Transistors drive LEDs to light the path

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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. Q1’s base-emitter voltage, $V_{BE}$, combines with resistor $R_2$ to set the LED current at approximately 20 mA. In this application, even a tolerance of $\pm 10\%$ 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 C535A-WJN series 110°-view-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.

You should use an automotive clearcoat 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.