the switch again and write the new outputs.
8. Write the output indications in the Truth Table below. Release the switch (T input = OFF) and write the outputs again.

Switch 4, Debounced = T Input	LED0, Q Output	LED1 Q, Output
Push Then Release		
Push Then Release		

Quiz 20

1. What does the letter "T" stand for?
2. Every change in the input will cause the output to be changed from _____ to _____ and from _____ to _____.
3. Look at the circuit diagram of the T Flip-Flop and "remove" 2 wires to get RS Flip-Flop. Which wires did you remove?
4. Where are the inputs of the new circuit from question 2?

LAB 21 • JK Flip-Flop

Objective

To connect and test a JK Flip-Flop using an 74LS76A IC.

Definition

A JK Flip-Flop is a bistable logic circuit, similar to the RS Flip-Flop, with additional features. There are three more input controls: Clock, Clear, and Preset. The date is entered through inputs "J" and "K." The outputs are "Q" and "Q/" that are always at opposite levels to each other. The outputs are reversible (toggle state) while both data inputs are in a logic level of "1".

Usage

Flip-flops are connected together to form shift registers and counters. At a high speed of operation, the pulse races through the circuits and the inputs may respond falsely to output conditions, creating a problem in accuracy. The JK Flip-Flop was designed to reduce or eliminate the circuit racing problem.

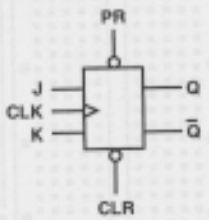


Fig. 66, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS76A IC
- [1] 74LS00 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

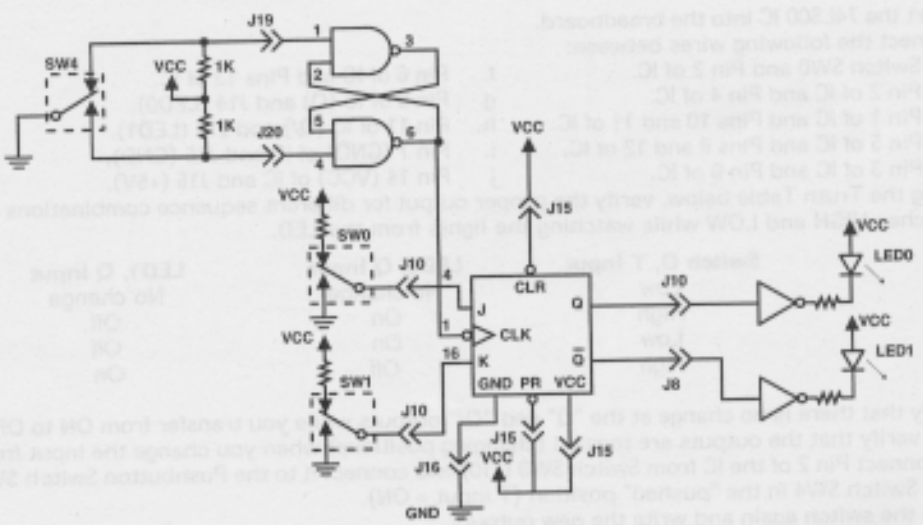


Fig. 67, Circuit Diagram

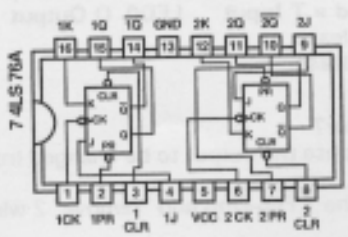
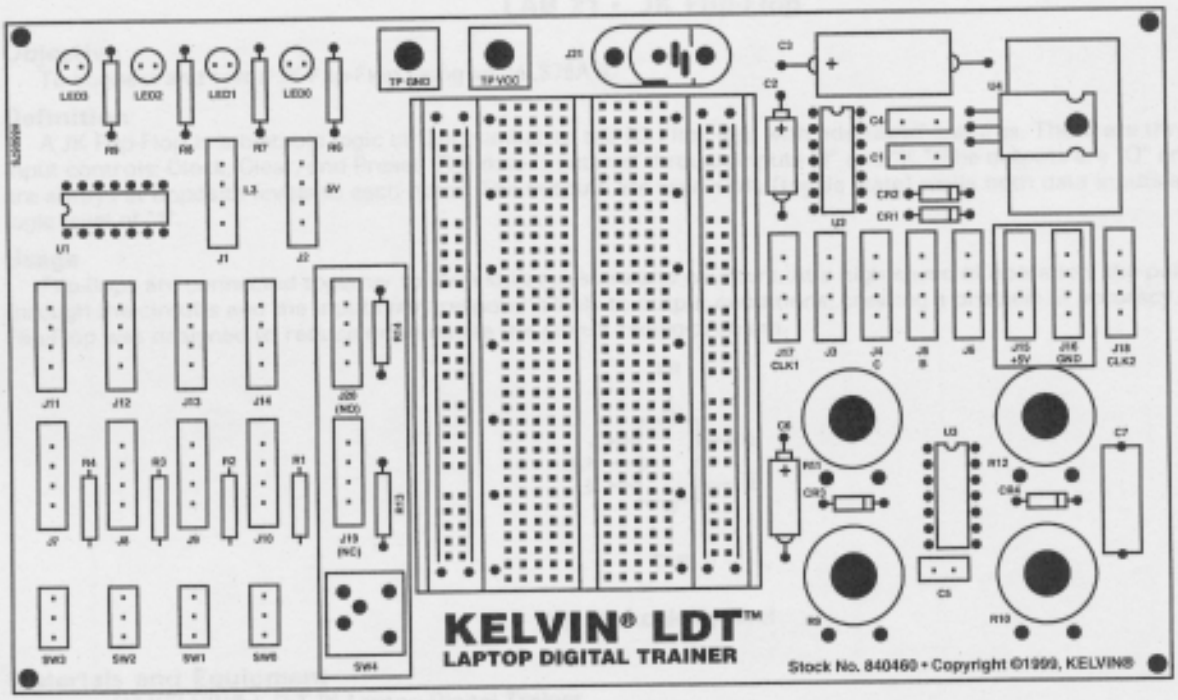


Fig. 68, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS76A IC into the breadboard.
2. Insert the 74LS00 IC into the breadboard.
3. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 4 of top IC.
   b. Switch SW4 (J20) and Pin 4 of bottom IC.
   c. Pin 3 of bottom IC and Pin 5 of bottom IC.
   d. Pin 2 of bottom IC and Pin 6 of bottom IC.
   e. Pin 6 of bottom IC and Pin 3 of top IC.
   f. Switch SW1 (J8) and Pin 16 of top IC (K1).
   g. Output of momentary switch SW(J19) to Pin 1 of bottom IC.
   h. Pin 2 of top IC (PR1) and Pin 3 of IC (CLR1).
   i. Pin 15 of top IC (Q1) and LED0 (J14).
   j. Pin 14 of top IC (Q1) and LED1 (J13).
   k. Pin 13 (GND) of top IC and J16 (GND).
   l. Pin 5 (VCC) of top IC and J15 (+5V).
   m. Pin 2 of top IC (PR1) and J15 (+5V).
4. Using the Truth Table below, verify the proper outputs for different combinations of Inputs. Set the switches to HIGH and LOW positions while watching the light from the LED. Notice that the clock transition will allow the next state to be performed by pushing SW4.

SW4, Debounced Clock	SW0, J Input	SW1, K Input	LED0, Q Output	LED1, Q/Output
	Low	Low	No Change	No Change
	Low	High	Off	On
	High	Low	On	Off
	High	High	Toggle	Toggle

5. Verify that there is no change at "Q" and "Q/" outputs while transferring the second, third, or fourth line of the Truth Table to the first line. You should see that the flip-flop is memorizing the last state.

Quiz 21

1. Draw two JK Flip-Flops. The first flip-flop (FF-1) should be on the left and the second flip-flop "FF-2" on the right. "Q1" and "J2" connected together, "Q1/" and "K2" connected together. The inputs are: J1=OFF, K1=ON and clock. The pushbutton is pushed to provide a positive pulse. Trace your circuit with a pencil to show the output logic levels at "Q2" and "Q2/."
2. Use the circuit from Question 1 to check what the new outputs are if the logic level of "1" is applied to both inputs "J1" and "K1."

LAB 22 • TTL311 HEXADECIMAL DISPLAY

Objective

To connect and test an hexadecimal display TTL311.

Definition

Hexadecimal displays have a four bit latch, decoder, driver, and 4 x 7 LED character including decimal point. The inputs are binary numbers from 0000 to 1111. The display shows the following hexadecimal numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

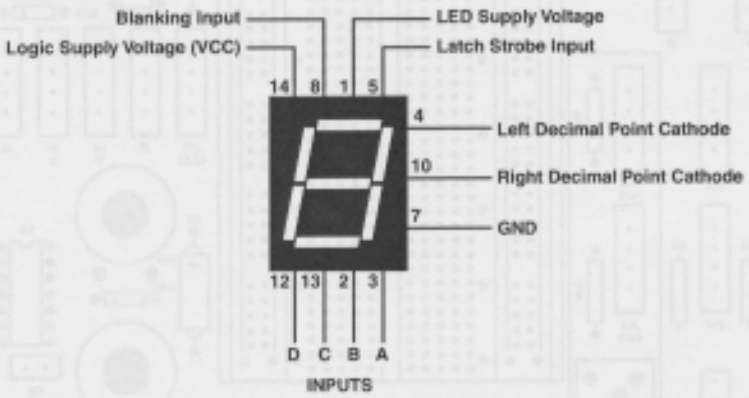


Fig. 69, Logic Symbol

Materials and Equipment

- [1] KELVIN® LDT IC Trainer
- [1] TTL311 Hex Display (Built In)
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

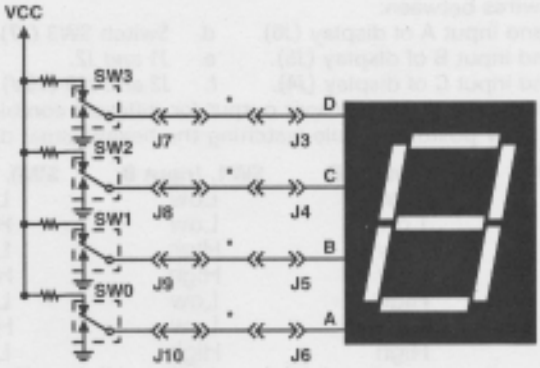
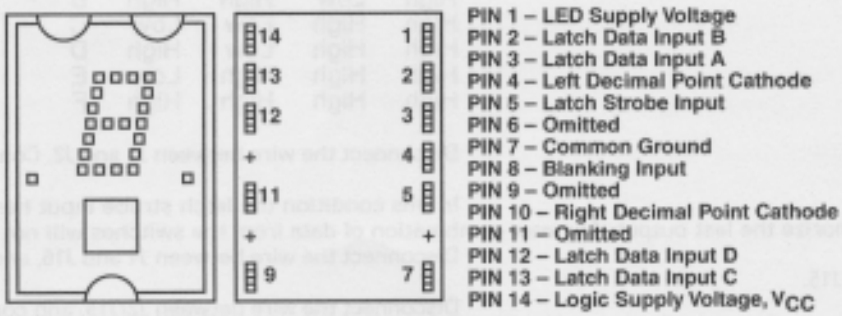
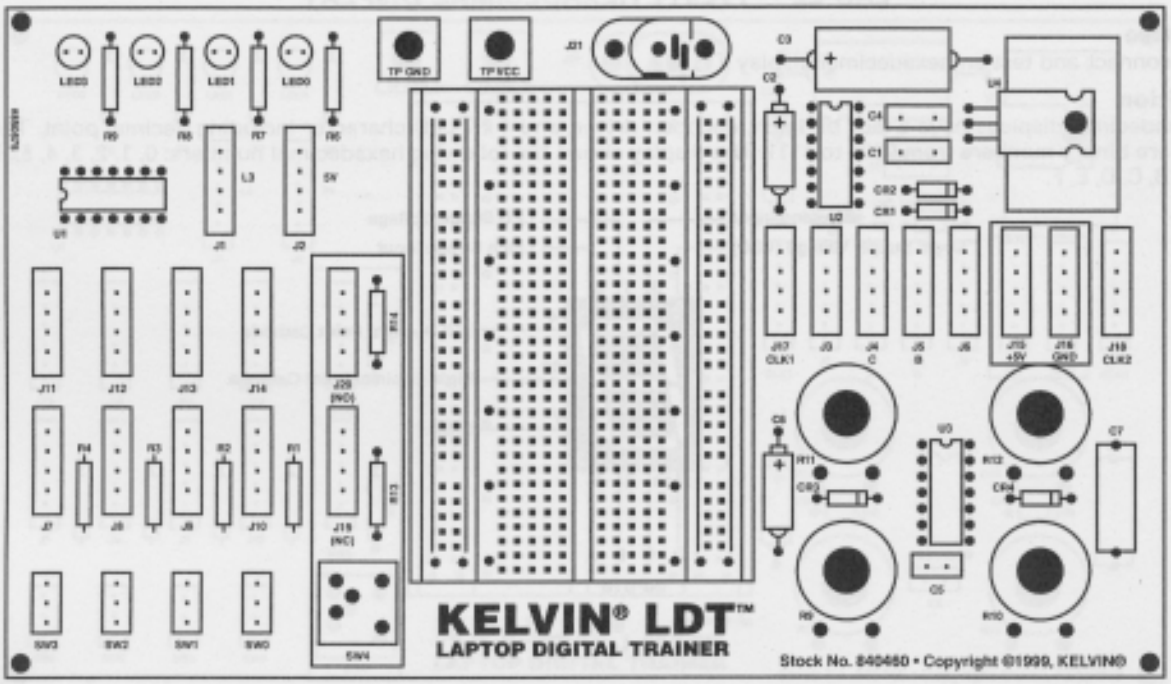


Fig. 70, Circuit Diagram



PIN 1 – LED Supply Voltage
PIN 2 – Latch Data Input B
PIN 3 – Latch Data Input A
PIN 4 – Left Decimal Point Cathode
PIN 5 – Latch Strobe Input
PIN 6 – Omitted
PIN 7 – Common Ground
PIN 8 – Blanking Input
PIN 9 – Omitted
PIN 10 – Right Decimal Point Cathode
PIN 11 – Omitted
PIN 12 – Latch Data Input D
PIN 13 – Latch Data Input C
PIN 14 – Logic Supply Voltage, V_{CC}

Fig. 71, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Connect the following wires between:
   a. Switch SW0 (J10) and input A of display (J6).
   b. Switch SW1 (J9) and input B of display (J5).
   c. Switch SW2 (J8) and input C of display (J4).
   d. Switch SW3 (J7) and input D of display (J3).
   e. J1 and J2.
   f. J2 and J15 (+5V).
2. Using the Truth Table below, verify the proper output for different combinations of inputs. You have to set the switches to HIGH and LOW positions while watching the hexadecimal display.

SW3, Input D	SW2, Input C	SW1, Input B	SW0, Input A	Display Output
Low	Low	Low	Low	0
Low	Low	Low	High	1
Low	Low	High	Low	2
Low	Low	High	High	3
Low	High	Low	Low	4
Low	High	Low	High	5
Low	High	High	Low	6
Low	High	High	High	7
High	Low	Low	Low	8
High	Low	Low	High	9
High	Low	High	Low	A
High	Low	High	High	B
High	High	Low	Low	C
High	High	Low	High	D
High	High	High	Low	E
High	High	High	High	F

3. Disconnect the wire between J1 and J2. Connect wire between J1 and J16.
4. In this condition the latch strobe input has high logic level that will memorize the last output. Any new combination of data from the switches will not change the output.
5. Disconnect the wire between J1 and J16, and connect it between J1 and J15.
6. Disconnect the wire between J2/J15, and connect it between J2/J16. In this condition, the display is blanked out.

Quiz 22

1. Convert from hexadecimal numbers to binary numbers:

a. C = ? b. E = ? c. 7 = ? d. 4 = ?

2. How would you memorize the last state of the hexadecimal display output?

LAB 23 • 74LS93 FOUR BIT COUNTER

Objective

To connect and test a 4-bit counter using IC 74LS93. The outputs are observed by 2 methods: 4 LED's and Hex display.

Definition

Digital circuit that contains 4 JK Flip-Flops connected together. The input is a clock pulse and the output is an indication of the number of pulses that arrived in sequence into the input. Each Q output of a flip-flop represents one binary digit. The counter counts up to 16 events (pulses) or from 0000 to 1111 (binary).

Usage and Application

Counters are made for counting and timing purposes in many electronic instruments. A simple example is the digital watch. Some counters can count up, others count down, and also both options are available in one unit. Digital multimeters using counters to measure the voltage, current, or resistance.

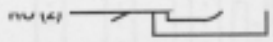


Fig. 72, Logic Symbol

Materials and Equipment

- [1] KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS93 IC
- [10] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

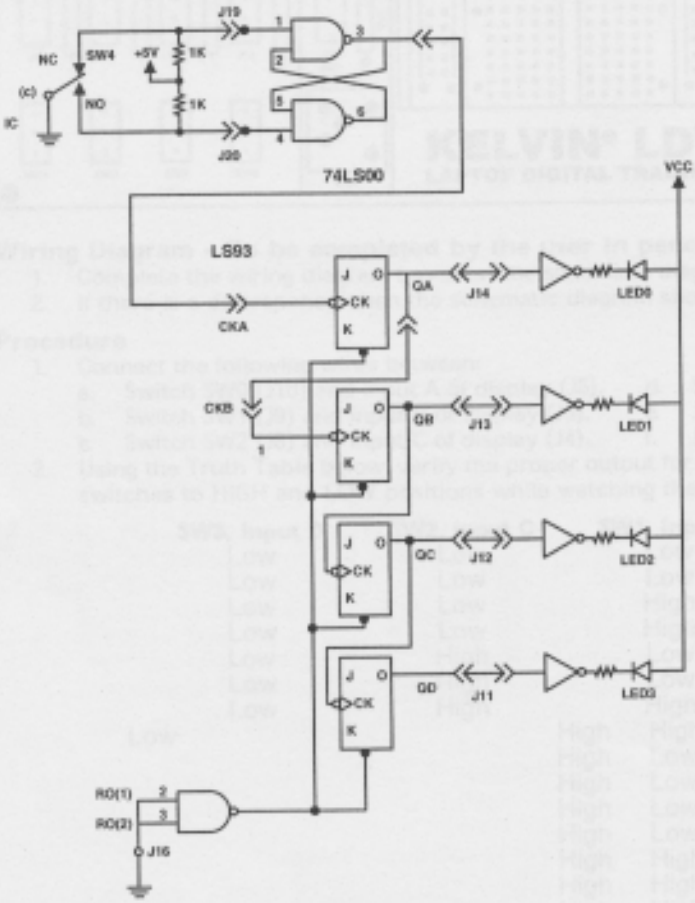


Fig. 73, Circuit Diagram

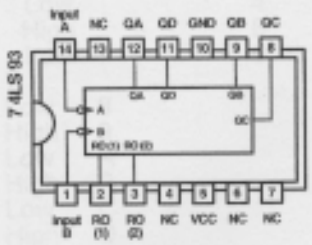
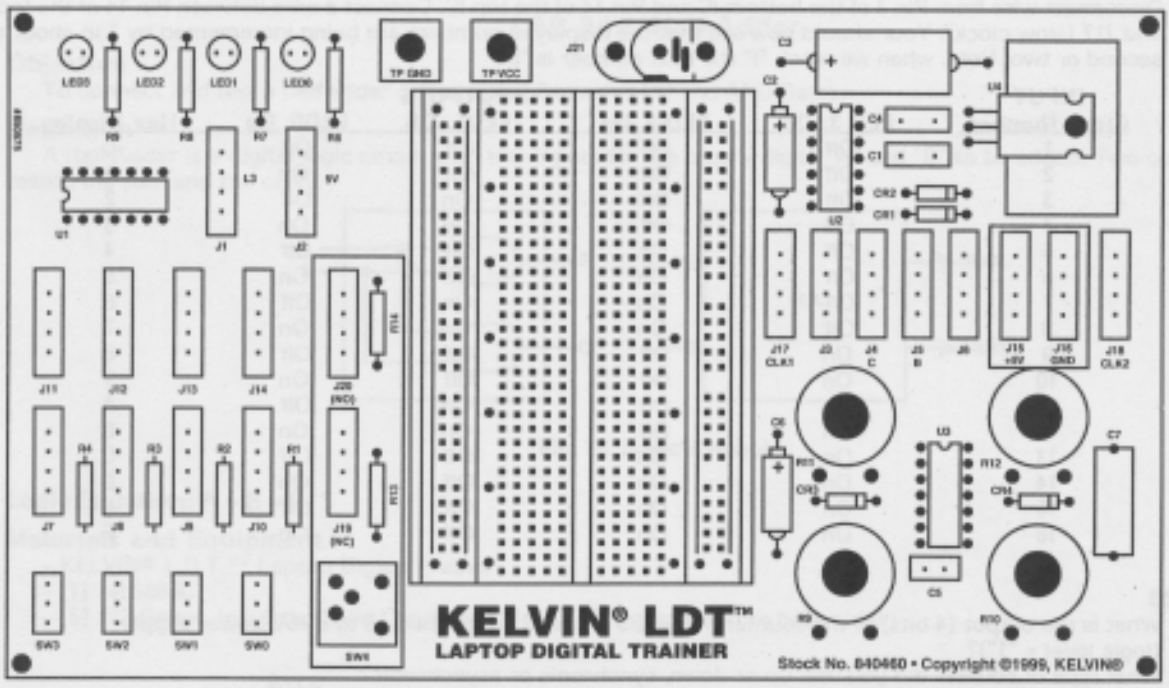


Fig. 74, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS93 IC into the top of the breadboard
2. Insert the 74LS00 IC into the bottom of the breadboard.
3. Connect the following wires between:
   a. Pin 1 of top IC and Pin 12 of top IC.
   b. Pin 12 of top IC (Qa) and LED0 (J14).
   c. Pin 9 of top IC (Qb) and LED1 (J13).
   d. Pin 8 of top IC (Qc) and LED2 (J12).
   e. Pin 11 of top IC (Qd) and LED3 (J11).
   f. Pin 2 of top IC and Pin 3 of IC.
   g. Pin 3 of top IC and J16 (GND).
   h. Pin 10 (GND) of top IC and J16 (GND).
   i. Pin 5 (VCC) of top IC and J15 (+5V).
   j. Pin 14 of top IC and Pin 3 of the bottom IC.
   k. Pin 5 of top IC and Pin 3 of bottom IC.
   l. Pin 2 of the bottom IC and Pin 6 of the bottom IC.
   m. J19 (SW4 - normally closed contact) and Pin 1 of the bottom IC.
   n. J20 (SW4 - normally open contact) and Pin 4 of the bottom IC.
4. Use a Truth Table to verify the proper output from the LED's. After you turn the power on, all LED's should show "0"'s, if not, push SW4 until all the LED's are OFF. Any push of Switch 4 (SW4) will increase the binary readout by 1. The maxim is 1111.
5. Disconnect the 4 wires from the LED's and connect them to the Hex display as follows:
   a. Pin 12 (Qa) of top IC and J6 (input A of hex display).
   b. Pin 9 (Qb) of top IC and J5 (input B of hex display).
   c. Pin 8 (Qc) of top IC and J4 (input C of hex display).
   d. Pin 11 (Qd) of top IC and J3 (input D of hex display).
6. Repeat all steps of the Truth Table and check the proper output for each clock pulse. Compare your results to the data in the right column of the Truth Table.

7. Disconnect wire from Pin 3 of the bottom IC and Pin 14 of the top IC. Connect a wire between Pin 14 of the top IC and J17 (slow clock). Your should now see that the displayed numbers are being incremented by 1 in about a second or two. Note, when we reach "f" the next number is "0".

INPUT	OUTPUTS				
Clock Number	LED 3, Qd	LED 2, Qc	LED1, Qb	LED0, Qa	Hex Display
1	Off	Off	Off	Off	0
2	Off	Off	Off	On	1
3	Off	Off	On	Off	2
4	Off	Off	On	On	3
5	Off	On	Off	Off	4
6	Off	On	Off	On	5
7	Off	On	On	Off	6
8	Off	On	On	On	7
9	On	Off	Off	Off	8
10	On	Off	Off	On	9
11	On	Off	On	Off	A
12	On	Off	On	On	B
13	On	On	Off	Off	C
14	On	On	Off	On	D
15	On	On	Off	Off	E
16	On	On	Off	On	F

Quiz 23

1. What is the output (4 bits) of the counter if Pins 2-3 of the IC are connected to a +5V power supply (logic level = "1")?
2. What type of counter did you use: up or down, synchronic or asynchronic?
3. If you disconnect the wire between Pins 1-12 and apply the clock to input "B" (Pin 1), you will get a new counter.
   a. In the new circuit, how many bits are there at the output?
   b. What is the maximum number at the outputs?

LAB 24 • Half-Adder

Objective

To connect and test a half-adder circuit using Exclusive-OR and AND Gates.

Definition

A Half-Adder is a digital logic circuit with two inputs for the binary digits "A" and "B" to be added. Two outputs is the result, the sum and the carry.

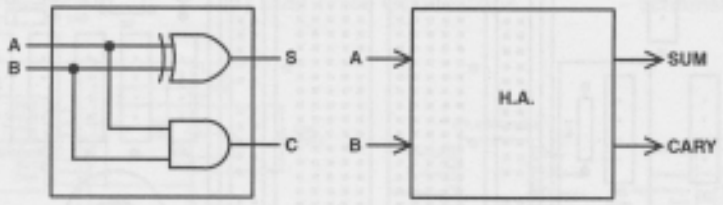


Fig. 75, Logic Symbol

Logic Equation: A + B = C, S

Materials and Equipment

- KELVIN® L.D.T.™ Laptop Digital Trainer
- [1] 74LS86 IC
- [5] #22 Gauge, Insulated Solid Conductor Wires (1/8" stripped from both sides)

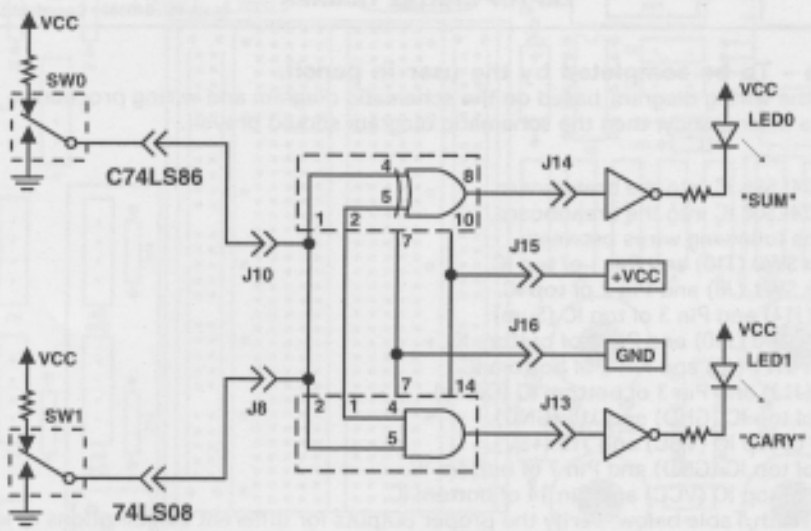


Fig. 76, Circuit Diagram

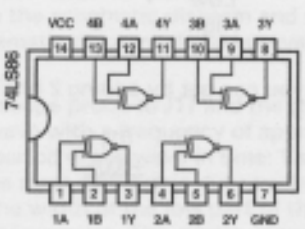
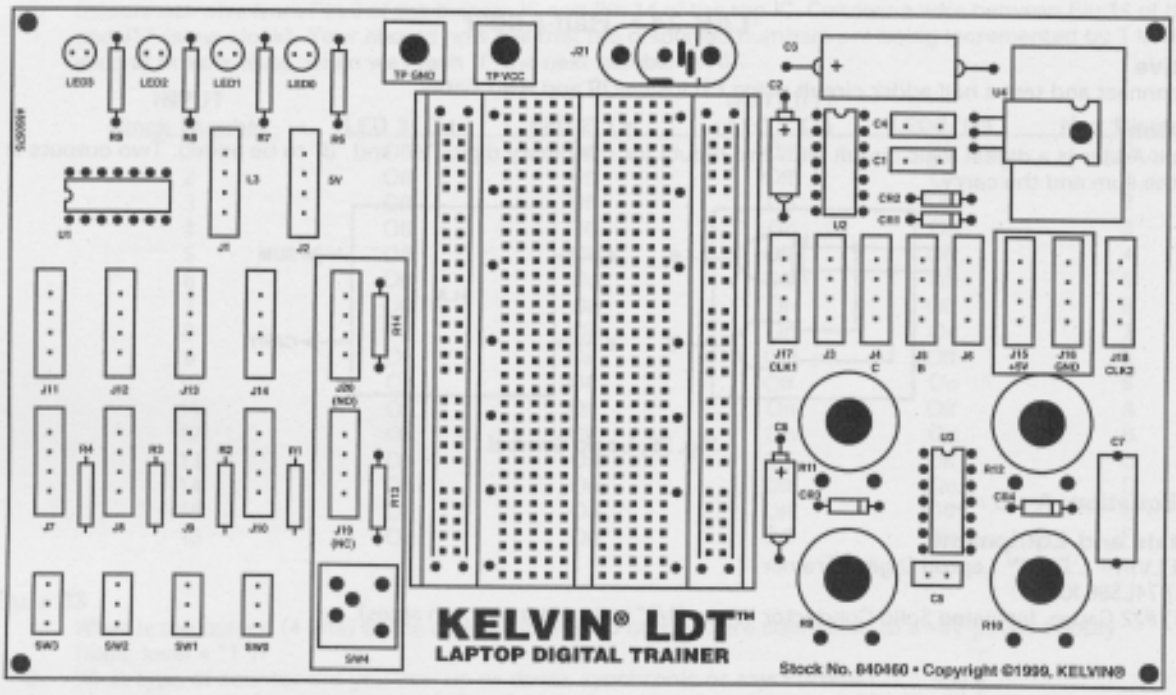


Fig. 77, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Insert the 74LS86 IC into the breadboard.
2. Insert the 74LS08 IC into the breadboard.
3. Connect the following wires between:
   a. Switch SW0 (J10) and Pin 1 of top IC.
   b. Switch SW1 (J8) and Pin 2 of top IC.
   c. LED0 (J14) and Pin 3 of top IC (Sum).
   d. Switch SW0 (J10) and Pin 1 of bottom IC.
   e. Switch SW1 (J8) and Pin 2 of bottom IC.
   f. LED1 (J13) and Pin 3 of bottom IC (Carry).
   g. Pin 7 of top IC (GND) and J16 (GND).
   h. Pin 14 of top IC (VCC) and J15.(+5V).
   i. Pin 7 of top IC (GND) and Pin 7 of bottom IC.
   j. Pin 14 of top IC (VCC) and Pin 14 of bottom IC.
4. Using the Truth Table below, verify the proper outputs for different combinations of Inputs. Set the switches to HIGH and LOW positions while watching the light from the LED.

SW0, Input A	SW1, Input B	LED1, Carry	LED0, Sum
Low	Low	Off	Off
Low	High	Off	On
High	Low	Off	On
High	High	On	Off

Quiz 24

1. What is the maximum result that you can get by adding 2 bits?
2. Add the following binary types:
   a. 1101 + 0011
   b. 0111 + 0001

LAB 25 • Built-In Clock Generator

Objective

A dual astable multivibrator is available in the KELVIN® LDT Kit. The 556 IC is used in a special configuration with RC (Resistor Capacitor) timing circuits to provide two square wave outputs. (High frequency output and low frequency output). The frequency and duty cycles are adjustable.

Materials and Equipment

- [1] KELVIN® LDT IC Trainer Kit
- [1] Dual Trace Oscilloscope
- Schematic Diagram

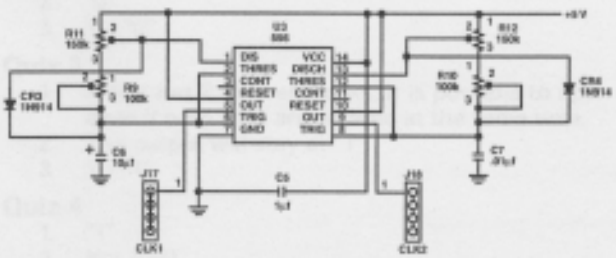


Fig. 78, Circuit Diagram

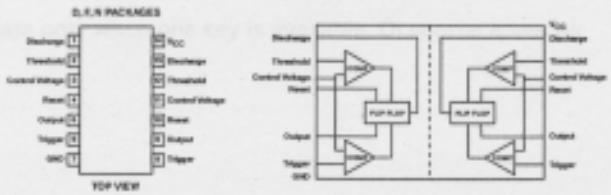
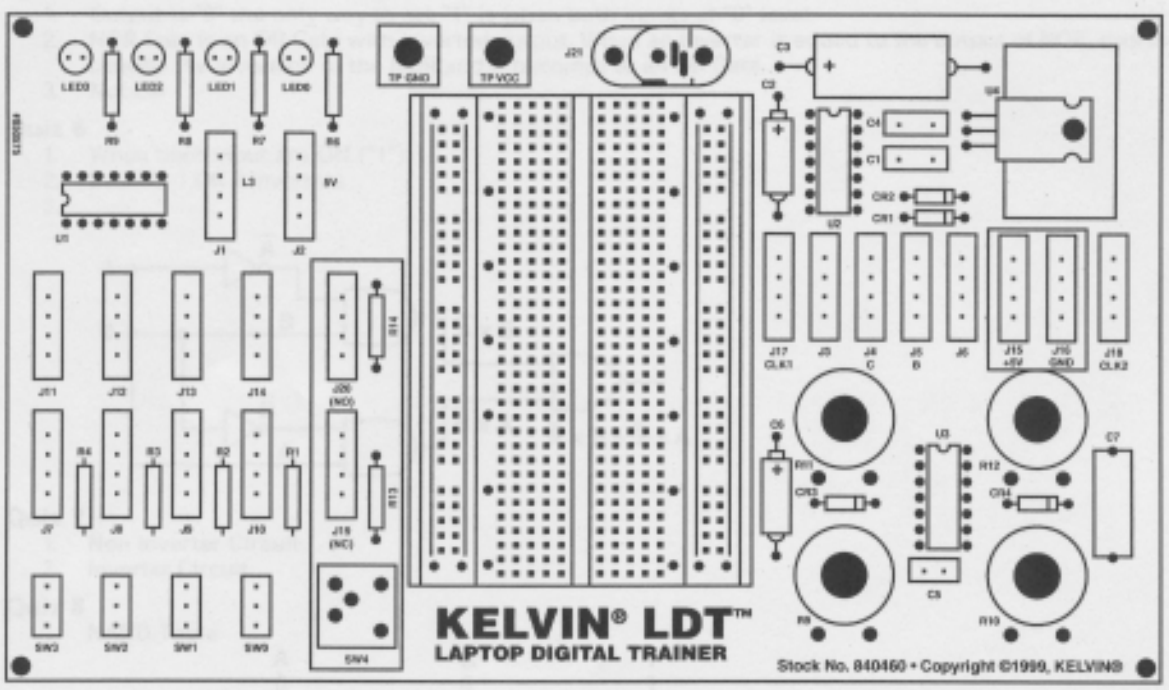


Fig. 79, IC Pin Diagram



Wiring Diagram – To be completed by the user in pencil.

1. Complete the wiring diagram based on the schematic diagram and wiring procedure.
2. If there is a discrepancy, then the schematic diagram should prevail.

Procedure

1. Connect the positive lead of the oscilloscope probe to J17 and the ground lead of the probe to TP_GND.
2. Adjust potentiometer R9 to receive a wave with a frequency of approximately 1 Hz on your oscilloscope screen. (It is more convenient to measure the period of the wave in time: 1 seconds, 2 seconds, etc.)
3. Adjust potentiometer R11 to receive the most symmetric duty cycle possible. The duty cycle is symmetric when the width of the high part is equal to the width of the low part of the square wave.
4. Repeat Step 3 to receive different low frequencies. The minimum you can get is 0.9 Hz and the maximum is 2 Hz.
5. Adjust R11 and observe the change of the duty cycle on your scope.
6. Connect the positive lead of the oscilloscope probe to J18 and the ground lead of the probe to TP_GND.
7. Adjust the potentiometer R10 to receive a wave with a frequency of approximately 2 kHz on your oscilloscope screen. (It is more convenient to measure the period of the wave by time: milliseconds.)
8. Adjust potentiometer R12 to receive the most symmetrical duty cycle you can get.
9. Repeat Step 9 to receive different high frequencies. The minimum should be 1.2 kHz and the maximum 3.3 kHz.

QUIZ ANSWERS

Quiz 1

1. A logic circuit with one input and one output. The logic levels are always opposite of each other.
2. 2
3. 6
4. Pins 7 and 14.

Quiz 2

1. Logic circuit that provides "1" at the output only when all inputs are "1"s.
2. "0"
3. Y = "0"

Quiz 3

1. A safe has 2 different locks. It is possible to open the safe only when one key is available. Of course it can be open if both keys are entered at the same time.
2. The output will stay at "1".
3. Y = "1"

Quiz 4

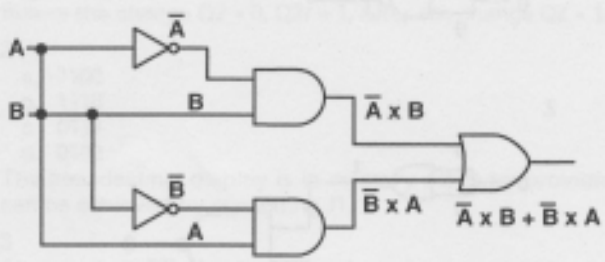
1. "1"
2. Not AND
3. "1"

Quiz 5

1. Output is "0" the only way to get "1" is when both inputs at "0" level.
2. NOR Gate is an OR Gate with inverted output. When an inverter is added to the output of NOR, this inverter cancels the inversion of the NOR and it becomes to an OR Gate.
3. Not OR

Quiz 6

1. When both input are ON ("1").
2. 2 ANDS, 1 OR 2 Inverters
3.



Quiz 7

1. Non Inverter Circuit
2. Inverter Circuit

Quiz 8

1. NAND Table

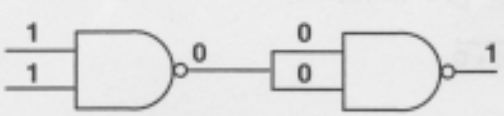
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

2. NOR Table

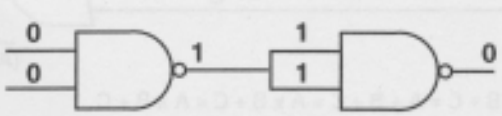
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Quiz 9

1.

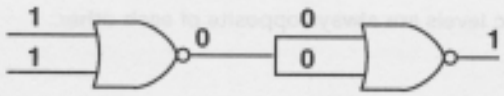


2.

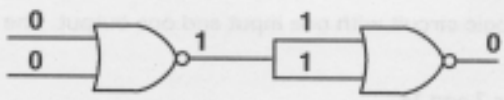


Quiz 10

1.

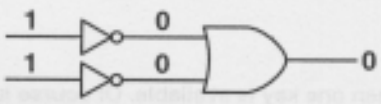


2.

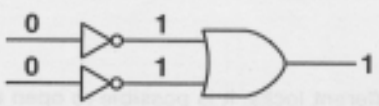


Quiz 11

1.

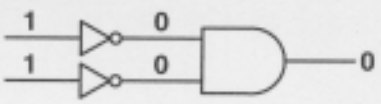


2.

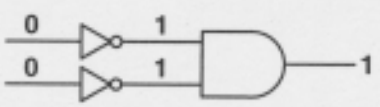


Quiz 12

1.

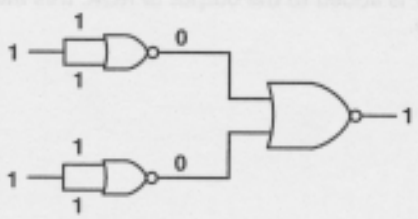


2.

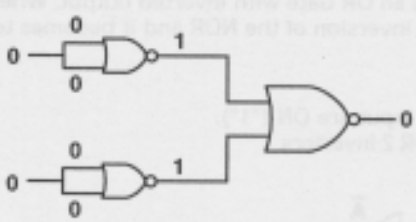


Quiz 13

1.

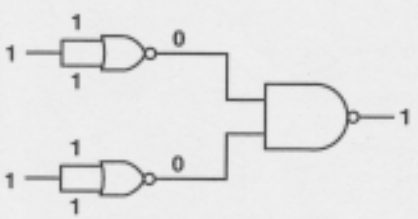


2.

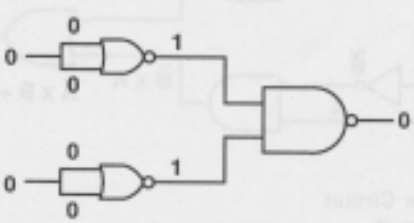


Quiz 14

1.



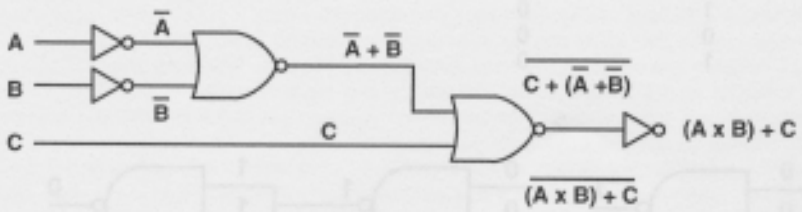
2.



Quiz 15

1. 0 x 0 + 0 = 0
   0 x 0 + 1 = 1
   0 x 1 + 0 = 0
   0 x 1 + 1 = 1
   1 x 0 + 0 = 0
   1 x 0 + 1 = 1
   1 x 1 + 0 = 1
   1 x 1 + 1 = 1

2.



3. A + B + C = A + B + C = A x B + C = A x B + C

Quiz 16

1. Astable multivibrator. The output level oscillates without external control.
2. By varying the values of the capacitor and/or the resistor.
3. The control input should be at logic level "1" in order to get the wave form inverted at the output. If the control is "0", the output will have a steady "0" level.
4. The 556 is a dual 555 IC. It is a circuit of 2 independent multivibrators that can be configured to be any of the following types: Free run (astable), one shot (monostable), or flip-flop (bistable). It can be done by jumpers between the proper Pins. The wave form frequency and the pulse width are controlled by variable resistors and/or variable capacitors.

Quiz 17

1.
2. Since S = 0, Q must be 1. The bottom NAND get "1" at both inputs that will force "0" at Q. Feedback from Q to the upper NAND input will force a steady "1" at output Q.
3. There is no change since the other input of bottom NAND is "1". (Connected to Q). Therefore, Q must provide "0".

Quiz 18

1. We use the debouncing switch in order to eliminate the multiple pulses generated by a mechanical switch during its switching process.
2. The debouncing circuit in the experiment uses a bistable multivibrator.

Quiz 19

1. In synchronous mode the outputs are effected by the clock pulse. In asynchronous mode the clock pulse doesn't influence the output since the preset and clear have "stronger" control.
2. a. Q = 0 Q = 1 b. Q = 1 Q = 0

Quiz 20

1. Toggle
2. "0" to "1" and "1" to "0".
3. Pin 3 (Gate A) to Pin 9 (Gate C). Pin 6 (Gate B) to Pin 13 (Gate D).
4. The new input are between Pins 9 and 13.

Quiz 21

1. Logic State
2. Before the change Q2 = 0, Q2/ = 1. After the change Q2 = 1, Q2/ = 0 (Toggle mode)

Quiz 22

1. a. 1100
   b. 1110
   c. 0111
   d. 0100
2. The hexadecimal display is in memory mode by providing high logic level to the latch strobe input (Pin 5) This can be achieved by grounding J1.

Quiz 23

1. All outputs is "0", this is the reset or clear condition.
2. Up counter, asynchronic
3. 3 (decimal) or 11 (binary).

Quiz 24

1. The maximum number for 2 binary digits is 11 binary or 3 decimal.
2. a. 10000 b. 1000

GLOSSARY

AND: a basic logic element in that a true (high) output occurs only if all the input conditions are true (high).
ASTABLE: having no stable state. Oscillates between two levels.
ASYNCHRONOUS: a circuit that operates without clock control or the clock does not control all circuit units simultaneously. (example: 74ls93 counter ic)
BAR: small line above part of boolean expression indicates the opposite of a normal logic level. (example: inverter input is at state a and the output is a/).
BINARY: base of two, the digits "0" and "1", or two states off and on, also known as low and high
BISTABLE: two stable states. Flip-flops and latches are bistable multivibrators.
BIT: binary digit that can be either 0 or 1.
BOOLEAN ALGEBRA: mathematical system for formulating logical statements with symbols in order to write and solve a problem.
CIRCUIT: an arrangement of electrical and/or electronic components connected together to perform a specified function.
CLEAR: to reset a flip-flop, to provide 0 at output q.
CLOCK: the basic timing signal in a digital system.
COMPUTER: a digital electronic system that can be programmed to perform various tasks such as calculations, at very high speed and that can store large amounts of data.
COUNTER: a digital device capable of counting electronic events, such as pulses, by progressing through a sequence of binary states.
DIGITAL: related to digits or discrete quantities. Having a set of discrete values as opposed to a continuos range.
DIP: dual in-line package. Type of IC package whose leads must pass through holes to the other side of the circuit board.
D FLIP-FLOP: a type of bistable multivibrator. The output follows the d input.
FLIP-FLOP: a bistable device used for storing a bit of information.
FREQUENCY: number of pulses in one second for a periodic wave form. Measured by hertz or cycles per second.
GATE: a logic circuit that performs a specific logic operation such as and, or, not, etc.
IC: integrated circuit. A type of circuit in that all the components are integrated into one chip. (very small semiconductor area)
INPUT: the signal or line going into a circuit. A signal that controls the operation of the circuit.
INVERTER: a not circuit. Circuit that changes from high input to low output and vice versa.
JK FLIP-FLOP: a type of flip-flop that can operate in the set, reset no-change, and toggle modes.
LATCH: a bistable digital device used for storing a bit. The device "remembers" the last state.
LED: light emitting diode. Semiconductor that light ups when a certain positive voltage is connected to its anode and cathode to ground.
LOGIC: representing high (or on) as true and low (or off) as false.
LSI: large scale integration. A level of ICcomplexity (100 to 1000 gates per chip).
MONOSTABLE: having only one stable state. A monostable multivibrator also called a one shot, produces a single pulse in response to a triggering input.
MULTIVIBRATOR: a class of digital circuits in that the output is connected back to the input (feedback) to produce either 2 stable states, one stable state or no stable state, depending on the configuration. (see bistable, monostable, and astable.)
NAND: not and. The output is low only when all inputs are high.
NOR: not or. The output is high only when all inputs are low.
OR: logic gate with a true (high) output occurs when one or more of the input conditions are true.
PULSE: a sudden change from one level to another followed after a short time by a sudden change back to the original level. The time elapsed between the two edges is called the "pulse width".
RACE: a condition in a logic network in that the differences in propagation times through few signal paths can create error at the output. The time elapsed between the two edges is called the pulse width.
REGISTER: a digital device capable of storing and shifting binary information.
RESET: the state of a flip-flop or latch when q output is 0 (off).
SEMICONDUCTOR: a material used to construct electronic devices such as: transistors, diodes, and ics. Silicon and germanium are the most common types of this material.
SET: the state of a flip-flop or latch when q output is 1 (on).
SSI: small scale integration. Up to 12 gates per chip.
STORAGE: memory capability of a digital device. Retaining data for a later use.
SYNCHRONOUS: having fixed time relationship with a clock signal. (clock controls of all circuit units simultaneously.)
TOGGLE: the action of a flip-flop when it changes state on each clock pulse.
TRIGGER: a pulse used to initiate a change in the state of the logic circuit.
TTL: transistor transistor logic. Methods of technology in production of ics.
VLSI: very large scale integration. More than 1000 gates per chip.
XOR: exclusive or gate. The output is high only when the 2 inputs are different (0 and 1).
SYMBOLS The direction of the arrows is not dependent on the signal direction.

Connection Point **Denotes Male Contact** **Denotes Female Contact**