INTRODUCTION

TTL is the best established and most diversified IC family. LS is functionally identical to TTL but is slightly faster and uses 80% less power. TTL/LS chips require a regulated 4.75-5.25 volt power supply. Here's a simple battery supply:

![Battery Supply Diagram]

The diode drops the battery voltage to a safe level. Both capacitors should be installed on the TTL/LS circuit board. Circuits with lots of TTL/LS chips can use lots of current. Use a commercial 5 volt line powered supply to save batteries, or make your own. (See the 7805 on page 94.)

OPERATING REQUIREMENTS

1. Vcc must not exceed 5.25 volts.
2. Input signals must never exceed Vcc and should not fall below GND.
3. Unconnected TTL/LS inputs usually assume the H state... but don't count on it! If an input is supposed to be fixed at H, connect it to Vcc.
4. If an input is supposed to be fixed at L, connect it to GND.
5. Connect unused and/NAND/or inputs to a used input of the same chip.
6. Force outputs of unused gates H to save current (NAND—one input H; NOR—all inputs L).
7. Use at least one decoupling capacitor (0.01-0.1 μF) for every 5-10 gate packages, one for every 2-5 counters and registers and one for each one-shot. Decoupling capacitors neutralize the hefty power supply sakes that occur when a TTL/LS output changes. States. They must have short leads and be connected from Vcc to GND as near the TTL/LS ICs as possible.
8. Avoid long wires within circuits.
9. If the power supply is not on the circuit board, connect a 1-10 μF capacitor across the power leads where they arrive at the board.

INTERFACING TTL/LS

1. TTL output will drive up to 10 TTL or 20 LS inputs.
2. LS output will drive up to 5 TTL or 10 LS inputs.
3. TTL/LS LED drivers:

![LED Driver Diagram]

TTL/LS TROUBLESHOOTING

1. Do all inputs go somewhere?
2. Are all IC pins inserted into the board or socket?
3. Does the circuit obey all TTL/LS operating requirements?
4. Have you forgotten a connection?
5. Have you used enough decoupling capacitors? Are their leads short?
6. Is Vcc at each chip within range?
QUAD NAND GATE
7400/74LS00

THE BASIC BUILDING BLOCK CHIP FOR THE ENTIRE TTL FAMILY. VERY EASY TO USE. HUNDREDS OF APPLICATIONS.

CONTROL GATE

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>OUT</th>
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<tbody>
<tr>
<td>L</td>
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NOR GATE

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>OUT</th>
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INVERTER

<table>
<thead>
<tr>
<th>A</th>
<th>OUT</th>
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<tr>
<td>L</td>
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AND GATE

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<th>A</th>
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4-INPUT NAND GATE

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<th>A</th>
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<th>C</th>
<th>D</th>
<th>OUT</th>
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EXCLUSIVE-OR GATE

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EXCLUSIVE-NOR GATE

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NOTE: PIN NUMBERS CAN BE REARRANGED IF DESIRED.
QUAD NAND GATE (CONTINUED)
7400/74LS00

HALF ADDER
RS LATCH

D FLIP-FLOP
GATED RS LATCH

WHEN ENABLE (E) INPUT IS HIGH, WHEN ENABLE (E) INPUT IS HIGH, IGNORES RS INPUTS
Q OUTPUT FOLLOWS D INPUT, NO HIGH, IGNORES RS INPUTS
CHANGE WHEN E IS LOW.

LED DUAL FLASHER
SWITCH DEBOUNCER

FLASH RATE IS
2 HZ WHEN C1
AND C2 ARE 47uF

PROVIDES NOISE FREE OUTPUT FROM
STANDARD SPDT TOGGLE SWITCH.
QUAD AND GATE
7408/74LS08

One of the basic building block chips. Not as versatile, however, as the 7400/74LS00 quad NAND gate.

AND GATE BUFFER

Use for interfacing without changing logic states.

NAND GATE

NOR GATE

AND-OR-INVERT GATE

4-INPUT NAND GATE

4-INPUT AND GATE
QUAD OR GATE
74LS32

FOUR 2-INPUT OR GATES.
NOT AS VERSATILE AS 7402/74LS02 QUAD NOR GATE,
BUT VERY USEFUL IN SIMPLE DATA SELECTORS.

AND-OR CIRCUIT

OUTPUT GOES HIGH WHEN BOTH
INPUTS OF EITHER OR BOTH AND
GATES ARE HIGH; OTHERWISE
THE OUTPUT IS LOW. THIS BASIC
CIRCUIT IS USED TO MAKE
DATA SELECTORS... AS SHOWN
BELOW.

DATA IN

SELCTS 1-OF-2 INPUTS
AND TRANSMITS ITS
LOGIC STATE TO THE
OUTPUT.

2-INPUT DATA SELECTOR

ADDRESS [DATA IN] [OUT]

A   B   A
L   X   L   L
L   X   H   H
H   L   X   H
H   H   X   H

NOTE: FOR 3-INPUT DATA SELECTOR,
USE 74LS27 NOR GATE FOLLOWED
BY INVERTER AND PRECEDED BY
74LS10 3-INPUT AND GATES.
QUAD NOR GATE
7402/74LS02

JUST AS VERSATILE AS THE 7400/74LS00 QUAD NAND GATE...
BUT NOT USED AS OFTEN.
ADD INVERTER (7404/74LS04)
TO BOTH INPUTS OF A NOR
GATE AND AN AND GATE IS
FORMED.

EXCLUSIVE-OR GATE

This circuit is equivalent
to a binary half-adder.

RS LATCH

4-INPUT NOR GATE

AND GATE

OR GATE

This circuit is a monostable
multivibrator or pulse stretcher.
An input pulse triggers an
output pulse with a duration
determined by R and C. Output
pulse width is approximately CBRC.
HEX INVERTER
7404/74LS04

VERY IMPORTANT. IN ALMOST
ALL LOGIC CIRCUITS, CHANGES
AN INPUT TO ITS COMPLEMENT
(i.e. H → L AND L → H).

BOUNCER FREE SWITCH

OUTPUT FOLLOWS
SWITCH POSITION.

1, 2 = 1/3 7404/74LS04

UNIVERSAL EXPANDER

ALLOWS ONE
SIGNAL TO
OUT (= IN)
CONTROL 2 OR
MORE INPUTS.

1-OF-2 DEMULTIPLEXER

DATA IN

1, 2, 3 = 7404/74LS04

OUT A

OUT B

14
12
10
9
8
7
6
5
4
3
2
1

DATA ADDRESS OUT A OUT B

L L L H
L L H H
H H L H
H H H H

THIS CIRCUIT STEERS THE
INPUT BIT TO THE OUTPUT
SELECTED BY THE ADDRESS.

THIS TECHNIQUE CAN BE
USED TO MAKE MULTIPLE
OUTPUT DEMULTIPLEXERS.
I-O~8 DATA SELECTOR
74LS151

Equivalent to 8-line to 1-line multiplexer.

PROGRAMMABLE GATE

3-bit address selects one switch and applies its status (open = high and closed = low) to the output. Any 3-input logic function can be programmed in seconds.

PATTERN GENERATOR

Pattern generator can be programmed to any desired low-high bit pattern, then play it back.

OCTAL KEYBOARD ENCODER

Press numbered switch and its binary equivalent appears on the readout LEDs. The LEDs are optional.

Readout LEDs:

ON = LOW (0)
OFF = HIGH (1)
**BCD-TO-DECMAL DECODER**  
**7441**

Decodes 4-bit BCD input into 1-of-10 outputs. Selected output goes low; all others stay high. Originally designed to drive gaseous glow discharge tubes. All outputs go high for binary inputs exceeding HLLH (1001).

**1-OF-10 DECODED COUNTER**

![Diagram of 1-OF-10 DECODED COUNTER]

LEDs flash on sequentially in response to decoded count. Only one LED series resistor is required.

**10-NOTE TONE SEQUENCER**

![Diagram of 10-NOTE TONE SEQUENCER]

Increase C1 to decrease tempo. Increase C2 to increase tone frequencies. Tones are determined by R3-R12.
4-LINE TO 16-LINE DECODER 74154

Each 4-bit address drives one output low. All others stay high. Enable inputs (E1 and E2) must be low. If one or both are high, all outputs go low.

1-TO-16 DEMULTIPLEXER

Selected output is low when address is low (selects 1-of-16 outputs). If data in is high, selected output is high.

BACK AND FORTH FLASHER

Increase R1 to slow flash rate.
BCD-TO-7 SEGMENT DECODER/DRIVER

7447 / 74LS47

Converts BCD data into format suitable for producing decimal digits on common anode LED 7-segment display. When lamp test input is low, all outputs are low (ON). When B1/RBO (blanking input) is low, all outputs are high (OFF). When DBCA input is LLLL (decimal 0) and RB1 (ripple blanking input) is low, all outputs are high (OFF). This permits unwanted leading 0's in a row of digits to be blanked.

MANUALLY SWITCHED DISPLAY

0-9 SECOND /MINUTE TIMER

Close S1 to start timing cycle. Calibrate 555 for 1 pulse (count) per second or 1 count per minute by adjusting R1.
BCD-TO-7-SEGMENT
DECODER/Driver
7448

Converts BCD data into format suitable for producing decimal digits on common cathode LED 7-segment display.

Display Dimmer

0-99 Two Digit Counter

Lowest Order Display

Highest Order Display

7448

7490 / 74LS90

7490 / 74LS90

Vcc (5V)

E Display

H Normal

L Dim

RBI *

B1 / RBO *

Lamp Test *

See 7447 for explanations.
DUAL D FLIP-FLOP
7474/74LS74

Two D (DATA) FLIP-FLOPS IN A SINGLE PACKAGE. DATA AT D INPUT IS STORED AND MADE AVAILABLE AT Q OUTPUT WHEN CLOCK PULSE (\(\phi\)) GOES HIGH. HERE'S THE TRUTH TABLE:

<table>
<thead>
<tr>
<th>PRESET</th>
<th>CLEAR</th>
<th>CLOCK</th>
<th>D</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>X</td>
<td>X</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>↑</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>↑</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

\(\phi\) IS CLOCK INPUT.
↑ IS RISING EDGE OF CLOCK PULSE.

2-BIT STORAGE REGISTER PHASE DETECTOR

THE LED GLOWS WHEN INPUT FREQUENCIES \(F_1\) AND \(F_2\) ARE UNEQUAL OR OUT OF PHASE. \(F_1\) AND \(F_2\) SHOULD BE SQUARE WAVES.

WAVE SHAPER

DIVIDE-BY-TWO COUNTER
DUAL J-K FLIP-FLOP
7473/74LS73

Two JK flip-flops in a single package. Note the clear inputs. These flip-flops will toggle (switch output states) in response to incoming clock pulses. When both J and K inputs are high, here's the truth table:

<table>
<thead>
<tr>
<th>CLEAR</th>
<th>CLOCK</th>
<th>J</th>
<th>K</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>L</td>
<td>H</td>
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<tr>
<td>H</td>
<td>L</td>
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<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

**Binary Counters**

The three circuits on this page are binary counters that count up to the maximum count and automatically recycle. Connect a decoder to output of divide-by-three and divide-by-four counters to obtain one-of-three and one-of-four operation. This truth table summarizes operation of these counters:

**Divide-by-two**

<table>
<thead>
<tr>
<th>Outputs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
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<tr>
<td>L</td>
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<tr>
<td>L</td>
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</tbody>
</table>

**Divide-by-three**

<table>
<thead>
<tr>
<th>Outputs:</th>
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<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
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<tr>
<td>L</td>
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<tr>
<td>L</td>
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<tr>
<td>L</td>
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<tr>
<td>H</td>
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</tbody>
</table>

**Divide-by-four**

<table>
<thead>
<tr>
<th>Outputs:</th>
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<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>L</td>
</tr>
<tr>
<td>L</td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td>L</td>
</tr>
<tr>
<td>H</td>
</tr>
</tbody>
</table>

\( \phi \) is clock input.
**DUAL J-K FLIP-FLOP**

7476 / 74LS76

Two J-K flip-flops in a single package. Similar to 7473/74LS73 but has both preset and clear inputs. Flip-flops will toggle (switch output states) in response to incoming clock pulses when both J and K inputs are high. Here's the truth table:

<table>
<thead>
<tr>
<th>PRE</th>
<th>CLR</th>
<th>CLK</th>
<th>J</th>
<th>K</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>H</td>
<td>L</td>
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<td>L</td>
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</tbody>
</table>

**4-BIT SERIAL SHIFT REGISTER**

Parallels out (A B C D)

**4-BIT BINARY UP COUNTER**

DCBA binary out → A(Z1) B(Z1') C(Z1') D(Z1')
QUAD LATCH
7475/74LS75

A 4-BIT BISTABLE LATCH, PRIMARILY USED TO STORE THE COUNT IN DECIMAL COUNTING UNITS. NOTE THAT BOTH Q AND Q' OUTPUTS ARE PROVIDED. ALSO NOTE THE E (ENABLE) INPUTS. WHEN E IS HIGH, Q FOLLOWS D.

4-BIT DATA LATCH

DATA ON BUS APPEARS AT OUTPUTS WHEN LATCH INPUT IS HIGH. DATA ON BUS WHEN LATCH INPUT GOES LOW IS STORED UNTIL LATCH INPUT GOES HIGH. (LATCH INPUT CONTROLS BOTH ENABLE INPUTS) TWO QUAD LATCHES CAN BE USED AS AN 8-BIT DATA LATCH.

DECIMAL COUNTING UNIT

EXPANDABLE DECADE COUNTER. FOR TWO DIGIT COUNT, CONNECT PIN 11 OF 7490/74LS90 OF FIRST UNIT TO INPUT OF SECOND UNIT. A LOW AT THE LATCH INPUT FREEZES THE DATA BEING DISPLAYED.
BCD (DECADE) COUNTER
7490/74LS90

ONE OF THE MOST POPULAR
DECADE COUNTERS. EASILY USED
FOR DIVIDE-BY-N COUNTERS.
LESS EXPENSIVE THAN MORE
SOPHISTICATED COUNTERS. RST
INDICATES RESET PINS. THIS
CHIP IS USUALLY USED IN
DECIMAL COUNTING UNITS, BUT
CIRCUITS ON THIS PAGE SHOW
MANY OTHER POSSIBILITIES.

DIVIDE-BY-5 COUNTER

DIVIDE-BY-8 COUNTER

DIVIDE-BY-6 COUNTER

DIVIDE-BY-9 COUNTER

DIVIDE-BY-7 COUNTER

DIVIDE-BY-10 COUNTER

84
4-BIT (BINARY) COUNTER

7493 / 74LS93

EASY TO USE 4-BIT BINARY COUNTER: LESS EXPENSIVE THAN MORE SOPHISTICATED COUNTERS. RST INDICATES RESET PINS. NOTE UNUSUAL LOCATION OF POWER SUPPLY PINS.

DIVIDE-BY-10 COUNTER

DIVIDE-BY-12 COUNTER

DIVIDE-BY-11 COUNTER

DIVIDE-BY-16 COUNTER

4-BIT BINARY COUNTER

COUNTER FROM 0-15 IN BINARY AND RECycles. GLOWING LED = L (0); OFF LED = H (1). SSS_TIMER IC MAKES GOOD INPUT CLOCK.

R1 = R2 = R3 = R4 = 270Ω

COUNTS FROM D C B A D C B A

TRUTH TABLE

0: LLLL
1: LLHL
2: LHLH
3: HLHL
4: HLLL
**BCD UP-DOWN COUNTER**

*74192/74LS192*

Fully programmable BCD counter. Operation is identical to 74193/74LS193 except count is 10-step BCD (L L L L - H H H) instead of 16-step binary. Many applications for 74192/74LS192 and 74193/74LS193 are interchangeable.

### Cascaded Counters

![Cascaded Counters Diagram](image)

**Up** (0-99)  **Down** (99-0)

### Single Up-Down Input

![Single Up-Down Input Diagram](image)

### Programmable Count Down Timer

![Programmable Count Down Timer Diagram](image)

Calibrate R1 and C1 to provide desired number of clock pulses per minute. Set desired N into S1-S4 (closed switch = low and open switch = high). Press S5 to load N and start (or reset) count LED. Glows at halt. Display.

---

88
4-BIT UP-DOWN COUNTER
74193/74LS193

Very versatile 4-bit counter with up-down capability. Any 4-bit number at the D0D1D2D3 inputs is loaded into the counter when the load input (Pin 11) is made low. The counter is cleared to LLLL when the clear input (Pin 14) is made high. The borrow and carry outputs indicate underflow or overflow by going low.

Count down from N and recycle

Set desired N into SI-S4 (closed switch = low and open switch = high). When count reaches LLLL and then underflows, the borrow pulse loads N and the count recycles.

Count up to N and halt

Press SI (normally closed) to reset.

Count up to N and recycle

Press SI to reset.
555 EQUIVALENT CIRCUIT

1 AND 2 ARE COMPARATORS... CIRCUIT CAN BE MADE FROM INDIVIDUAL PARTS AS SHOWN... BUT 555 IS MUCH SIMPLER.

ONE-SHOT TIMER

VALUES SHOWN GIVE 1 SECOND OUTPUT PULSE.

ONE-SHOT TIMER

VALUES OF R1 AND C1 SHOWN WILL PULL RELAY IN FOR UP TO ABOUT 11 SECONDS. USE POINTER KNOB AND PAPER SCALE TO HELP CALIBRATE CIRCUIT USES INCLUDE DARKROOM TIMING. CIRCUIT CAN BE TRIGGERED BY A NEGATIVE PULSE OR WITH A PUSHBUTTON SWITCH ACROSS PINS 1 AND 2.
LED TRANSMITTER

TOY ORGAN

PULSE GENERATOR

MISSING PULSE DETECTOR

MISSING PULSE DETECTOR

THIS CIRCUIT IS A ONE-SHOT THAT IS CONTINUALLY RETRIGGERS BY INCOMING PULSES. A MISSING OR DELAYED PULSE THAT PREVENTS RETRIGGERING BEFORE A TIMING CYCLE IS COMPLETE CAUSES PIN 3 TO REMAIN LOW UNTIL A NEW INPUT PULSE ARRIVES. RI AND CI CONTROL RESPONSE TIME. USE IN SECURITY ALARMS, CONTINUITY TESTERS, ETC.
TIMER (CONTINUED)

555

ULTRA-LONG TIME DELAY

TOUCH SWITCH

+9

R1 CONTROLS
PULSE RATE
FROM 555.
THIS RATE IS
DIVIDED BY
THE 4017's
TO GIVE x10,
X100 AND
X1000 DELAYS.

CI 10μF

CI 4.7μF

C2 1μF

C3 5μF

10K

1K

4017

4017

4017

+5-15

TOUCH WIRE
(TOUCH AND
LED WILL
GLOW 1 SECOND)

WORKS BEST
INDOORS DUE
TO STRAY AC
FIELD. ELSE-
WHERE TRY
TOUCHING
PINS 1 AND 2.

ADDITIONAL
STAGES

1 = RESET
TYPICAL OUTPUT: 555 (PIN 3)
2 = RUN
4017 (X10 OUTPUT)

LIGHT DETECTOR

DARK DETECTOR

+9

CdS. PHOTOCELL (RADIO SHACK 276-116)

+9

CdS. PHOTOCELL (RADIO SHACK 276-116)

PRODUCES WARNING TONE WHEN LIGHT STRIKES
PHOTOCELL MAKES A GOOD OPEN DOOR
ALARM FOR REFRIGERATOR OR FREEZER.

SILENT WHEN LIGHT STRIKES PHOTOCELL
REMOVE LIGHT AND TONE SOUNDS FASTER
RESPONSE THAN ADJACENT CIRCUIT.
NEON LAMP POWER SOURCE FREQUENCY DIVIDER

- WORKS BEST WITH BETTER QUALITY NEON LAMPS, REDUCE R1 SLIGHTLY FOR MORE OUTPUT VOLTAGE.

ONE-SHOT TONE BURST

- PRESS SI AND STEADY OUTPUT FREQUENCY APPEARS AT PIN 3.
- RELEASE SI AND OUTPUT FREQUENCY CONTINUES UNTIL C2 IS DISCHARGED BY R4. INCREASE C2 (OR R4) TO INCREASE LENGTH OF THE BURST; CHANGE FREQUENCY OF TONE BURST VIA R2 OR C1.

ADJUST R1 TO PROVIDE UP TO 10 kHz OUTPUT FREQUENCY.

THIS HIGH PRODUCES CLOSELY SPACED TRIANGLE WAVES. THE WAVES ARE SEPARATED AT SLOWER FREQUENCIES (√3 √3 √3).
**DUAL TIMER**

**556**

Contains two independent timers on a single chip. Both timers are identical to the 555. All the application circuits can also be built with two 555's. This pin cross reference will simplify substituting two 555's for a 556 or half a 556 for a 555.

<table>
<thead>
<tr>
<th>Function</th>
<th>555</th>
<th>556(1)</th>
<th>556(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Trigger</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Output</td>
<td>3</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Reset</td>
<td>4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Control V</td>
<td>5</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Threshold</td>
<td>6</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Discharge</td>
<td>7</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Vcc</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**3-STATE TONE SOURCE**

**INTERVAL TIMER**

**555/556 SCR OUTPUT**

- Timer 1 is connected as astable to 555/556.
- Oscillator timer 2 is a one-shot output.
- Relay driver fires 2 once each cycle.
- Timer 2 pulls relay in for 3-5 seconds.
- Load: small motor, lamp, etc.
DUAL TIMER (CONTINUED)

556

SOUND SYNTHESIZER

TWO-STAGE TIMER

This circuit is an oscillator followed by a frequency divider. Adjust R1 and R4 for very unusual sound effects.

PROGRAMMABLE 4-STATE TONE GENERATOR