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Test continuity with an LED

Raju R Baddi, Raman Research Institute, Bangalore, India

You sometimes need to know whether a resistance exceeds a preset limit. The continuity tester in **Figure 1** lets you determine that fact for resistances of 0.5Ω to 10 kΩ. The heart of the circuit is the transistor pair comprising Q_1 and Q_2, whose emitters draw current from a single source, R_E. Insert the circuit under test, R_{CY}, between Point A and Point B. To set the limit, use a known resistance for R_{CY} and set the trimming potentiometer until the LED begins to light.

The current through R_E divides between Q_1 and Q_2 in proportions based on the resistances of the two loops. The circuit lets you set the low limits to values as low as 0.5Ω because the emitter current in Q_2 can change rapidly with small changes in its V_{BE} (base-to-emitter voltage). The remaining current originating in R_E goes through the emitter of Q_1, whose collector then suffers voltage changes on the order of approximately 100 mV because most of a transistor's emitter current flows to its collector.

At extremely low limits, a large change in emitter current can easily accommodate the drop in voltage across R_{CY} in Loop 2. The extra current goes through Loop 1. At the critical value of R_{CY}, Loop 1 conducts a much higher current than Loop 2, which again means a much smaller V_{BE} change for Q_2.

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The online version of this Design Idea, available at www.edn.com/110106dia, includes an appendix that provides

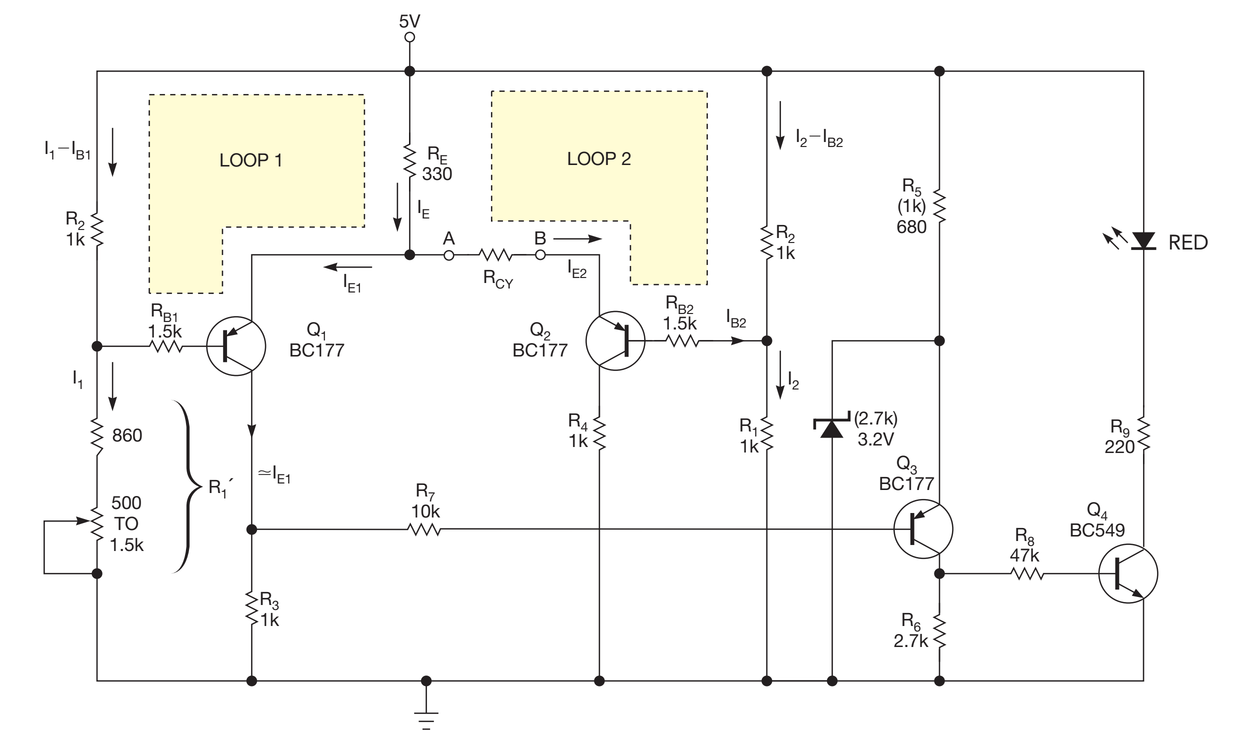

Figure 1 This continuity tester lets you know whether a resistance exceeds a preset limit.

a detailed analysis of the circuit's dc performance.

When R_{CY} is an open circuit or has a resistance above the set limit, a larger portion of the current through R_E flows to the emitter of Q_1, which produces a voltage across R_3. That voltage is close to the voltage at the emitter of Q_3. Thus, Q_3 doesn't have sufficient V_{BE} to turn on. In turn, Q_4 is off, and the LED doesn't illuminate.

When the resistance of R_{CY} is under the set limit, Q_2 begins to draw its share of current from R_E. This step reduces the current through the collector of Q_1, and the voltage drop across R_3 also decreases. The difference in voltages between the collector of Q_1 and the emitter of Q_3 exceeds V_{BE}. Q_3 then conducts, turns on Q_4, and lights the LED.

The tester's quiescent current is 10 mA, making the tester suitable for a bench instrument. If you need battery power, such as a 3.6V nickel-cadmium or lithium-ion battery, however, you can reduce the LED's series resistance by less than 47Ω and change Q_3's emitter voltage. (See the appendix, which is available online at www.edn.com/110106dia.)

Use two variable potentiometers in series whose values—1 kΩ and 100Ω, for example—differ by an order of magnitude. This approach allows you to make precise limit adjustments at lower limits.

The values in parentheses in **Figure 1** are substitute values. You can substitute five 1N4148 diodes for the 3.2V zener diode. Both arrangements perform well. The LED may go a bit dim toward the low limit, approximately 0.5Ω, so use one with a transparent lens. EDN

Flash an LED from ac-mains power

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LED technology is opening the door to a variety of high-power-illumination applications. The circuit in **Figure 1** can let you know when ac power is available. To drive a power LED from the ac line requires a converter or a similar arrangement. In this circuit, a passive dropper greatly simplifies the total design. You can also simplify the circuit to run on dc power, which lets you use it from automotive batteries to supply light at night.

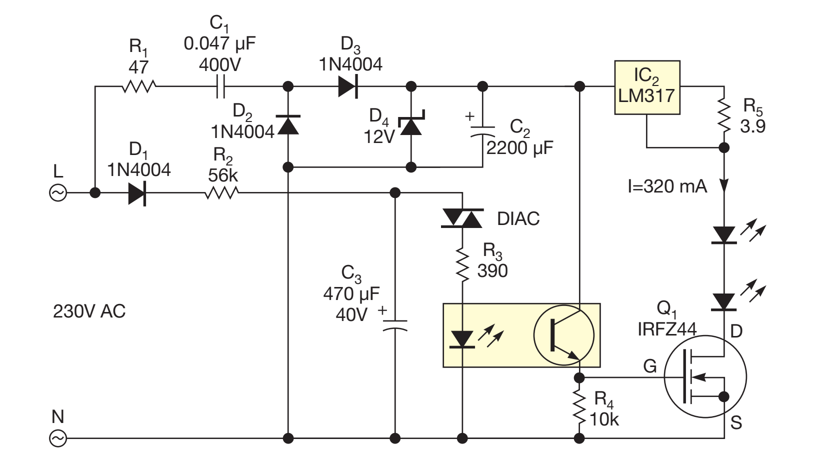

Figure 1 This circuit uses a simple DIAC relaxation oscillator, which activates a constant-current-switching circuit.

The design comprises an inrush-limiting resistor, R_1; a half-wave rectifier with a filtering capacitor comprising D_2, D_3, D_4, and C_2; a relaxation oscillator; and two high-power LEDs. Because the circuit drives the LED with a constant current, you can use any LED color to suit the situation.

The circuit uses a simple DIAC (diode-alternating-current) relaxation oscillator, which activates a constant-current switching circuit comprising IC_2 and Q_1. The DIAC turns on when capacitor C_3 charges through diode D_1 and resistor R_2 from the mains voltage. After a number of half-cycles of the mains, the voltage on C_3 exceeds the break-over voltage of the DIAC, the DIAC conducts, and C_3 discharges through R_3 and optocoupler IC_1. The optocoupler activates the constant-current switching circuit, resulting in a brief, intense flash of light from the LEDs.

High-voltage capacitor C_1, part of the passive dropper, limits the current drawn from the power line, as the following **equation** shows:

$$I_{RMS}=\frac{V_{AC}}{X_{ACCAPACITOR}}=\frac{V_{AC}}{\frac{1}{2\pi FC}}=2\pi FCV_{AC}.$$

A 47Ω metal-oxide resistor, R_1, acts as an inrush-current limiter. Because the LEDs require a lot of energy, it's not feasible to directly drive them using a small-value capacitive dropper. Instead, this circuit uses a 2200-µF capacitor, C_2, to collect and store energy from the power line between flashes. Zener diode D_4 limits the capacitor voltage to 12V.

The easiest constant-current approach is to use an adjustable linear regulator, such as Linear Technology's (www.linear.com) LM317. The regulator maintains a voltage of 1.25V across series resistor R_5. The 1.25V is the reference voltage of the regulator. Consequently, you can determine the load current with the following equation: $I_{LED}=1.25/R_5$. The active current limiting is 320 mA, which is sufficient to produce an intense light flash.

As a note of caution, this circuit has no galvanic isolation from the ac mains. Most nodes are, therefore, at mains potential and hence dangerous. You should not construct this circuit unless you have experience in handling high-voltage circuits. EDN

Reliable 555 timer doesn't falsely trigger

John Dawson, Opelika, AL

Circuits employing the popular 555 timer circuits are often reliable under many conditions. When you use them in electrically noisy environments, however, the timer can produce a false trigger, no matter how well you filter its power-supply lines. The circuit in **Figure 1** sends a pulse to an SCR (silicon-controlled-rectifier) crowbar circuit when the 555's input pulls low due to a fault-detection circuit. The 555 timer chip is unpowered until a crowbar fault signal occurs. The logic-low signal forces the 74LS02 NOR gate's output high, which provides enough power to operate to the 555 timer circuit. The timer triggers on power-up. Capacitor C_2 holds the trigger signal low until it charges to 5V. The 555 timer's output should drive a low-current device—in this case, a transistor switch. This circuit solves the problem of false triggers. The pulse transformers connect to two SCRs in series that pulse 1600 to 2000V dc to fire a crowbar for a 22-kV dc power supply. The SCR-controlled high-voltage power supplies are electrically noisy, causing many false triggers from the 555 timer circuit. EDN

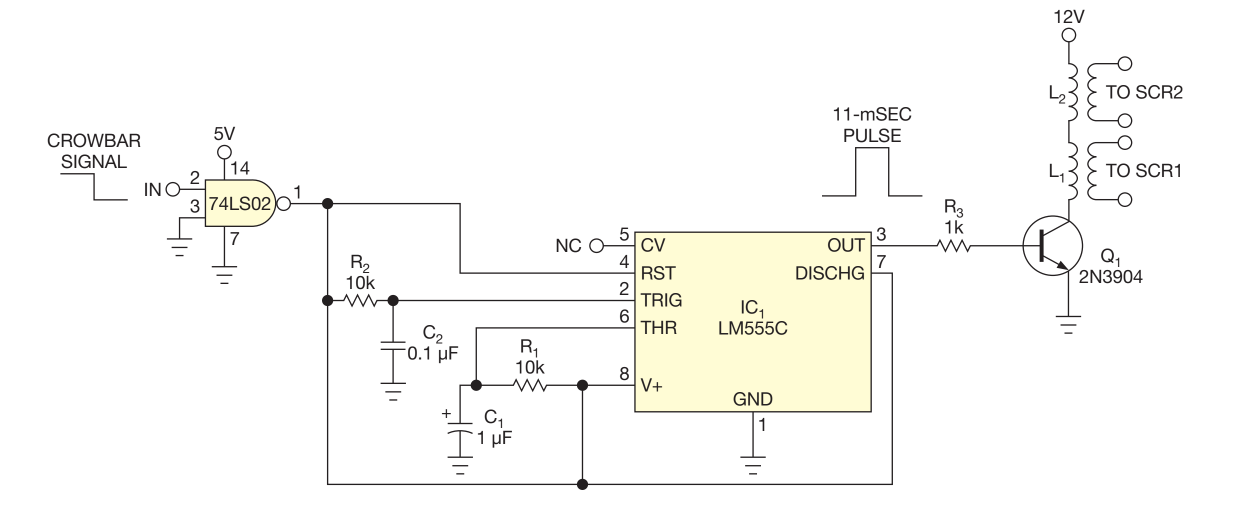

Figure 1 Powering the 555 timer from a NOR gate results in no false triggers from an electrically noisy environment.

Transistors drive LEDs to light the path

Eliot Johnston, Comnet International, Richardson, TX

Keeping low-voltage outdoor lights illuminated takes some effort. Bulbs burn out, and connections corrode. HB LEDs (high-brightness light-emitting diodes) seem like acceptable replacements, but most are available only in surface-mount packages, which aren't conducive to a backyard project. In addition, you must create a reflector for tiered lighting. Low-power LEDs, which come in finished packages, are more appealing, but you must have a way to drive them. Numerous driver ICs are available, but they, too, usually are available in surface-mount packages. Furthermore, the cost of the parts can add up to an expensive project. The simple two-transistor, two-resistor circuit in **Figure 1** provides a better fit for this application.

The two transistors and two resistors act as a simple current source. Q_1's base-emitter voltage, V_{BE}, combines with re-

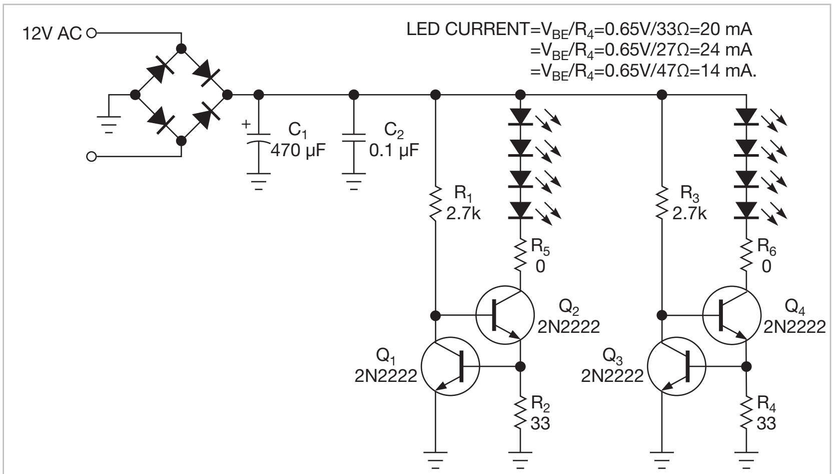

Figure 1 A simple two-transistor, two-resistor circuit is a good fit for outdoor-lighting applications.

Figure 2 Two identical circuits on a round PCB can drive eight LEDs, producing a relatively consistent light output.

sistor R_2 to set the LED current at approximately 20 mA. In this application, even a tolerance of ±10% doesn't significantly affect LED performance. Thus, only the value of R_2 is somewhat critical.

The 7 and 11W incandescent outdoor lights in this setup receive their power from a 12V-ac photoelectric timer. The bridge rectifier and filter capacitor produce approximately 15V dc—enough to drive four white LEDs, each with an approximately 3.2V forward-voltage drop. A small-value resistor, R_5, may be necessary to offload some of the power dissipation of the main pass transistor. In this setup, however, Q_2 dissipates only around 50 mW, so it can use just a jumper wire for R_5—hence, the schematic shows it with a value of 0Ω. Two identical circuits on a round PCB (printed-circuit board) can drive eight LEDs, producing a relatively consistent light output using Cree (www.cree.com) C535A-WJN series 110°-viewing-angle LEDs (**Figure 2**).

The lighting network uses two 144W transformers, which probably consume more energy than the new LED lamps. Once you replace all the bulbs with LEDs, power consumption should drop from approximately 200W to approximately 20W. You then connect the two strings together and remove one of the transformers. You could also build an efficient 120V-ac to 15V-dc power supply into the transformer housing and send dc down the wire rather than 12V ac.

SOLDER THE WIRES DIRECTLY TO THE PCB, LEAVING THE POTENTIAL FOR CORROSION AT THE CONNECTION TO THE MAIN WIRE.

You should use an automotive clear-coat spray to seal everything from moisture. This circuit should provide more than 10 years of service life. Contact corrosion causes reliability problems. Corrosion tends to set into the stab connection to the main wire and at the bulb itself. Instead of plugging in the replacement, you can solder the wires directly to the PCB, leaving the potential for corrosion at the connection to the main wire. Removing some insulation and soldering the wires makes for a more reliable connection. Remember to coat each splice with some silicon RTV (room-temperature-vulcanizing) sealant.EDN

Use an optocoupler to make a simple low-dropout regulator

Marc Ysebaert, De Pinte, Belgium

Although a monolithic low-dropout regulator has superior dynamic characteristics, the discrete regulator in this Design Idea is so simple that you can adapt it to many purposes. Using a common transistor, it has a dropout voltage of 0.1V. This dropout voltage can be even less if you use a FET. In the circuit in **Figure 1**, the optocoupler's LED determines the approximately 1V output voltage, which the circuit adds to the voltage of the zener diode. A low-current zener diode gives the best results because regulation occurs at less than 1 mA, depending on the current gain of the transistor. To regulate the voltage of one battery cell, you can omit the zener diode to a given output voltage of approximately 1V. You can also replace the zener diode with a potentiometer to obtain a variable output voltage. Another alternative is to use a combination of one or more LEDs or regular or Schottky diodes to obtain a fixed output voltage. You can insert a low-current LED as part of the voltage-reference branch to give an indication of the proper operation of the regulator.

The circuit in **Figure 1** consumes approximately 1 mA and starts to limit the current at currents higher than approximately 50 mA. With a lower value for the resistor, the LED glows brighter, the output voltage is slightly higher, and the current consumption and the current limit are proportionally high-

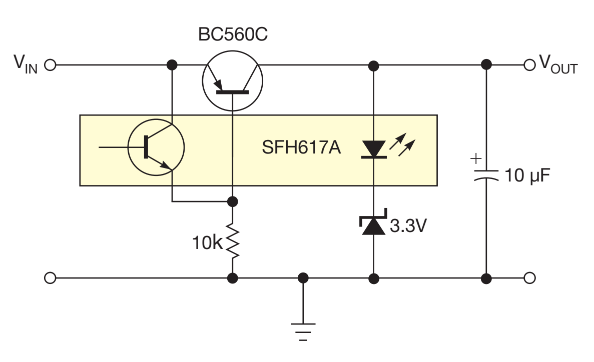

Figure 1 This simple low-dropout circuit is ideal for higher voltages that a zener diode sets.

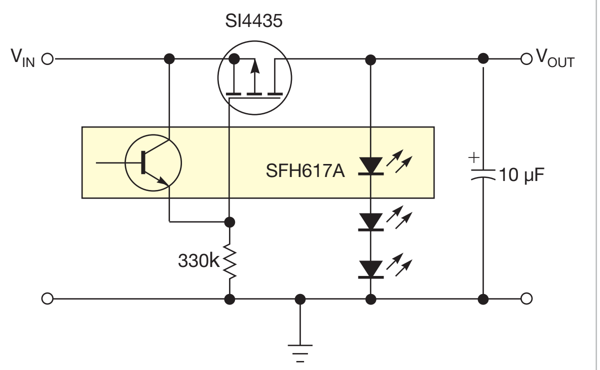

Figure 2 Using LEDs or diodes makes the circuit suited for lower regulation voltages.

er. You can replace the transistor and the optocoupler with almost any other type, but a high current gain and transfer ratio are preferable. When you use a high-voltage transistor, the input voltage can be much higher than is possible with common monolithic regulators. You can use a Darlington transistor for higher currents if your design can tolerate a dropout voltage of 0.7V. An output capacitor with a value of approximately 10 to 47 µF is necessary to avoid oscillation. Higher values are necessary for higher output currents. The circuit requires no input capacitor.

The circuit in **Figure 2** replaces the transistor with a P-channel FET and uses a 330-kΩ resistor. In this configuration, the circuit consumes about 50 µA and should suit many battery-powered devices. There is no inherent current limiting. You can reduce R_1 to 10 kΩ or lower to have a faster response to load change and to obtain a visual indication with the LEDs.EDN