NAME ____________________ DATE __________

1-1 LAB EXPERIMENT: CLOCK CIRCUIT

OBJECTIVE

To wire and test a free-running clock circuit.

MATERIALS

Qty.		Qty.	
1	555 timer IC	1	470-kΩ, ¼-W resistor
1	LED indicator-light assembly	1	5-V dc regulated power supply
1	1-kΩ, ¼-W resistor	1	1-μF electrolytic capacitor
1	100-kΩ, ¼-W resistor	1	10-μF electrolytic capacitor

SYSTEM DIAGRAM

You will wire and operate a free-running clock circuit. This circuit will generate a TTL-level digital signal. The 555 timer IC is used to generate the continuous string of square-wave pulses. The frequency is low (1 to 2 pulses per second), and therefore the pulses may be directly observed on a simple LED output indicator. A schematic diagram for the astable multivibrator (free-running clock) circuit is shown in Fig. 1-2.

A very simple LED output indicator light assembly is shown connected to the free-running clock circuit in Fig. 1-2. A HIGH logic level is indicated when the LED lights. A LOW logic level is indicated when the LED does not light. Although very simple, the LED output indicator in Fig. 1-2 does have the disadvantage of loading the output of the IC more than recommended.

A more complicated LED output indicator-light assembly that may be used on your digital lab trainer is sketched in Fig. 1-3. This circuit contains a general-purpose NPN driver transistor. When the input voltage is HIGH, the transistor turns on (conducts), causing the LED to light. When the input voltage is LOW (near ground), the transistor is turned off, causing the LED to turn off. This commonly used circuit does not exceed the drive capabilities of the ICs energizing the output indicators.

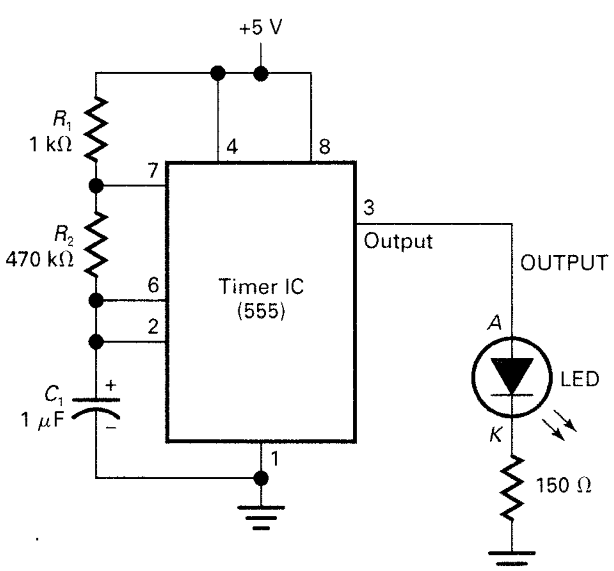

Fig. 1-2 Schematic diagram of a free-running clock circuit.

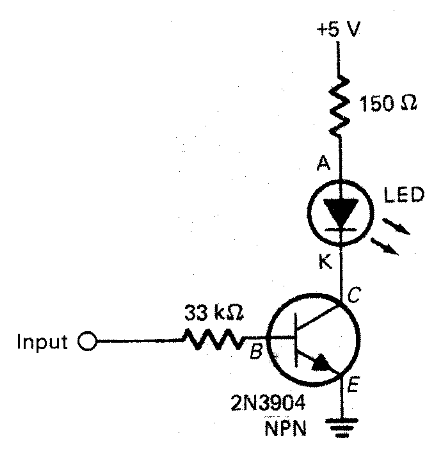

Fig. 1-3 Alternative circuit for LED indicator-light assembly.

Many digital lab trainers have the LED indicator-light assemblies prewired. If not, your instructor will tell you which LED indicator-light assembly to use in your experiments.

PROCEDURE

1. Insert the 555 IC into a mounting board. Use care because the eight pins may not match the holes in the mounting board.
2. Refer to Fig. 1-4. This is a simplified view of solderless breadboards similar to those on a digital trainer manufactured by Dynalogic Concepts.
   a. *Power block.* The four holes on the left side of the power block supply GND (like the negative of a battery). The eight holes on the right side of the power block supply +5 V. The main power switch on the trainer is used to energize the power block.
   b. *Power distribution strip.* All the holes in the top row of the power distribution strip are connected and distribute +5 V in this example. Likewise, all the holes in the bottom row are connected and distribute GND voltage in this example.
   c. *IC mounting board.* On the main IC mounting board, only the four holes in each vertical group are connected.

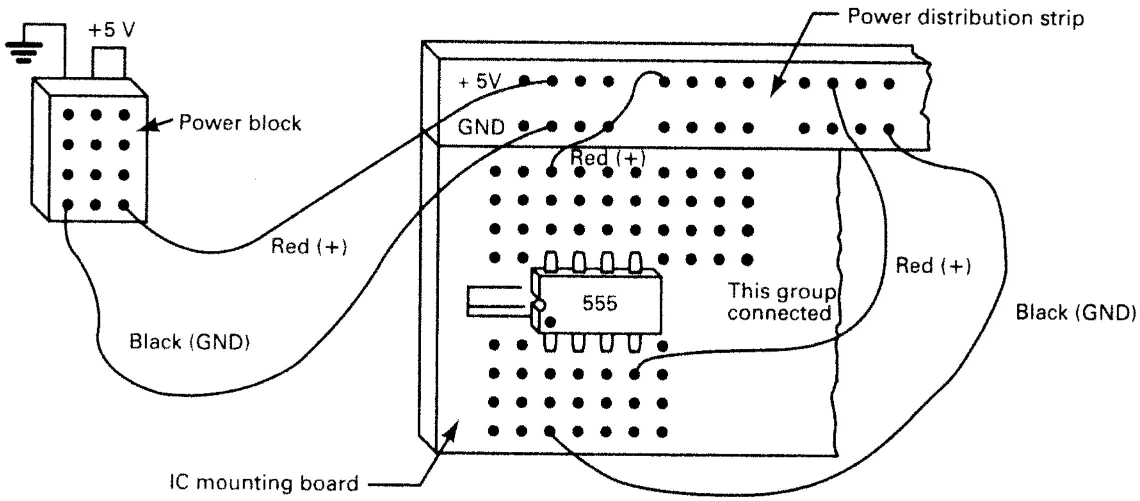

Fig. 1-4 Mounting and powering the 555 IC on a typical trainer.

3. Power OFF. Refer to Fig. 1-4. Connect power from the power block to the power distribution strip. Color-code wires as shown.
4. Power OFF. Refer to Fig. 1-4. Connect power to the 555 timer IC. Use color-coded wires as shown.
5. Power OFF. Refer to the schematic diagram in Fig. 1-2. Wire the entire free-running clock circuit. For inexperienced students, a typical wiring layout for the clock circuit is detailed in Fig. 1-5.
6. Refer to Fig. 1-5.
   a. *Output connector.* A solderless breadboard has been added at the upper right in Fig. 1-5 as a convenient method of connecting to prewired LED indicator-light assemblies. Each vertical group of four holes is connected. In this example, output LED indicator-light assembly L_1 is being used.
   b. *Output LED indicator-light assembly.* A schematic of a typical output LED indicator-light assembly using a driver transistor is shown near the top in Fig. 1-5.

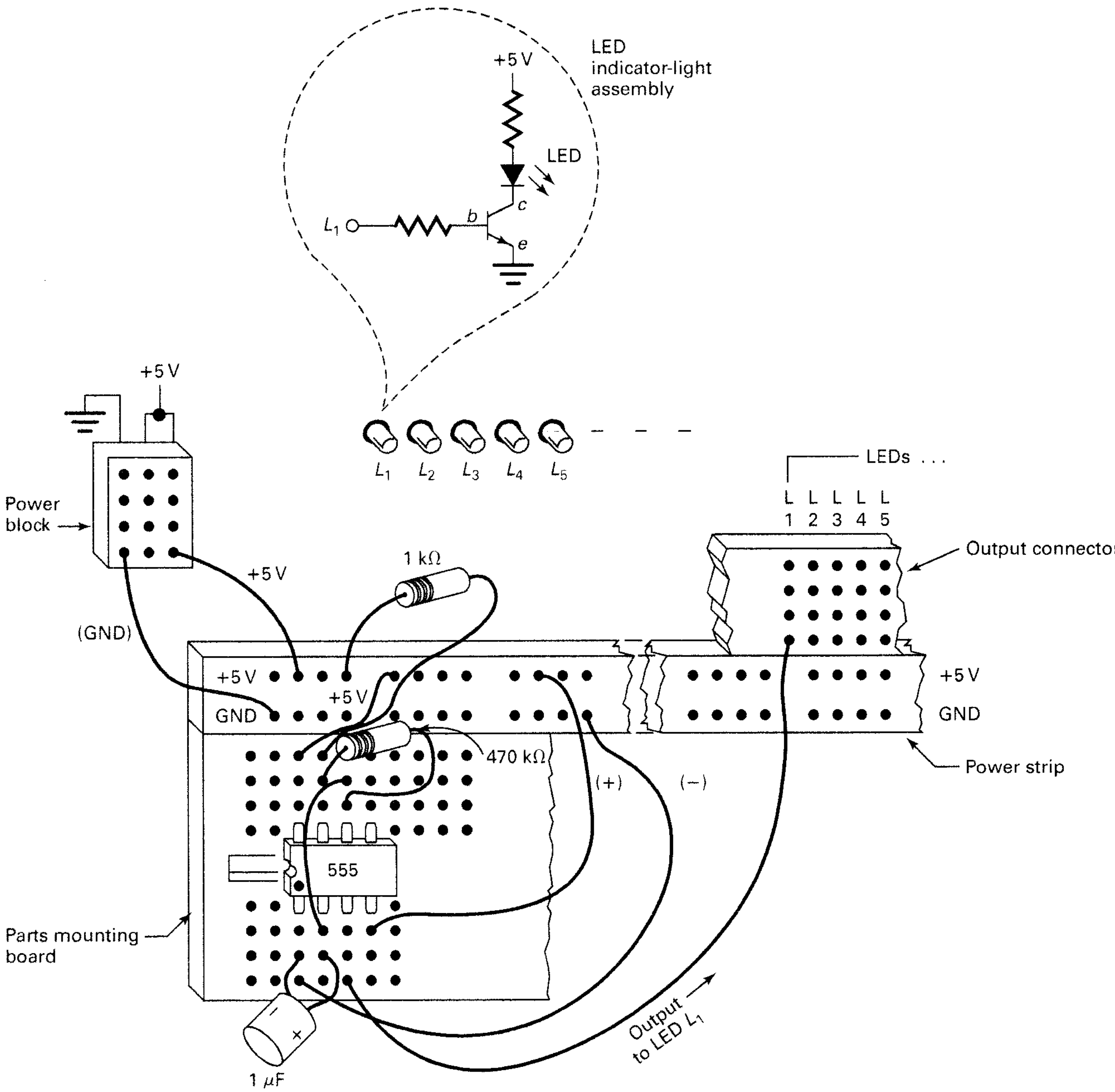

Fig. 1-5 Wiring clock circuit on digital trainer. (Trainer is DT-1000 by Dynalogic Concepts.)

7. Power ON. The output LED should flash on and off at a low frequency. A light means a HIGH or logical 1. No light means a LOW or logical 0 digital signal.
8. Have your instructor check the proper operation of your free-running clock.
9. Power OFF. Remove the 470-kΩ resistor (R_2), and replace it with the 100-kΩ resistor.
10. Power ON. What happened to the frequency of the digital signal when the value of R_2 was reduced?

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11. Power OFF. Remove the 1-μF (C_1) capacitor, and replace it with a 10-μF electrolytic capacitor.
12. Power ON. What happened to the frequency of the digital signal when the value of C_1 was increased?

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13. Power OFF. Take down the circuit, and return all equipment to its proper place. The IC removes easily from the mounting board without damage to the pins if you *carefully* pry it up from both ends with a small screwdriver or use an IC removal tool.

QUESTIONS

Complete questions 1 to 9.

1. The clock in Fig. 1-2 is sometimes called a(n) ____________ multivibrator. 1. ____________
2. When the LED indicator lights, the output of the clock is ____________ (HIGH, LOW). 2. ____________
3. When the LED indicator is not lit, the output of the clock is ____________ (HIGH, LOW). 3. ____________
4. The clock wired in this experiment is based on the ____________ IC. 4. ____________
5. Refer to Fig. 1-2. Decreasing the value of the resistor between pins 6 and 7 of the IC ____________ (decreases, increases) the output frequency of the digital clock. 5. ____________
6. Refer to Fig. 1-2. Increasing the value of capacitor C_1 will ____________ (decrease, increase) the output frequency of the digital clock. 6. ____________
7. Refer to Fig. 1-2. The 555 timer integrated circuit (IC) is commonly considered an analog device. The *output* from the clock circuit using the 555 timer IC is ____________ (analog, digital) in nature. 7. ____________
8. Refer to Fig. 1-2. If the output (pin 3) of the 555 timer IC goes ____________ (HIGH, LOW), the LED does not light. 8. ____________
9. Refer to Fig. 1-3. If the voltage at the input (base) of the transistor goes positive (HIGH), the transistor turns on and ____________ (less, more) current flows from emitter to collector of the transistor causing the LED to light. 9. ____________

NAME ____________________ DATE ____________

1-2 LAB EXPERIMENT: ONE-SHOT MULTIVIBRATOR AND DEBOUNCED SWITCH

OBJECTIVES

1. To wire and test a one-shot multivibrator circuit.
2. To add a debounced input switch to the one-shot multivibrator.
3. *OPTIONAL:* To measure the time duration of the output pulse from the one-shot multivibrator with an oscilloscope.

MATERIALS

Qty.		Qty.	
1	74121 one-shot multivibrator IC	1	0.01-μF capacitor
1	555 timer IC	1	0.033-μF capacitor
1	LED indicator-light assembly	1	0.1-μF capacitor
1	330-Ω, ¼-W resistor	1	10-μF electrolytic capacitor
1	1-kΩ, ¼-W resistor	1	N.O. push-button switch (not debounced)
1	33-kΩ, ¼-W resistor	1	debounced switch assembly
2	100-kΩ, ¼-W resistor		*OPTIONAL:* oscilloscope
1	5-V dc regulated power suppy		

SYSTEM DIAGRAM

You will wire a monostable multivibrator circuit based on the 74121 IC. The circuit in Fig. 1-6 shows the wiring of the 74121 one-shot MV. The external components R_3 and C_1 determine the pulse width (time duration) of the positive pulse. This circuit was designed to emit a positive pulse of about 2 to 3 ms. A positive pulse of 2 to 3 ms is long enough to produce a visible flash on the attached LED indicator-light assembly. The one-shot is triggered by a positive voltage appearing at *input B* of the 74121 IC caused by the closing of SW_1. The normal Q output of the 74121 emits a short positive pulse. Remember that the pulse width is determined by the design of the multivibrator circuit and not on how long the input switch (SW_1) was pressed. To increase the pulse width of the one-shot in Fig. 1-6, the values of R_3 and/or C_1 would be increased.

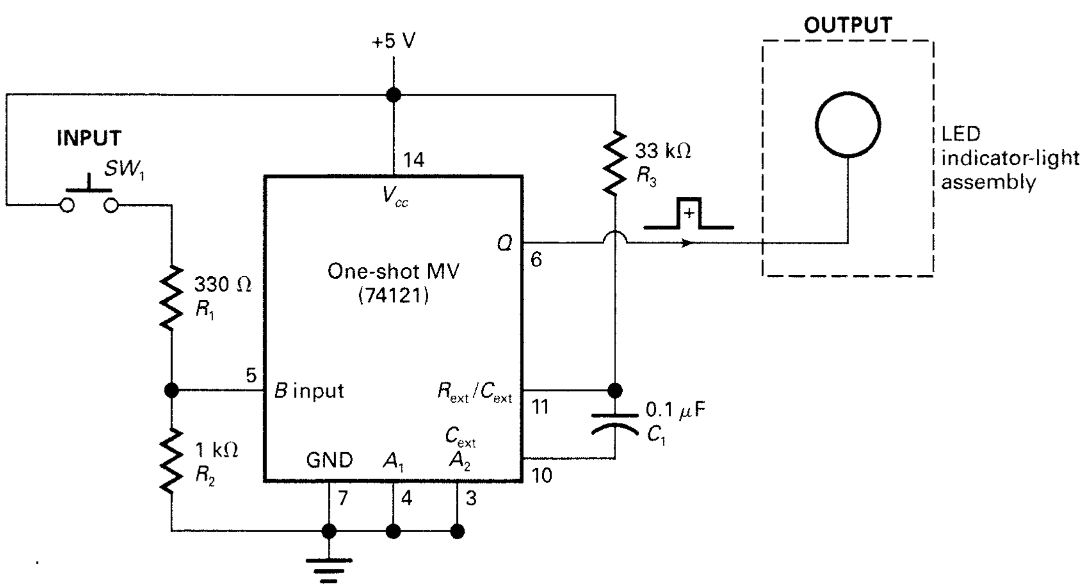

Fig. 1-6 A one-shot multivibrator circuit.

The one-shot MV circuit in Fig. 1-6 should emit only one pulse with the press and release of SW_1. As a practical matter, the 74121 IC may be triggered more than once with a single press and release of input switch SW_1 because of *switch bounce*. A revised schematic for the one-shot multivibrator is drawn in Fig. 1-7. A debounced switch provides the positive trigger voltage in the revised circuit.

The normal output Q (pin 6 on the 74121 IC) in Fig. 1-7 emits a positive pulse when the input is triggered. The complementary output $\bar{Q}$ (pin 1) is also identified in Fig. 1-7 and could be used if a negative pulse were required.

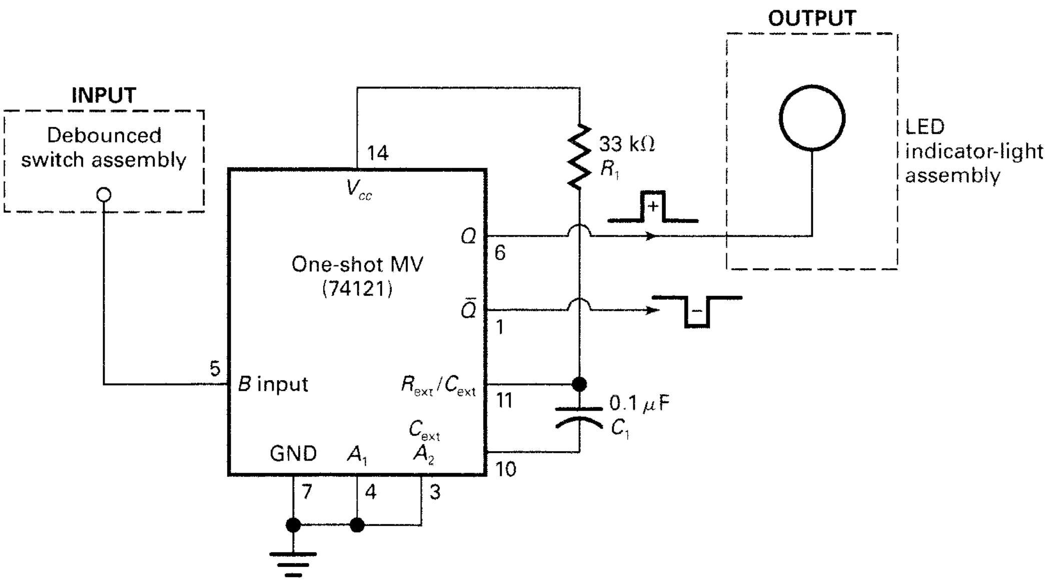

Fig. 1-7 A debounced switch input to a one-shot multivibrator circuit.

In the lab your digital trainer may have a debounced switch available as the input to the one-shot MV circuit in Fig. 1-7. If you do not have a debounced switch available, Fig. 1-8 provides a debouncing circuit based on the 555 timer IC. The output from the debouncing circuit emits a positive voltage beginning when input switch SW_1 is first pressed. The output remains

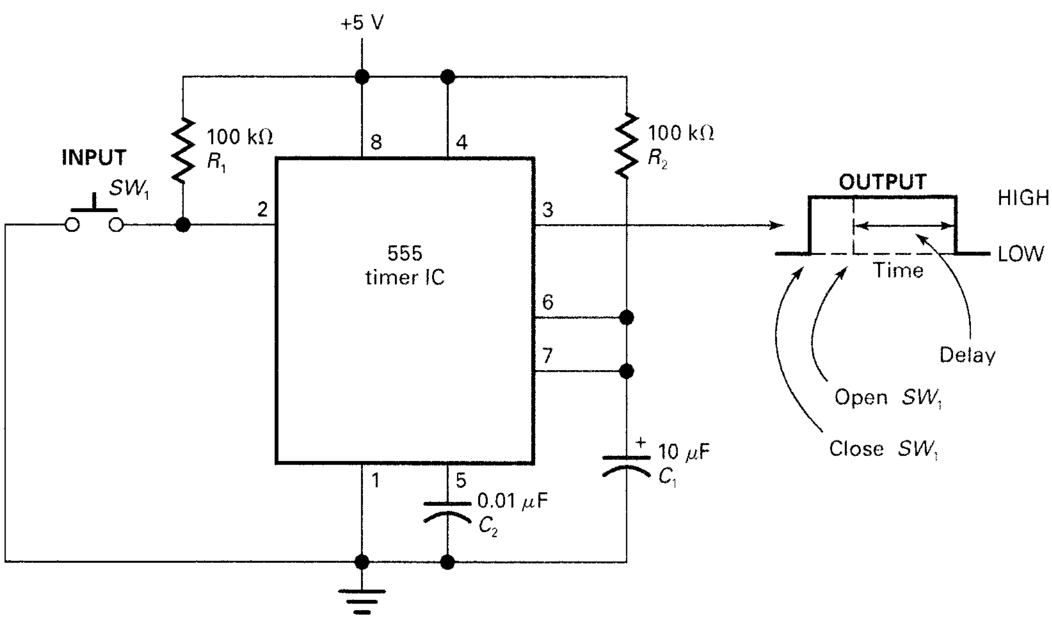

Fig. 1-8 A switch debouncing circuit.

HIGH for a time after SW_1 is released (opened). This delay time is adjustable by changing the value of capacitor C_1. Decreasing the value of C_1 decreases the delay time. The delay time designed into the circuit in Fig. 1-8 is about 1 second so it can be easily observed on the output LED.

PROCEDURE

1. Insert the 74121 IC into a mounting board.
2. Power OFF. Connect power to the IC. Color-code the wires: red for +5 V and black for GND.
3. Power OFF. Refer to Fig. 1-6. Wire the entire circuit. Pin numbers for the 74121 IC are shown on the outside of the symbol. See your instructor if you have any questions about the input switch or output LED indicator-light assemblies.
4. Power ON. Operate the one-shot multivibrator by pressing and releasing the input switch SW_1. Carefully observe the output LED. You should get a single short flash on the LED as you first press the input switch. Because of switch bounce you may also observe other flashes on the output LED. These "extra" output pulses are *not normal* and indicate false triggering of the 74121 IC.
5. Did you observe false triggering when operating the one-shot MV circuit in Fig. 1-6?

   ______

6. Power OFF. Refer to Fig. 1-7. Rewire the one-shot multivibrator circuit using a *debounced switch assembly*. The debounced switch input will eliminate false triggering, and the circuit will emit only a single positive pulse at output Q as the input switch is closed and opened. Check with your instructor on which debounced switch assembly to use (from digital trainer or the debounced switch circuit furnished in Fig. 1-8).
7. Power ON. Operate the one-shot multivibrator circuit, carefully observing the output LED. The one-shot MV circuit should *emit only one positive pulse* as the input switch closes and opens.
8. Show your instructor the normal operation of the circuit from Fig. 1-7.
9. *OPTIONAL:* Connect an oscilloscope to the normal output Q (pin 6) of the one-shot multivibrator shown in Fig. 1-7, and observe the time duration of the positive pulse emitted by the 74121 IC. It will be in the range of 2 to 3 ms. Suggested initial scope settings might include DC mode, auto triggering, 1 V per division, and 1 ms per division.
10. Connect the oscilloscope to the complementary output $\overline{Q}$ (pin 1 of the 74121 IC), and observe the output. Is the output a positive or negative pulse?

    ______

11. Power OFF. Refer to Fig. 1-7. Try replacing C_1 with a 0.033 μF capacitor to change the time duration of the positive pulse from the 74121 one-shot.
12. Power ON. Measure the time duration of the positive pulse (from pin 6 of the 74121 IC) emitted after changing the value of C_1. What is the time duration of the pulse from the revised one-shot MV?

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13. Show your instructor your measurements on the circuit in Fig. 1-7 when $C_1 = 0.1\ \mu$F and when $C_1 = 0.033\ \mu$F. Be prepared to answer questions on the one-shot MV circuit and your measurements.
14. Power OFF. Take down the circuit and return all equipment to its proper place. Use an IC removal tool to extract the IC from the mounting board.

QUESTIONS

Complete questions 1 to 8.

1. The 74121 IC is a one-shot multivibrator and is classified as a(n) ____________ (astable, monostable) MV. — 1. ____________
2. Refer to Fig. 1-6. The false triggering that was observed during the operation of this MV circuit was caused by switch ____________ (bounce, hysteresis). — 2. ____________
3. Refer to Fig. 1-7. Which debounced switch did you use when operating this MV circuit? — 3. ____________
4. Refer to Fig. 1-7. Why does the 74121 have two outputs? — 4. ____________
5. Refer to Fig. 1-8. This circuit uses the popular 555 timer IC wired as a ____________ (one-shot MV, switch debouncer). — 5. ____________
6. Refer to Fig. 1-7. What is the approximate pulse width for this one-shot MV circuit? — 6. ____________
7. Refer to Fig. 1-7. If you decrease the value of capacitor C_1 from 0.1 μF to 0.033 μF, the pulse width ____________ (decreases, increases). — 7. ____________
8. Refer to Fig. 1-8. If you decrease the value of capacitor C_1 from 10 μF to 1 μF, the time delay after the input switch opens ____________ (decreases, increases). — 8. ____________