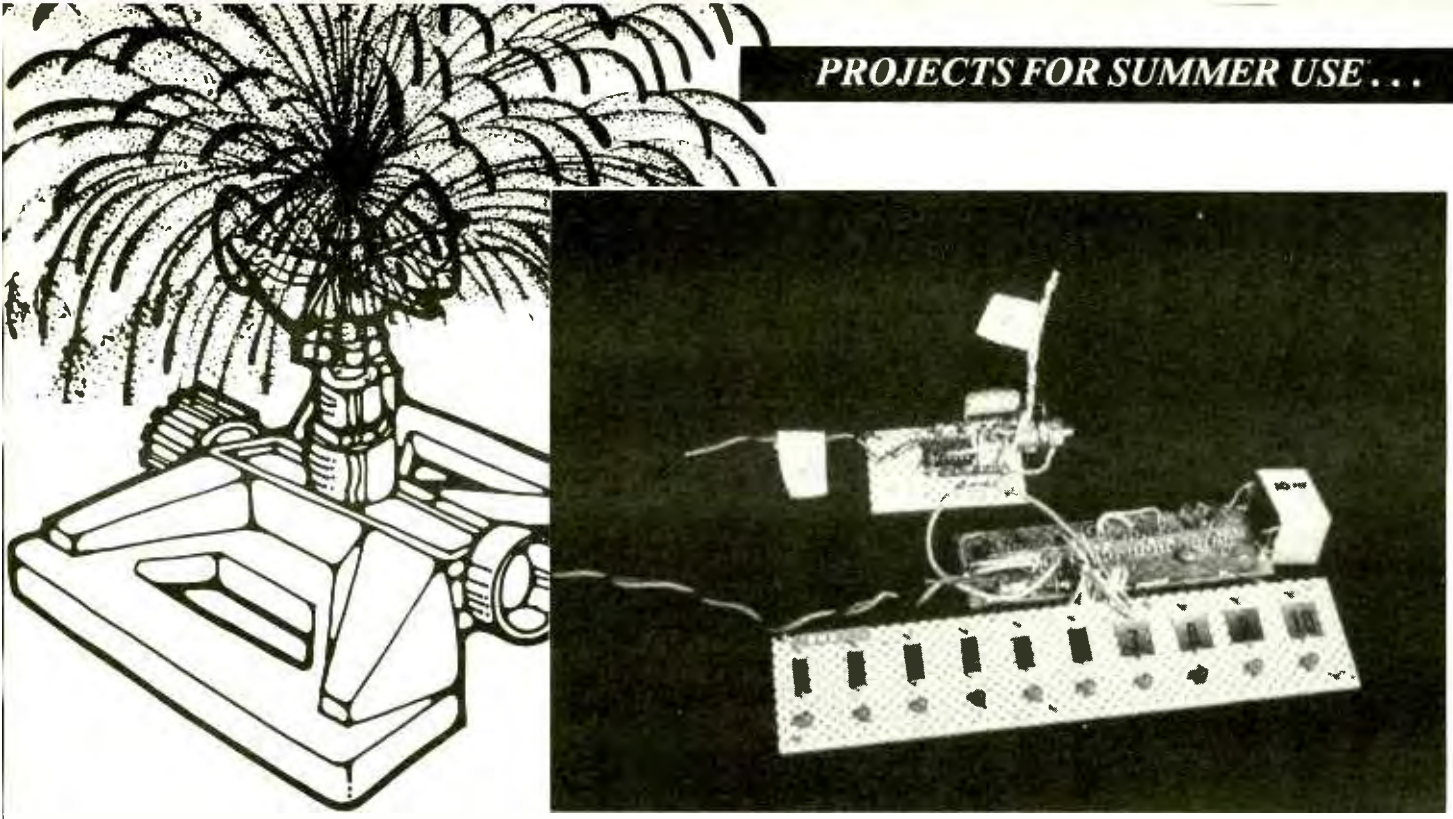

Lawn Sprinkler Controller

Solid-state solenoid sequencer allows you to tailor lawn sprinkler head outputs to watering needs and solves low-water-pressure problems.

By Imre Gorgenyi

There's nothing like an automatic lawn sprinkler controller that allows you to tailor your sprinkler heads' watering automatically to the turf's requirements. The automatic controller described here does this efficiently, economically and safely.

The Automatic Sprinkler System described here is designed for residential watering needs. It's built around electrically activated solenoid valves and solid-state circuitry that's coupled to an inexpensive 24-hour electromechanical timer. Optical coupling between the ac line voltage that operates the solenoids and the low-voltage driver circuitry satisfies the need for electrical safety.

A sequencing technique takes care of the low-pressure problem common to residential water delivery. So instead of watering a large lawn and/or garden in a single pass, solenoid valves water different areas at different times within a programmed time "window." Moreover, the solid-state system allows you to automatically give an extra-dry lawn section additional watering. The project can handle up to 10 sequence steps.

About the Circuit

Keeping the sequencer portion of the system simple was made possible by eliminating all fancy switching and other expense frills, like dials and indicator lights, as shown in the basic Automatic Sprinkler Sequencer circuit in Fig. 1. An ordinary 24-hour timer with setting pins (not shown) turns on and off the + 15-volt line of the Sequencer's timer circuit. When power is applied to the circuit, timer *IC1* begins 1-minute-on/1-minute-off cycling. Timing is governed by the RC time constant of *R4* and *C4*.

Output pulses at pin 3 of *IC1* are coupled through *C5* into divider *IC2*, which divides by 10 the number of pulses delivered to its pin 14 input. Therefore, only one of every 10 pulses generated by *IC1* are passed on to *IC3*.

Up to 10 solenoid driver circuits can be sequenced by *IC3*, another divide-by-10 chip. Each solenoid driver

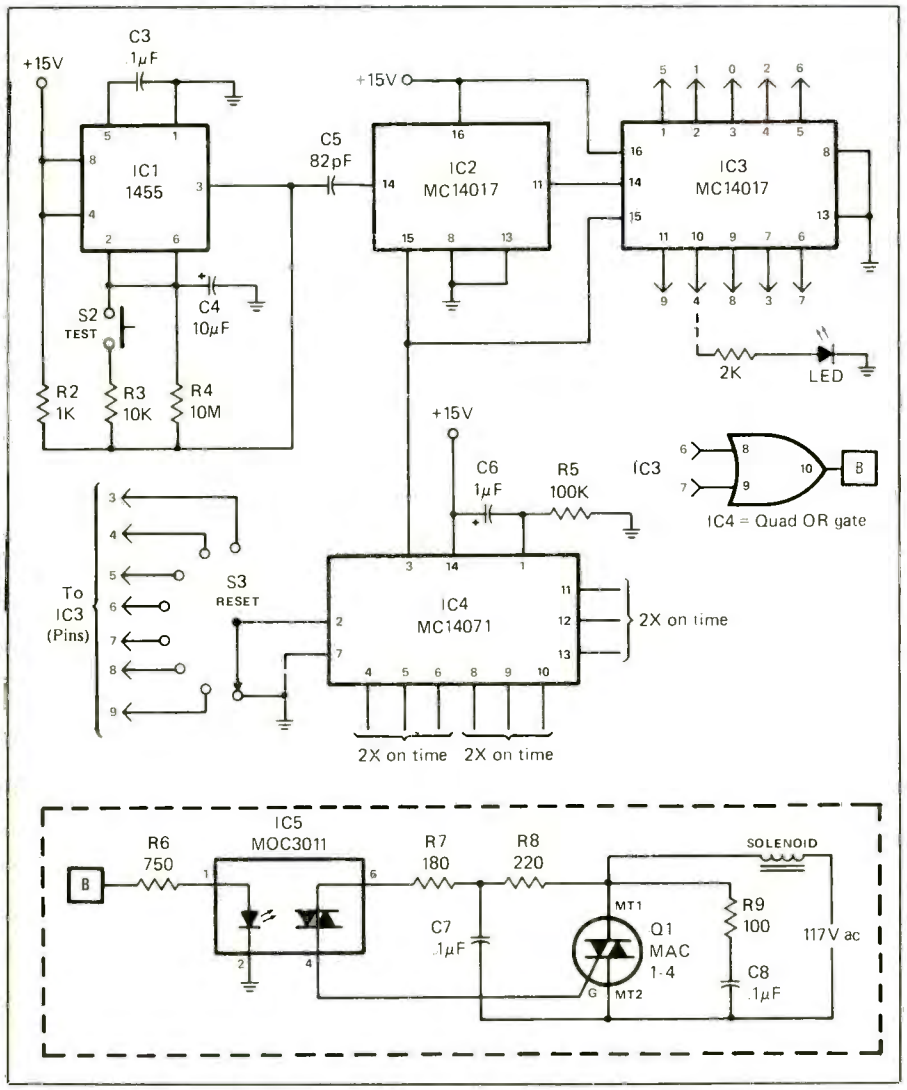

Fig. 1. Schematic diagram of Lawn Sprinkler Controller, minus power supply. Components shown inside dashed-line box are located remotely from main circuit.

circuit consists of an optoisolator/triac arrangement, shown as *IC4* and *Q1* in Fig. 1. Note that the only moving part of this system is the solenoid valve shown in series with *Q1* and the 117-volt ac line.

Normally, you would use a separate circuit arrangement like that shown in the dashed-line box for each solenoid valve to be controlled. However, if you wish, up to four solenoid valves in parallel can be driven by the triac specified for *Q1* so that more of a lawn can be watered with each timing cycle.

Automatic reset for the system is taken care of by *IC4*. When the system is first turned on, the sequence always starts at the first sprinkler head. Contained inside *IC4* are three more OR gates tha can be used to double the on-time simply by inserting a gate between *IC9* and point B, as shown in the detail drawing just below *IC3* in Fig. 1. TEST switch *S2* can be pressed to speed up the sequence to about 2 to 3 seconds so that overall operation of the circuit can be verified.

Operating safety is provided by using an optical device to isolate the Sequencer circuit from the driver circuit. In an actual installation, the low-voltage Sequencer/power supply cir-

PARTS LIST

Semiconductors

D1—1N4744 or similar 15-volt zener diode
IC1—MC1455 timer (Motorola)
IC2,IC3—MC14017 counter (Motorola)
IC4—MC14071 OR gate (Motorola)
IC5—MO3011 optoisolator (Motorola)*
Q1—MAC-1-4 (Motorola)*
RECT1—MDA-920-2 bridge rectifier (Motorola)

Capacitors

C1,C2—100-μF, 25-volt electrolytic
C3,C7*,C8*—0.1-μF, 200-volt disc
C4—10-μF, 25-volt electrolytic
C5—82-pF, 50-volt disc
C6—1-μF, 25-volt electrolytic

Resistors (½-watt, 10% tolerance)

R1—150 ohms
R2—1000 ohms
R3—10,000 ohms
R4—10 megohms
R5—100,000 ohms
R6—750 ohms*
R7—180 ohms*
R8—220 ohms*
R9—100 ohms*

Miscellaneous

S1—Dpdt toggle or slide switch
S2—Spst normally-open pushbutton switch
S3—Single-pole 8-position, nonshorting rotary switch (optional)
T1—18-volt power transformer (Triad No. F-90X or similar)
24-hour ac timer with time-setting pins; solenoid valve*; perforated or printed-circuit board; suitable enclosure for timer circuit; watertight box for solenoid/driver circuits (see text)*; 2 standard line cords with plugs; 3-conductor ac cord with plug*; sockets for ICs; panel-mount light-emitting diodes and 2000-ohm resistors (optional—see text); multiple-contact screw-type terminal strip (see text); silicon adhesive; lettering kit; clear acrylic spray; spacers; machine hardware; hookup wire; solder; etc.

***Note:** you need one set of all these items for each solenoid valve you want the system to control.

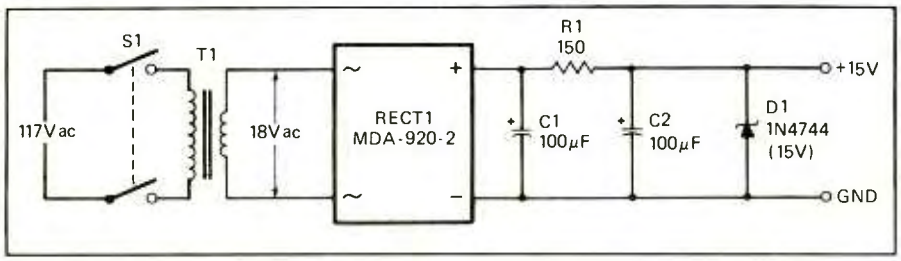

Fig. 2. Power for the Sprinkler Controller is obtained from the ac line.

cuit would be located inside your house, garage or other area protected from the elements where ac power is available. The valve solenoid driver circuits would be housed inside a watertight enclosure and located near the sprinkler heads. The driver circuits then connect to the Sequencer via a low-voltage line instead of a 117-volt ac line. Ac power for the sprinkler heads is then delivered to the solenoids via parallel wiring from the ac line to the triac circuits.

The programmable timer provides a time "window" in which the sequencer will turn on the water lines connected into the system, each for about 10 minutes. If the window's time is set for a long enough period, the Sequencer will automatically repeat the cycle. This way, the same part of your lawn/garden can be watered for two or three 10-minute periods within a couple of hours.

If you require double the watering time (20 minutes) for a certain area, simply wire an OR gate between two outputs of *IC3* and the solenoid driver circuit at point B for two consecutive 10-minute cycles. Three gates wired into the circuit permit three double time and four single time sequences. If necessary, you can set the timer to repeat the cycle by making the window period longer.

You can calculate the timer window so that the last cycle isn't allowed to time out. This lets you program in a short last cycle. Thus, the system can be tailored to your specific needs without switching just by choosing an appropriate timer setting.

You can wire the OR gates directly into the circuit. Alternatively, you can use a switching arrangement that lets you "program" what you want the system to do at any time you desire. Also, optional RESET switch *S3* provides a simple means to restart the cycle if only a few outputs are used. For example, setting *S3* to position 7 allows the circuit to reset after turning on the first six solenoid valves (counting starts at 0), without having to go through the last four cycles. If you are using all 10 outputs, *S3* isn't needed.

If cost isn't an object, LEDs and current-limiting resistors (shown phantomed in Fig. 1) can be added to tell you which solenoid valve(s) are on at any given time.

Power for the timing circuit comes from the ac line, via the simple power supply shown in Fig. 2.

Construction

There's nothing critical about circuit layout. Therefore, you can use any construction technique you prefer for assembling the circuit. You can design and fabricate a printed-circuit board, or use perforated board soldering hardware, or Wire Wrap the project. Whichever way you go, it's a good idea to use sockets for all ICs.

Be careful when wiring the Sequencer/power-supply circuit to observe proper polarity of the electrolytic capacitors and zener diode and the orientations of the ICs as you install them in their sockets. Wire the circuit exactly as shown in Figs. 1 and 2.

Machine a metal or plastic box by drilling mounting holes for the Sequencer/power-supply assembly, entry of the cables from the programmable timer and driver/solenoid-valve assemblies, the ac line cords and any switches and LEDs you decide to use. You can drill a separate hole for each control line going to the separate driver assemblies, or you can cut a long slot in one side of the box in which to mount a screw-type barrier block or terminal strip with enough contacts to accommodate the number of cables you plan to run to the driver assemblies.

If you're using a metal box, deburr all holes and insert a rubber grommet into each that will be used for cables. Pass the free end of one of the ac line cords through the appropriate grommet and tie a knot about 5" from this end inside the box. Prepare the line cord conductors and connect and solder them into the circuit as shown in Fig. 2. Pass the free end of the second line cord through another grommet and repeat the above procedure. This time, connect and solder the conductors between the power supply's +15-volt output and the +15-volt bus in the Sequencer circuit. This is the *only* conductor that should bridge these two points. Cut off and discard the plug from this line cord.

Pass the cables that go to the driver/solenoid subassemblies (their lengths will depend on how far away the various driver/solenoid-valve circuits will be from the Sequencer circuit's location) through the remaining holes and tie a knot in each about 5" from the free end inside the box. If you've decided to use a barrier block or terminal strip instead, connect and solder wires from its lugs to the appropriate points in the Sequencer circuit.

Connect and solder into the circuit any switches and/or LEDs you've decided to use. Then mount the Sequencer/power-supply assembly inside the box with the aid of spacers and machine hardware. Finish up assembling the Sequencer section by mounting the switches and LEDs in their respective holes. Before you

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An Automatic Lawn Sprink

assemble the box, wire *IC3*'s gates into the circuit for the operating conditions you desire, as described above.

Label the cable entry holes, switch positions and LEDs with appropriate identifying legends using a dry-transfer lettering kit. Spray two or three *light* coats of clear acrylic over the lettering to protect it. Assemble the box.

You *must* use watertight enclosures for the driver subassemblies. You can make such enclosures from standard chassis boxes simply by sealing all joints and holes with silicone adhesive after the circuit has been installed and tested and the boxes have been assembled.

Wire each driver circuit on a small pc or perforated board exactly as shown inside the dashed-line box in Fig. 1. Make sure you electrically isolate all parts of the circuits from the metal boxes and the low- and ac-voltage sections from each other, and connect the neutral wire of the three-conductor ac cords to the boxes. The cables from the solenoids connect to the appropriate points in the circuits inside the boxes.

Drill three holes in each box, one for the low-voltage lines from the Sequencer, a second for the solenoid's leads, and the last for the three-conductor ac wiring. Line each hole through which a wire is to pass with a rubber grommet and tie a strain-relieving knot in the ac cords and low-voltage cables inside the boxes before connecting and soldering the conductors into place.

Liberally coat the cables, knots and grommets with silicone adhesive, overlapping it onto the inside box walls. Repeat on the outside. Assemble the boxes, using the hardware supplied with them, and liberally coat all seams and screw heads with silicone adhesive. *These must be watertight seals!*

When installing the system, make certain you observe all local electrical

ker *(from page 28)*

wiring codes. Mount the Sequencer/power-supply assembly and programmable timer in a protected location near a pair of ac outlets.

Connect the solenoid valves between the water supply line and individual sprinkler heads. Then wire together the system.

In Closing

Now that you have the Automatic Sprinkler Sequencer installed, turn it on and relax. Instead of having to remember when to water your lawn and garden, dependable solid-state electronics is at work. ME