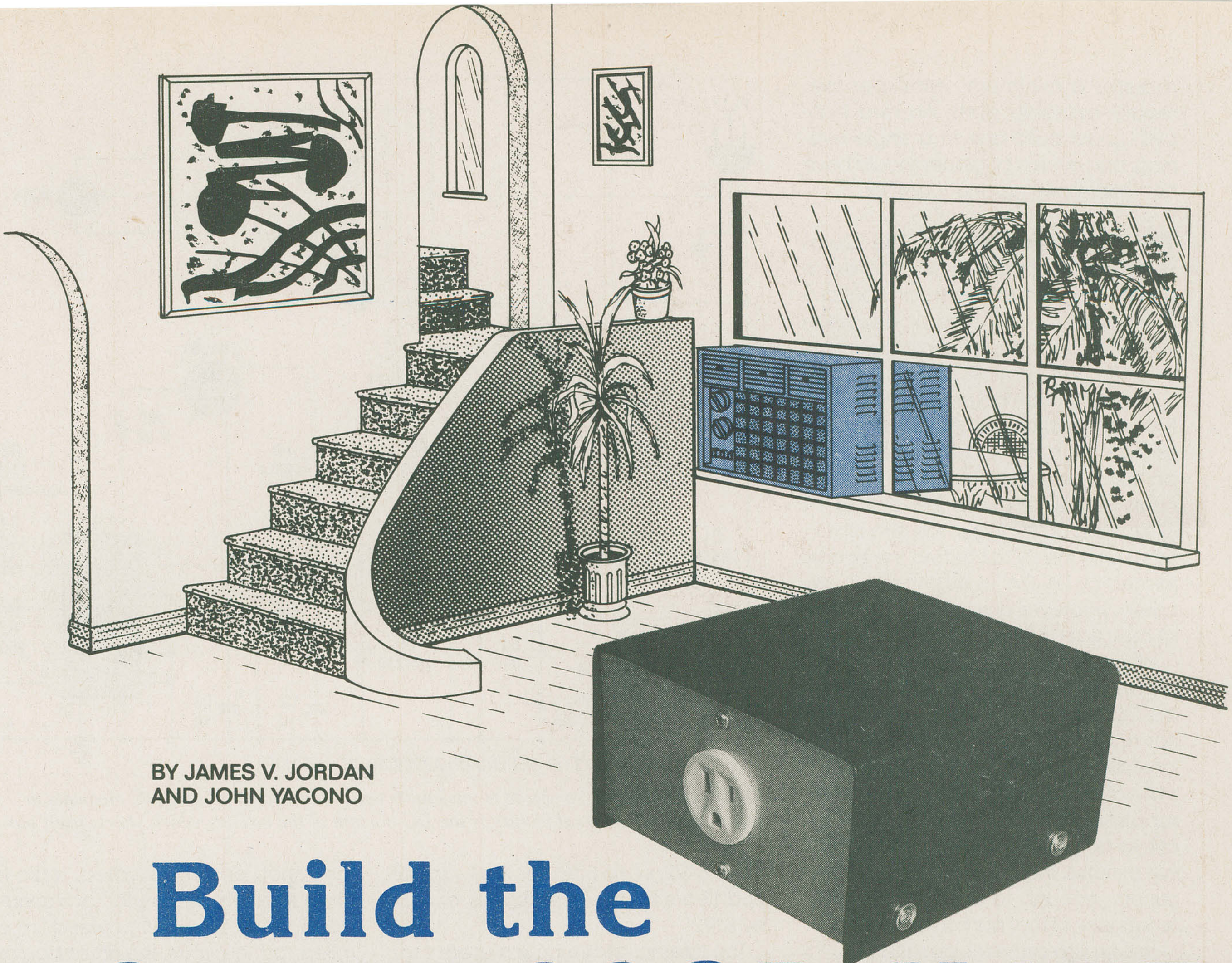


BY JAMES V. JORDAN
AND JOHN YACONO

Build the COMPRESSOR-MATE

Although the compressors found in refrigerators, freezers, and air conditioners are heavy-duty devices, their life can be shortened by frequent power outages—unless you have a Compressor-Mate.

It's a great mystery how my development, which has an underground power-distribution system, can have as many power failures as it does (at least two a month). Mystery or not, it's an unpleasant reality that I and my electronic hardware must endure. I shudder to think of what people who live in really windy areas with pole-mounted distribution networks must put up with.

While everyone is aware of what a nuisance power outages are—what with having to re-program the VCR, all the clocks in the house, and a stubborn microwave that refuses to work unless informed of the time—many people don't know that frequent outages can really cost them. If your local power is as unreliable as mine, the compressors in your home appliances are probably taking a silent beating.

If a compressor is running at the time of a brown-out or intermittent power failure, it inevitably stalls and the overload-protection circuit cycles on and off a few times. As any refrigeration specialist will tell you, starting a compressor over and over under the load of compressed gas puts a lot of wear and tear on the equipment.

Since compressors form the heart of any appliance they're in, they don't come cheap. Depending on the age and cost of a machine, an owner is sometimes better off buying a new appliance instead of replacing a compressor.

To protect your present (and future) investments, you can build a solid-state timer—the *Compressor-Mate*—that will keep the compressors that you own from destructively cycling on and off. The project consists of a solid-state, voltage-monitoring circuit with a five-minute delay timer controlling an electromechanical, 30-amp power relay. The relay, in turn, controls power to the appliance being protected.

When power fails and comes back on, the Compressor-Mate waits about five minutes before it restores power to the appliance. That gives the unit time to cool down and permits system pressures to equalize for unloaded restarting.

Beyond that, the project can be adapted to control AC or DC loads in the 24- to 240-volt range, so it can be used in a variety of other applications. It requires a minimum of inexpensive, readily available parts. An avid hobbyist could build one in a single evening, and even a beginner should have no trouble putting one together.

The How's and Why's. The Compressor-Mate's schematic diagram is shown in Fig. 1. Although it can control a DC device, for the sake of discussion let's first talk about how it operates when it controls an AC device.

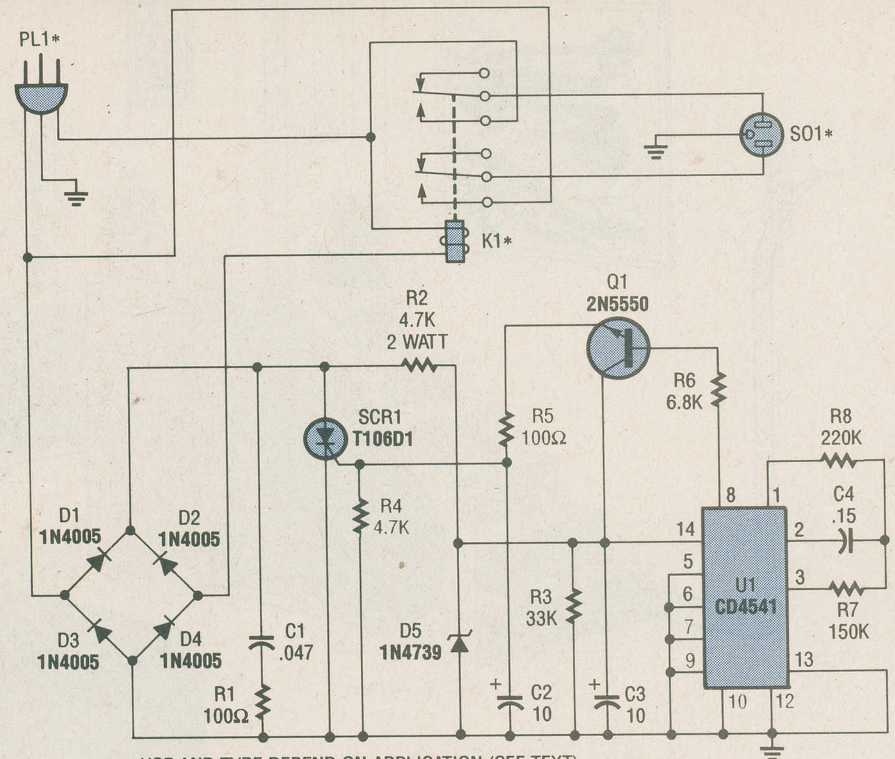
The circuit can be broken down into two main sections: an AC portion, consisting of PL1, K1, and SO1; and a DC portion, made of the rest of the components. Oddly enough, the coil of K1 (which is in an AC leg of the circuit) is in series with the DC circuit via the bridge formed by D1–D4. That's important because whatever current flows through K1 must flow through the DC circuit.

When power is first applied to the circuit, perhaps after a power failure, the DC circuit draws very little current (for reasons that will become obvious later). In fact, the current is so small that K1 is not activated. So when power is first supplied, K1 is inactive and SO1 receives no power. However, after about five minutes, the DC circuit draws lots of current, enough to engage the relay. So let's look at that portion of the circuit.

The bridge provides pulsating DC to a filter made up of capacitor C1 and resistor R1. The filter smooths out the pulsating DC and absorbs AC-line voltage transients to protect the other DC components. Zener diode D5, resistors R2 and R3, and capacitor C3 form a filtered-DC power supply. Resistor R2 limits current flow through D5 to a safe level. That allows the diode to provide 9 volts to another filter comprised of C3 and R3.

The power supply supports a timing circuit. At the heart of the timer is U1, a programmable 16-stage binary counter with an integral oscillator circuit. Its extremely low power requirements ensure that little current will flow through the circuit, preventing the relay from engaging.

The counter is a multi-faceted device that can be programmed to act in a variety of ways. For example, its internal oscillator can be replaced by sending the pulses of an external oscillator to pin 3. Whether you use the internal or an external oscillator, the pulses are sent to an internal programmable counter/divider. Depending on the logic levels presented to pins 12 and 13, the counter divides the pulses by 256,



*USE AND TYPE DEPEND ON APPLICATION (SEE TEXT)

Fig. 1. The Compressor-Mate is unusual because it contains AC and DC elements in series. Another unusual feature is the DC portion of the circuit, which shorts itself out.

1024, 8192, or 65,536. Because pins 12 and 13 are tied low, the counter divides by 8192.

The internal oscillator was used. It requires R7, R8, and C4 to set the frequency. The values specified for those components set the frequency to around 26 Hz. That might seem pretty slow, but the 4541 can operate with an oscillator frequency of from close to DC to 100 kHz. The oscillator (running at 26 Hz) combined with the counter (dividing by 8192) set the timing interval at about 315 seconds, or 5 minutes and 15 seconds.

The timer has an array of other features that the circuit takes advantage of. For example, tying pin 5 to ground, as shown in the schematic, causes the timer to start timing on receipt of power. If that pin were tied high, the chip would wait for a low-to-high transition on pin 6 before operating.

If a low is placed on pin 9, as is shown in Fig. 1, the output of U1 at pin 8 goes low for the duration of a timing interval. However, if pin 9 of U1 was held high, the output would be high during a timing interval. Pin 10, which is connected to ground in the circuit, allows you to select between one-shot (if set to logic low) and astable (with a logic high) modes.

To summarize, the timer is set up as a one-shot, power-activated, logic-low output timer with a period of 5 minutes, 15 seconds. So, when power is first applied to the circuit, the timer begins a timing interval and holds the output of U1 at pin 8 low for about five minutes. The low power drain of the timer prevents K1 from latching.

When the interval is over, pin 8 goes high and provides sufficient base bias to Q1 via R6 to cause it to conduct. The transistor then provides sufficient current to the gate of SCR1 through R5 to cause it to conduct. Capacitor C2 and resistor R4 prevent false triggering of SCR1. (Note that the diode bridge ensures that the SCR is always forward biased.)

The voltage drop across the SCR is so small it effectively shorts the DC portion of the circuit and draws more than enough current to cause K1 to latch. The relay, in turn, provides power to SO1, turning on anything connected to it. Since the SCR is always forward biased, the relay remains on. If power is removed and reapplied, another timing interval begins, permitting the device connected to SO1 five minutes to settle down before receiving power.

As was mentioned, the device is suitable for DC applications. You will need to select K1, PL1, and SO1 to suit your

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COMPRESSOR-MATE

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application. Although not needed for DC use, the diodes will make the unit immune to polarity reversal.

Assembly and Testing. The DC portion of the circuit may be assembled on a piece of perfboard using point-to-point wiring, as in the prototype. Be mindful of the orientation of diodes D1 through D4 and especially that of D5. The same holds true for capacitors C2 and C3, as they are electrolytic units. Both Q1 and SCR1 are available in a variety of case styles and lead configurations, so check their pin configurations before wiring them into the circuit. The use of a socket for U1 is highly recommended, but **do not install U1 until called for during the test procedure.**

When all components have been installed (except U1), check the wiring carefully. If you are satisfied that the wiring is correct, strip the insulation from the ends of two leads and connect them to the AC points on the diode bridge. The wire should be thick enough to easily carry current for the relay.

Wire the relay's coil in series with one of the DC circuit's two leads. Connect the appropriate connectors (PL1 and SO1) to the remaining lead of the DC circuit and the relay. The wire that delivers power from PL1 to SO1 via the relay should be selected to withstand the current needed by the device that you're protecting.

It's a good idea to test the circuit before placing it in an enclosure. When testing the unit, be sure to place it on a non-conductive surface. Apply power to the unit; the power relay should not energize at this time. If it does, remove power and recheck the wiring before going any further. If the relay coil does not pull in the armature, but hums slightly, that is acceptable.

Remove power and take a piece of small diameter, insulated bus wire and jumper pins 8 and 14 of U1's empty socket. (Never do this with U1 in place, it will destroy the IC.) Now apply power to the circuit. The relay should pull in its armature and remain energized even if you remove the jumper wire (which you should do carefully if you are using the project to control line current).

Disconnect power to the project and carefully install U1 in its socket. Reconnect power to the project. In 315 seconds, the power relay should energize. After the relay energizes, momentarily interrupt the power. The relay should de-energize and then re-energize again 315 seconds later.

Note that during the first five timing cycles R2 will become warm and may smell. That's no cause for concern unless the condition persists or if the resistor seems seriously overheated. If the tests go well, house the project in a grounded metal box with holes cut for the appropriate male and female power connectors. ■

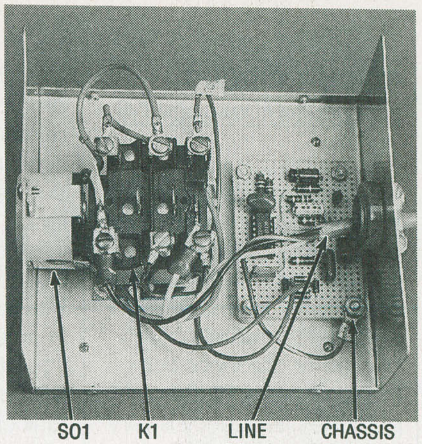
PARTS LIST FOR THE COMPRESSOR-MATE

SEMICONDUCTORS
- U1—CD4541 programable-timer, integrated circuit
- Q1—2N5550, or equivalent, NPN silicon transistor
- SCR1—T106D1 or similar, 4-amp, 400-PIV, sensitive-gate, silicon-controlled rectifier
- D1–D4—1N4005 1-amp, 600-PIV, rectifier diode
- D5—1N4739 9-volt, 400-mW, Zener diode

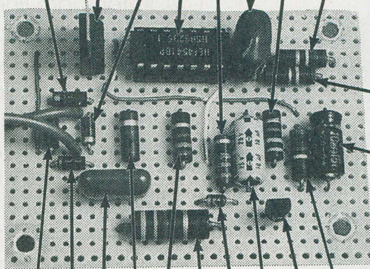
RESISTORS
(All resistors are ¼-watt, 5% units unless otherwise noted.)
- R1, R5—100-ohm
- R2—4700-ohm, 2-watt
- R3—33,000-ohm
- R4—4700-ohm
- R6—6800-ohm
- R7—150,000-ohm
- R8—220,000-ohm

CAPACITORS
- C1—.047-µF, 400-WVDC, Mylar
- C2—10-µF, 15-WVDC, electrolytic
- C3—10-µF, 25-WVDC, electrolytic
- C4—0.15-µF, 100-WVDC, Mylar

ADDITIONAL PARTS AND MATERIALS
- K1—30-amp DPDT power relay with 117-volt coil
- PL1—3-terminal AC power plug with line cord
- SO1—3-terminal AC socket, chassis mount
- Perfboard, metal enclosure, wire, solder, hardware, etc.



The wiring within the cabinet should be neat. It should also be heavy enough to handle the current required for its task. Note that the chassis is connected to the ground lead of the power cord via a mounting screw and nut.



Here is the Compressor-Mate's circuit board—with all board-mounted components called out—prior to installation in its cabinet. When assembling the circuit, be sure to use a 2-watt or more resistor for R2.