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HOLIDAY LIGHT SEQUENCER

Illuminate your Yuletide celebration with this light-controller circuit

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If you are looking for that special decoration to adorn your humble home this holiday season, then look no farther! With this easy-to-build project—the *Holiday Light Sequencer*—you can transform your standard Christmas lights into an exciting display that will rival even the most expensive commercial systems!

The Holiday Light Sequencer is so-named because it interfaces a digital sequencing circuit with four 117-volt AC (household-current) sockets. The Sequencer consists of a variable-frequency pulse generator and four D-type flip-flops. The circuit produces several different selectable sequences that are fed to the four AC sockets via optoisolator/couplers (with triac-driver outputs) and power triacs.

To see how the circuit operates, refer to the schematic diagram of the Holiday Light Sequencer circuit shown in Fig. 1. Integrated circuit U1 (a 555 oscillator/timer) is wired as a conventional pulse generator. The frequency of the pulse generator is controlled by potentiometer R11. Resistor R2 puts a reasonable limit on the highest speed attainable.

The output of the pulse generator is fed to the common clock input of U2, a 74C175 quad D-type flip-flop. Each flip-flop is configured so that its Q output is coupled to the D input of the subsequent flip-flop (as shown in Fig. 2).

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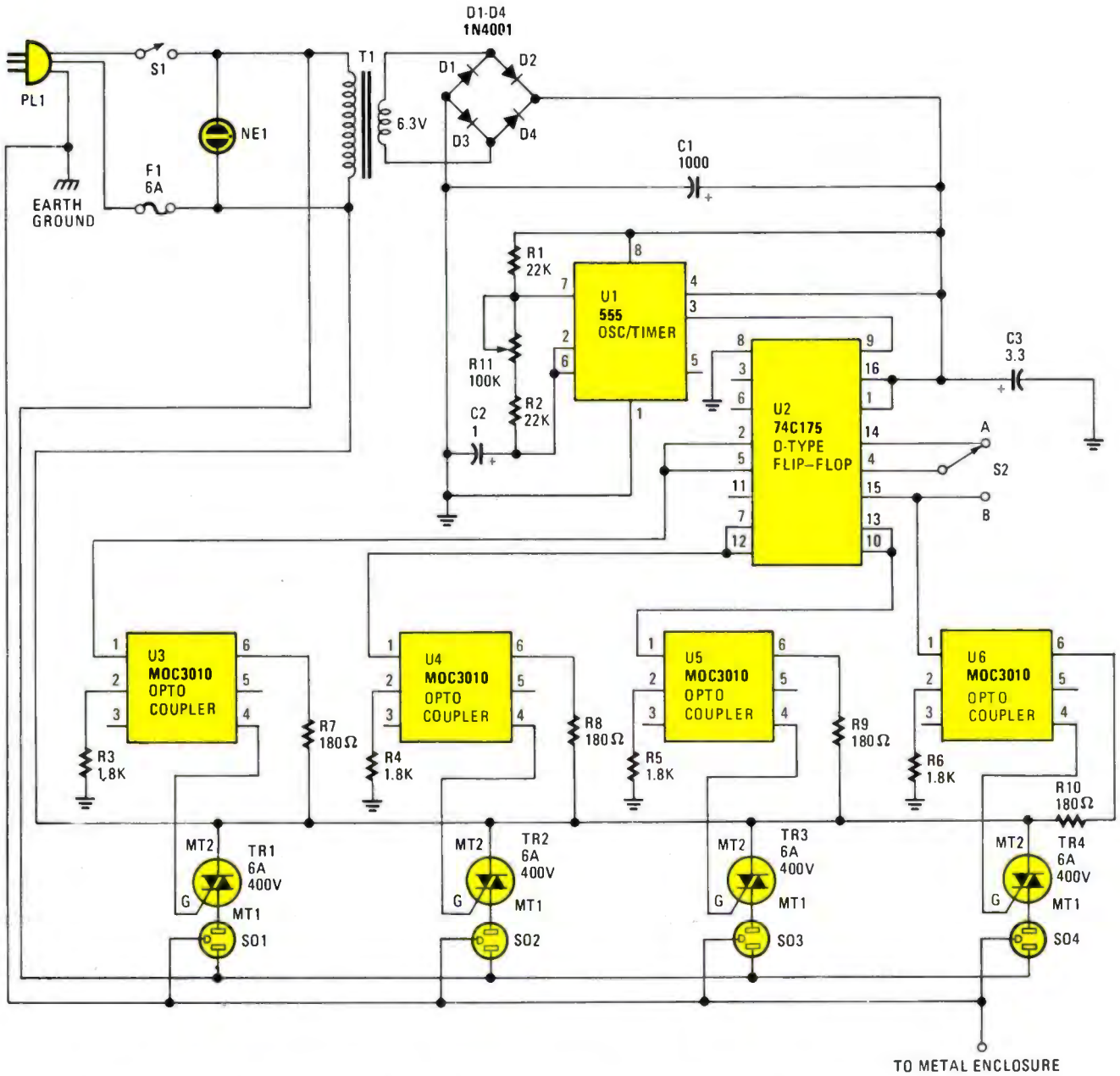


Fig. 1—The Holiday Light Sequencer circuit consists of a 555 oscillator/timer (configured as a pulse generator), feeding a 74C175 quad D-type flip-flop. The four flip-flops, in turn, drive four MOC3010 optoisolator/couplers, which are used to trigger four triacs to provide power to the four strings of lamps.

Information on the D input of each flip-flop is transferred to the Q (and $\overline{Q}$) outputs on the leading edge of each clock pulse. Switch S2 allows you to invert the information on the D input of the first flip-flop at any time during the cycle. That allows you to create a number of different sequences, which are determined by the state of the $\overline{Q}$ output at the time of the switching.

Some of the possible sequences are:

- 1 through 4 on, 1 through 4 off;
- 1 of 4 on sequence;
- 1 of 4 off sequence;
- 2 of 4 on sequence;
- 1 and 3 on to 2 and 4 off;
- and others where the sequence of events is difficult to determine.

However, if S2 is switched to position B while all outputs are high or all are low, which seldom occurs, the sequence stops and the outputs remain either all on or all off. If that happens, you only need to switch back to position A for at least one pulse duration, and then back to position B again.

Likewise, S2 should be in position A (pin 4 connected to pin 14) each time the power is turned on. That's because the data on pin 4 must be a logic 1 in order to start a sequence; otherwise all outputs remain at logic 0 regardless of the clock pulses.

Interface. Each output of the sequencing circuit is connected to an MOC3010 optoisolator/coupler (U3–U6), which contains an infrared-emitting diode with an infrared-sensitive diac (triac driver or trigger) in close proximity. (See Fig 3.) The diac is used as a trigger for the triac, which carries the 117-volts AC.

Each time the infrared-emitting diode receives a logic 1, it turns on, causing the diac to conduct. With the optoisolator/coupler's internal diac conducting, the triac turns on, and power is supplied to whatever load is plugged into the corresponding AC socket. So the sequencing circuit and

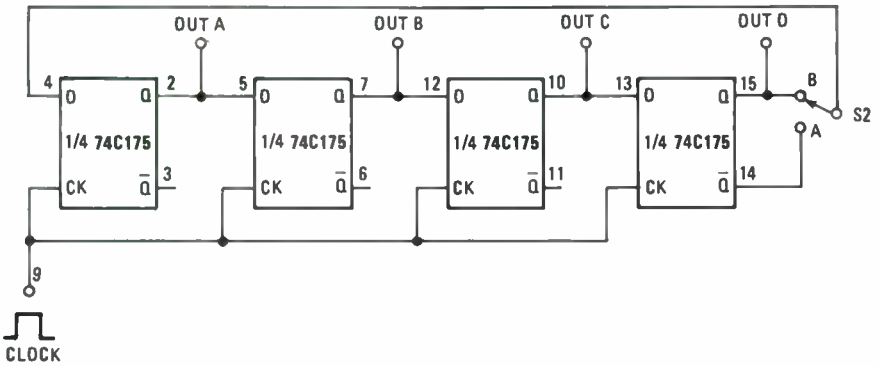


Fig. 2—Shown here is a functional diagram illustrating the actual configuration of the four flip-flops in the Holiday Light Sequencer circuit.

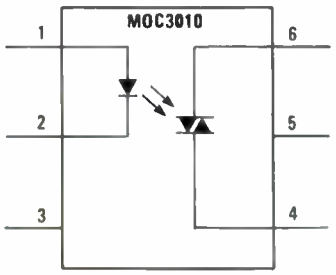


Fig. 3—This block diagram shows the inner workings of the MOC3010 opto-isolator/coupler. Its output element is a diac or triac driver.

the 117-volt AC outputs are "optically coupled" and are effectively isolated from each other.

Power for the sequencing circuit is provided by a 6.3-volt miniature transformer. The output of the transformer is rectified by a four-diode bridge circuit, the output of which is filtered by C1 (a 1000-μF electrolytic capacitor). Capacitor C3 is added at the supply pin of U2 to suppress transients.

Construction. First of all, you absolutely must break off the links between the terminals on the duplex sockets (SO1–SO4), so that each socket can be controlled individually. That is very important! Do it before anything else so you can't forget later. Next, mark the locations of all the components that are to be mounted to the front and rear panels of the enclosure.

Drill and cut holes in the metal enclosure for the panel-mounted components. The holes for the sockets are a little hard to make. However, you can use a wall plate (socket cover) as a template to mark the holes, and then drill with the largest size bit available (without going oversize). The socket holes can then be shaped and/or enlarged as needed with a small file or grinding wheel.

The author's prototype was built on printed-circuit board, the foil pattern for which is shown in Fig. 4. Once the board is etched and drilled, begin installing the board-mounted components, using Fig. 5 as a guide. Note from the diagram that R2 is not mounted on the PC board, but is soldered directly to potentiometer R11. Use #18 insulated wire (or heavier) for all 117-volt AC connections. Use a copper or aluminum heat sink for the four triacs if you plan on using high-wattage lamps. Mount the circuit board on insulating spacers, making sure that none of the connections on the foil side touch the metal case. Make sure that the AC ground is connected to the appropriate terminal on all the sockets and to the metal enclosure. Secure the power cord with a suitable connector or strain relief.

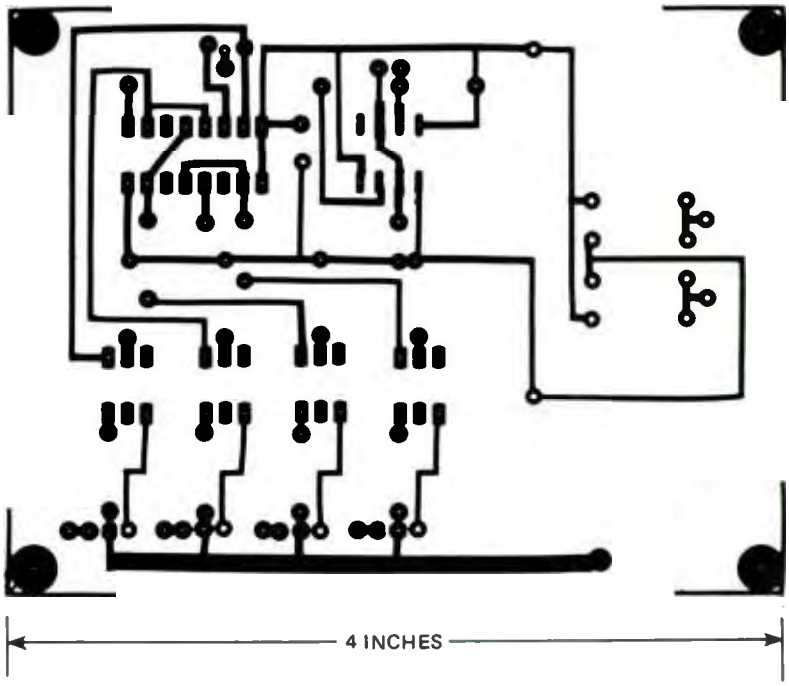


Fig. 4—Shown here is a full-size foil pattern for the Holiday Light Sequencer's printed-circuit board.

The Lights. For the Holiday Light Sequencer to produce the aforementioned sequences, the lights must be arranged in sequence also. Figure 6 shows how that's done. No wires are shown in the diagram because it is the positioning of the lights that is important. The lamps are kept in their proper positions by wire ties or electrical tape around the wires.

The plugs should be marked with the letters A, B, C, and D so that they can be plugged into the corresponding sockets on the Holiday Light Sequencer. If your lights are the "flashing" type, locate the flasher bulb and replace it with an ordinary one.

Warning. Always keep in mind that household current (117-volts AC) can be lethal! Never turn on the power unless the circuit is completely enclosed. Never try to make repairs or modifications to the circuit without first unplugging the unit. The AC fuse must not be omitted from the circuit. The fuse assures that the project won't be damaged in the event of a wiring error.

The Holiday Light Sequencer is intended for indoor use only. Do not use it outdoors, unless you can completely shield it from all forms of precipitation.

Troubleshooting. After checking your wiring several times, put the cover on, plug in the Holiday Light Sequencer, and plug the four sets of lights into the corresponding sockets. (You should check all the lights beforehand by plugging them into a household wall socket).

With R11 set at mid-position and S2 to position A, flip on the power switch, S1. If nothing happens after several seconds, you should set S2 to the other position. If the lights now start to se-

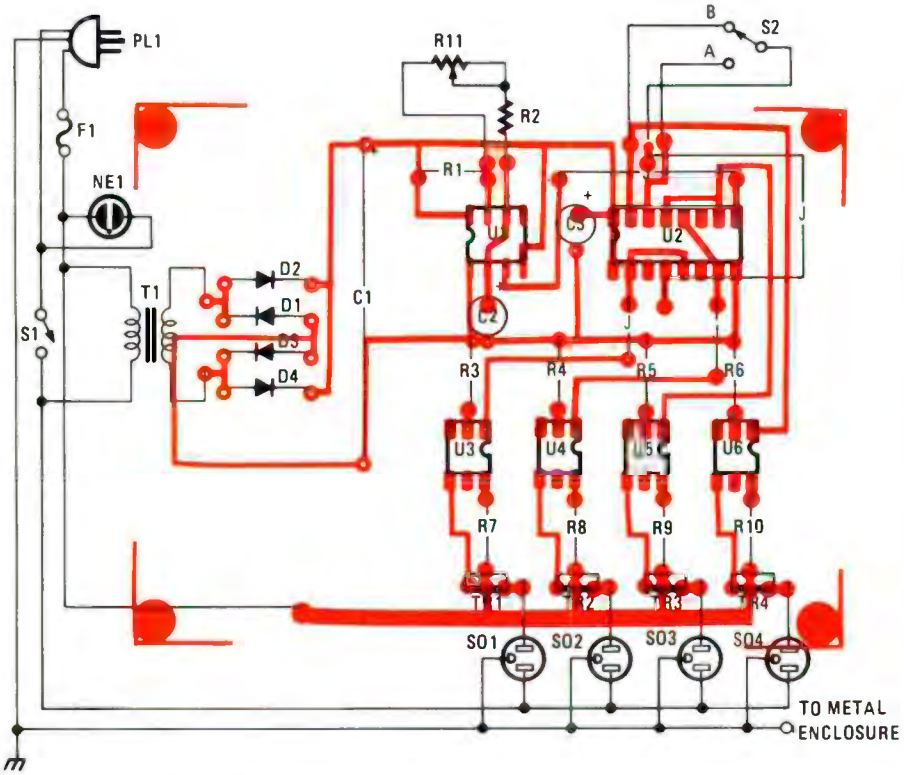
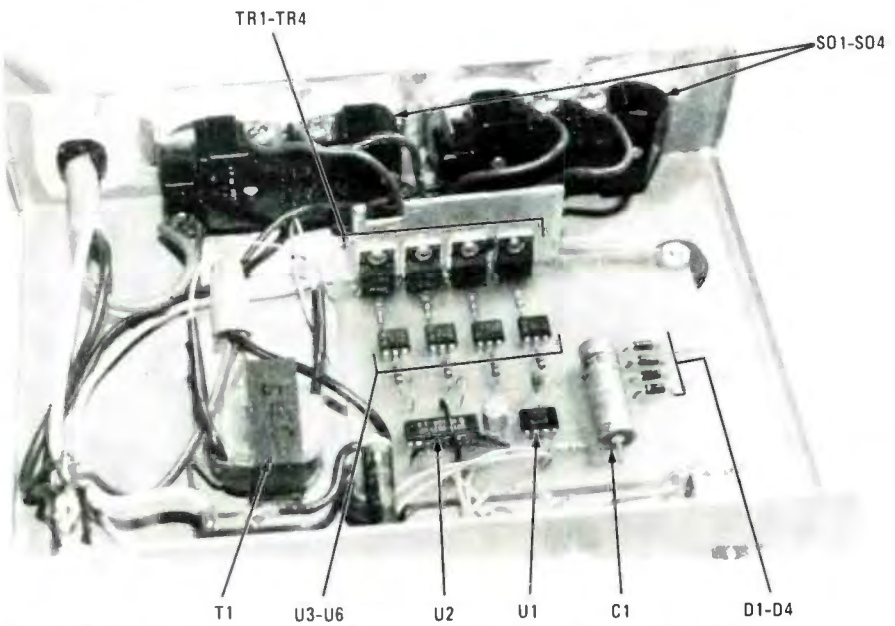


Fig. 5—Shown here is the parts-placement diagram for the Holiday Light Sequencer. When installing the parts, pay strict attention to the orientation of the components. Also it is a good idea to use sockets for the six ICs.



Here is the finished project prior to being sealed into its enclosure. Note that SO1–SO4 consist of two duplex sockets, which come with a shorting bar between the two individual sockets. It is necessary to sever the shorting bar between the sockets to allow the strings of lamps to be controlled individually.

quence, then either the wires to S2 should be reversed (with the unit unplugged of course), or that setting can be marked as position A.

If nothing happens with S2 in either position, check the fuse. If it is blown, then unplug the unit and look for a short in the 117-volt AC wiring. Solder bridges are another possible problem. For instance, solder bridges on the triacs may cause the corresponding socket(s) to stay on constantly.

Improper orientation of the IC(s), missing jumper wires, or poor solder connections can also cause problems. But, if the schematic diagram of the circuit is followed very closely, there should be no problem in getting the Holiday Light Sequencer to work.

PARTS LIST FOR THE HOLIDAY LIGHT SEQUENCER

SEMICONDUCTORS

U1—555 oscillator/timer, integrated circuit
U2—74C175 or 40175B quad D-type flip-flop, integrated circuit
U3–U6—MOC3010 optoisolator/coupler (Radio Shack 276-134 or similar), integrated circuit
TR1–TR4—6-amp, 400-volt triac (Radio Shack 276-1000 or similar)
D1–D4—1N4001 (or similar) 1-amp, 50-PIV, silicon rectifier diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R2—22,000-ohm
R3—R6—1800-ohm
R7—R10—180-ohm
R11—100,000-ohm potentiometer

CAPACITORS

C1—1000-µF, 16-WVDC (or better) electrolytic
C2—1-µF, 16-WVDC (or better), Tantalum or radial-lead electrolytic
C3—3.3-µF, 16-WVDC (or better) Tantalum or radial-lead electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—117-volt primary, 6.3-volt secondary, miniature power transformer
F1—6-amp fuse 3AG
S1—Single-pole, single-throw, rocker switch
S2—Single-pole, double-throw, miniature toggle or slide switch
NE1—117-volt snap-in neon lamp
PL1—117-volt AC molded 3-conductor plug with power cord
SO1–SO4—117-volt AC sockets

Printed circuit or perfboard materials, metal enclosure (Radio Shack 270-272 or similar), IC sockets, fuse holder, hookup wire, solder, hardware, etc.

Operation. While the sequencer is working properly with S2 in position A, try switching to position B at various times during the cycle to create an amazing variety of sequences. Several other sequences are obtainable by plugging set B into the C socket and vice versa. Adjust potentiometer R11 for the desired rate and just sit back and enjoy the show!

And when the Yuletide season is over, don't pack the Holiday Light Sequencer away with the rest of the decorations. Try plugging in a 150-watt floodlamp (to any socket) for wild strobe-type lighting effects! Or maybe you can do something with your patio lanterns. ■