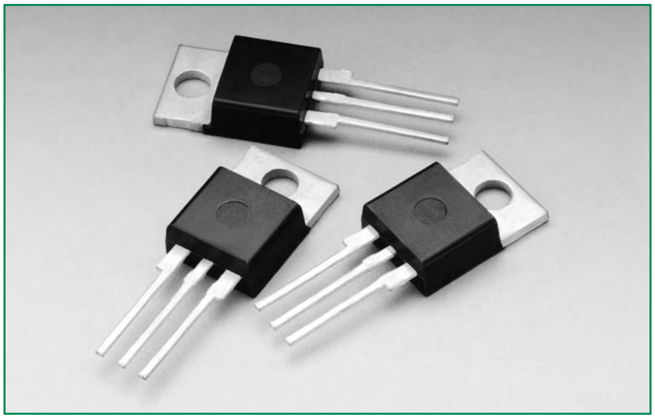
# Q6012LTH1LED Series

RoHS



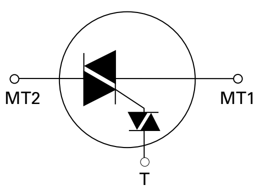
## Agency Approval

| Agency | Agency File Number |
|---|---|
| UL | L Package : E71639 |

## Main Features

| Symbol | Value | Unit |
|---|---|---|
| $I_{T(RMS)}$ | 12 | A |
| $V_{DRM}$ / $V_{RRM}$ | 600 | V |
| DIAC $V_{BO}$ | 33 to 43 | V |

## Schematic Symbol




## Description

The Quadrac is an internally triggered Triac designed for AC switching and phase control applications. It is a Triac and DIAC in a single package, which saves user expense by eliminating the need for separate Triac and DIAC components.

Q6012LTH1LED series is designed to meet low load current characteristics typical in LED lighting applications.

By keeping holding current at 8mA maximum, this Quadrac series is characterized and specified to perform best with LED loads. The Q6012LTH1LED series is best suited for LED dimming controls to obtain the lowest levels of light output with a minimum probability of flickering.

Q6012LTH1LED series is offered in the industry standard TO-220AB package with an isolated mounting tab that makes it best suited for adding an external heat sink.

## Features

- As low as 8mA max holding current
- UL Recognized TO-220AB package
- 110°C rated junction temperature
- di/dt performance of 70A/μs
- QUADRAC version includes intergrated DIAC

## Benefits

- Provides full control of light out put at the extreme low end of load conditions.
- 2500V $_{AC}$ min isolation between mounting tab and active terminals
- Improves margin of safe operation with less heat sinking required
- Enable survivability of typically LED load operating characteristics
- Simplicity of circuit design & layout

## Additional Information

Datasheet | Resources | Samples

## Applications

Excellent for AC switching and phase control applications such as lighting and motor speed controls. Typical applications are AC solid-state switches, light dimmers with LED loads, small low current motor in power tools, and low current motors in home/brown goods appliances.

Internally constructed isolated package is offered for ease of heat sinking with highest isolation voltage.

## Absolute Maximum Ratings

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $I_{T(RMS)}$ | RMS forward current | Tc = 90°C | 12 | A |
| $I_{TSM}$ | Peak non-repetitive surge current | single half cycle; f = 50Hz; $T_J$ (initial) = 25°C | 110 | A |
| | | single half cycle; f = 60Hz; $T_J$ (initial) = 25°C | 120 | |
| $I^2t$ | $I^2t$ value for fusing | $t_p$ = 8.3ms | 60 | $A^2s$ |
| di/dt | Critical rate-of-rise of on-state current | f = 60Hz; $T_J$ =110°C | 70 | A/μs |
| $I_{GM}$ | Peak gate current | $T_J$ = 110°C | 1.5 | A |
| $T_{stg}$ | Storage temperature range | | -40 to 150 | °C |
| $T_J$ | Operating junction temperature range | | -40 to 110 | °C |

## Electrical Characteristics ($T_J$ = 25°C, unless otherwise specified) – Alternistor Quadrac

| Symbol | Test Conditions | | Value | Unit |
|---|---|---|---|---|
| $I_H$ | $I_T$ = 20mA (initial) | MAX. | 8 | mA |
| dv/dt | $V_D$ = $V_{DRM}$; gate open; $T_J$=110°C | MIN. | 45 | V/μs |
| dv/dt(c) | di/dt(c) = 0.54 x $I_{T(rms)}$ / ms; $T_J$ = 110°C | MIN. | 2 | V/μs |
| $t_{gt}$ | (note 1) | TYP. | 3 | μs |

(1) Reference test circuit in figure 7 and waveform in figure 8; $C_T$ = 0.1μF with 0.1μs rise time.

## Trigger DIAC Specifications

| Symbol | Test Conditions | | Value | Unit |
|---|---|---|---|---|
| $\Delta V_{BO}$ | Breakover Voltage Symmetry | MAX. | 3 | V |
| $V_{BO}$ | Breakover Voltage, forward and reverse | MIN. | 33 | V |
| | | MAX. | 43 | |
| [ΔV±] | Dynamic Breakback Voltage, forward and reverse (note 1) | MIN. | 5 | V |
| $I_{BO}$ | Peak Breakover Current | MAX. | 25 | uA |
| $C_T$ | Trigger Firing Capacitance | MAX. | 0.1 | μF |

(1) Reference test circuit in figure 7 and waveform in figure 8.

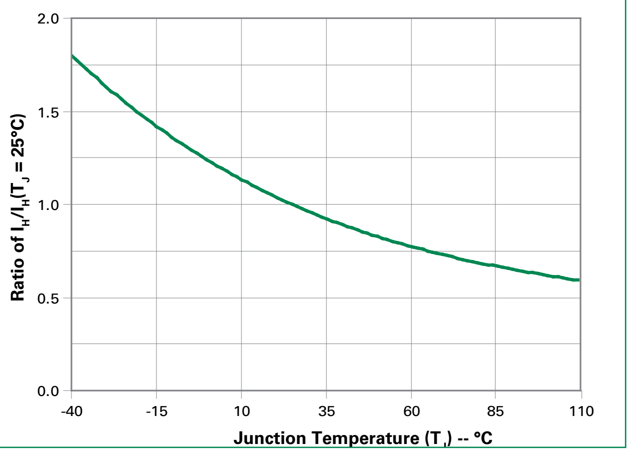
## Static Characteristics

| Symbol | Test Conditions | | | Value | Unit |
|---|---|---|---|---|---|
| $V_{TM}$ | $I_T$ = 1.41 x $I_{T(rms)}$ A; $t_p$ = 380μs | | MAX. | 1.6 | V |
| $I_{DRM}$ / $I_{RRM}$ | $V_{DRM}$ / $V_{RRM}$ | $T_J$ = 25°C | MAX. | 10 | μA |
| | | $T_J$ = 110°C | | 1000 | |

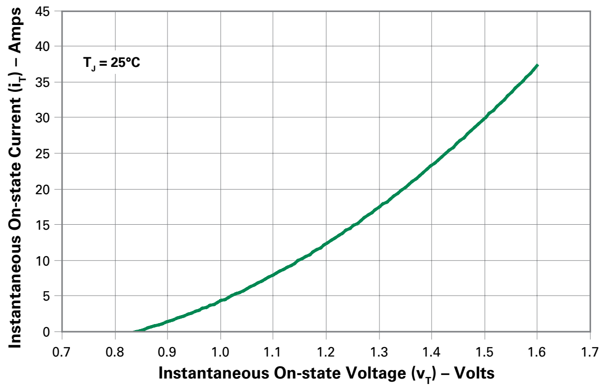
## Thermal Resistances

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{\theta(J-C)}$ | Junction to case (AC) | 2.3 | °C/W |
| $R_{\theta(J-A)}$ | Junction to ambient | 50 | °C/W |

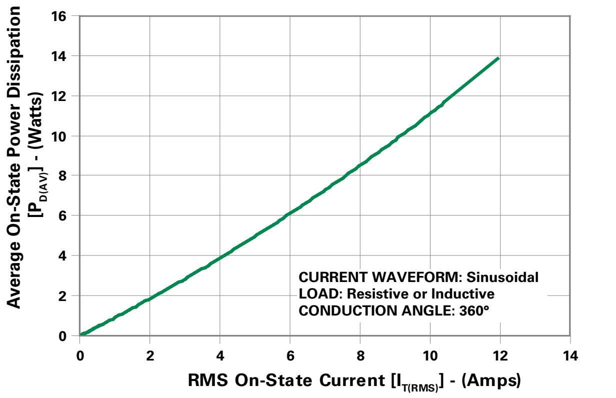
## Figure 1: Normalized DC Holding Current vs. Junction Temperature



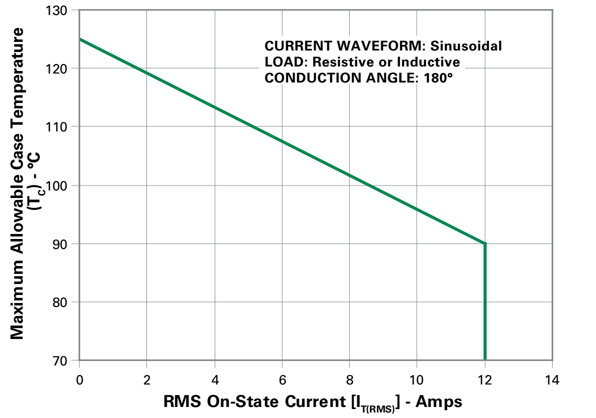

## Figure 2: On-State Current vs. On-State Voltage (Typical)



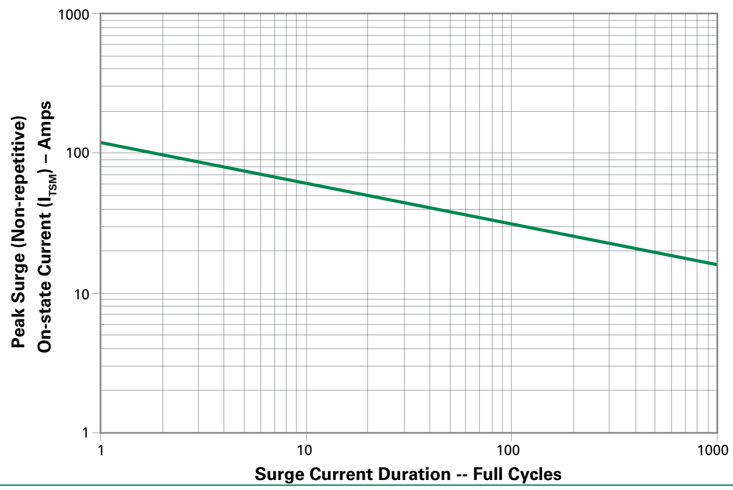

## Figure 3: Power Dissipation vs. RMS On-State Current (Typical)




## Figure 4: Maximum Allowable Case Temperature vs. RMS On-State Current




## Figure 5: Surge Peak On-State Current vs. Number of Cycles

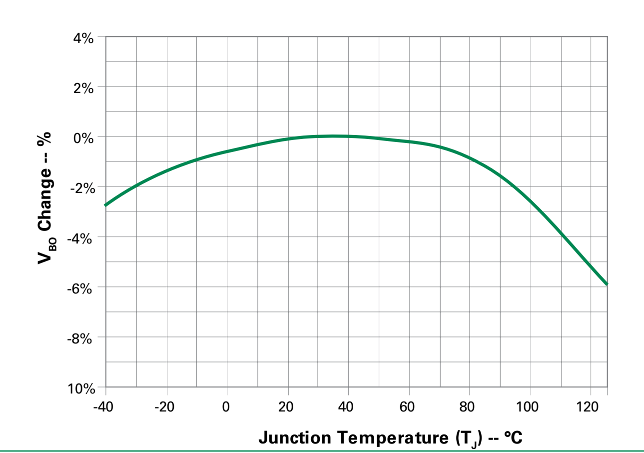



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specific Case Temperature

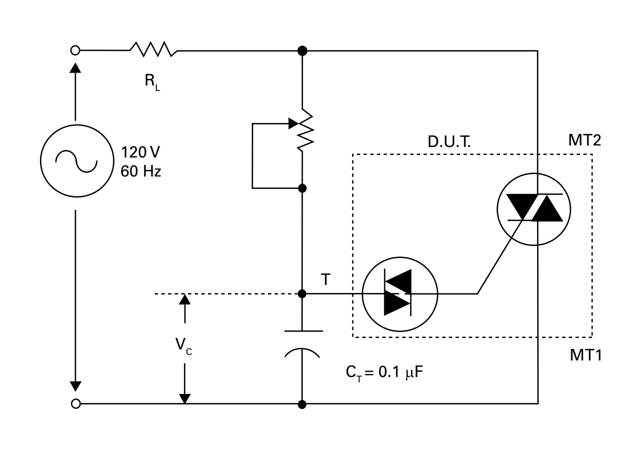
Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

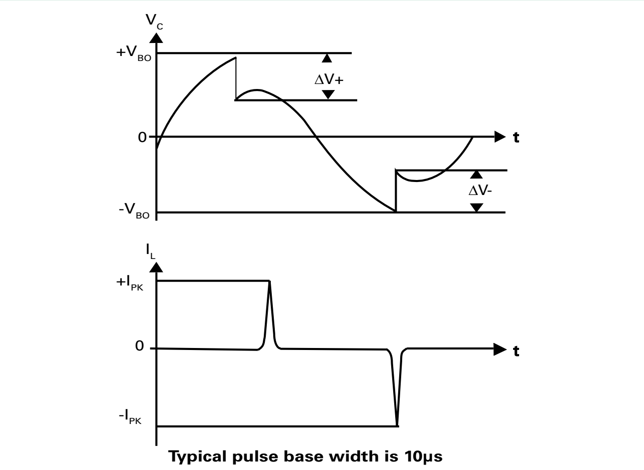
## Figure 6: DIAC $V_{BO}$ Change vs. Junction Temperature



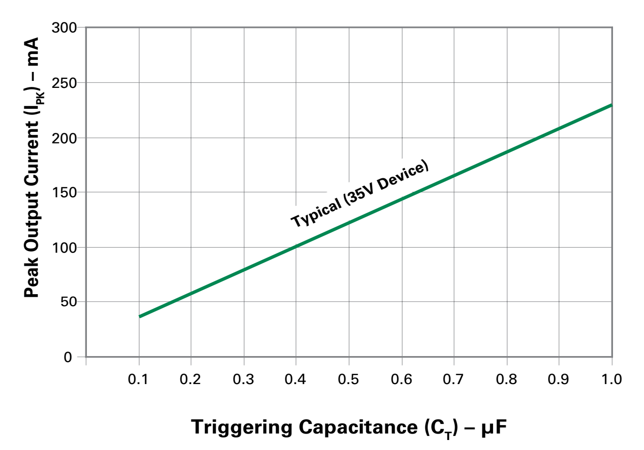

## Figure 7: Test Circuit




## Figure 8: Test Circuit Waveform

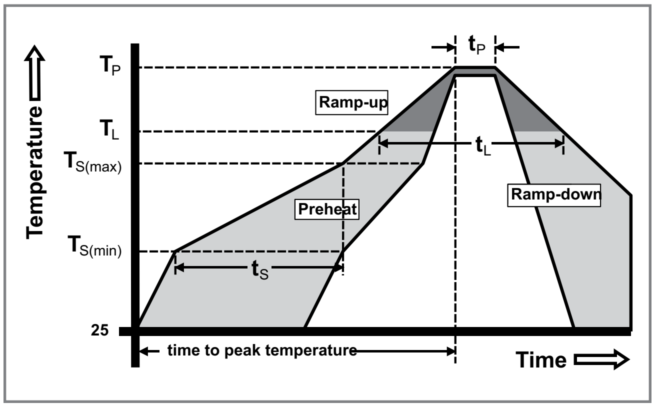



## Figure 9: Peak Output Current vs Triggering Capacitance (Per Figure 7)



## Soldering Parameters

| | | |
|---|---|---|
| Reflow Condition | | Pb – Free assembly |
| Pre Heat | -Temperature Min ($T_{s(min)}$) | 150°C |
| | -Temperature Max ($T_{s(max)}$) | 200°C |
| | -Time (min to max) ($t_s$) | 60 – 180 secs |
| Average ramp up rate (Liquidus Temp) ($T_L$) to peak | | 5°C/second max |
| $T_{S(max)}$ to $T_L$ - Ramp-up Rate | | 5°C/second max |
| Reflow | -Temperature ($T_L$) (Liquidus) | 217°C |
| | -Temperature ($t_L$) | 60 – 150 seconds |
| Peak Temperature ($T_P$) | | 260°C $^{+0/-5}$ |
| Time within 5°C of actual peak Temperature ($t_p$) | | 20 – 40 seconds |
| Ramp-down Rate | | 5°C/second max |
| Time 25°C to peak Temperature ($T_P$) | | 8 minutes Max. |
| Do not exceed | | 280°C |




## Physical Specifications

| | |
|---|---|
| **Terminal Finish** | 1005 Matte Tin-plated |
| **Body Material** | UL Recognized epoxy meeting flammability classification 94v-0 |
| **Lead Material** | Copper Alloy |

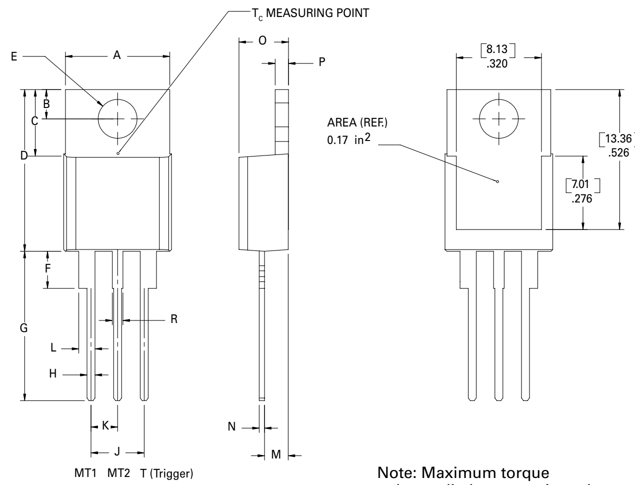
## Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

## Environmental Specifications

| Test | Specifications and Conditions |
|---|---|
| **High Temperature Voltage Blocking** | MIL-STD-750: Method 1040, Condition A Rated $V_{DRM}$ (VAC-peak), 110°C, 1008 hours |
| **Temperature Cycling** | MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles |
| **Biased Temperature & Humidity** | EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours |
| **High Temp Storage** | MIL-STD-750: Method 1031 150°C, 1008 hours |
| **Low-Temp Storage** | -40°C, 1008 hours |
| **Resistance to Solder Heat** | MIL-STD-750: Method 2031 260°C, 10 seconds |
| **Solderability** | ANSI/J-STD-002, Category 3, Test A |
| **Lead Bend** | MIL-STD-750: Method 2036, Condition E |

## Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab




Note: Maximum torque
to be applied to mounting tab
is 8 in-lbs. (0.904 Nm).

| Dimension | Inches | | Millimeters | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.380 | 0.420 | 9.65 | 10.67 |
| B | 0.105 | 0.115 | 2.67 | 2.92 |
| C | 0.230 | 0.250 | 5.84 | 6.35 |
| D | 0.590 | 0.620 | 14.99 | 15.75 |
| E | 0.142 | 0.147 | 3.61 | 3.73 |
| F | 0.110 | 0.130 | 2.79 | 3.30 |
| G | 0.540 | 0.575 | 13.72 | 14.61 |
| H | 0.025 | 0.035 | 0.64 | 0.89 |
| J | 0.195 | 0.205 | 4.95 | 5.21 |
| K | 0.095 | 0.105 | 2.41 | 2.67 |
| L | 0.060 | 0.075 | 1.52 | 1.91 |
| M | 0.085 | 0.095 | 2.16 | 2.41 |
| N | 0.018 | 0.024 | 0.46 | 0.61 |
| O | 0.178 | 0.188 | 4.52 | 4.78 |
| P | 0.045 | 0.060 | 1.14 | 1.52 |
| R | 0.038 | 0.048 | 0.97 | 1.22 |

## Product Selector

| Part Number | Type | Package |
|---|---|---|
| Q6012LTH1LED | Alternistor Quadrac | TO-220L |

## Packing Options

| Part Number | Marking | Weight | Packing Mode | Base Quantity |
|---|---|---|---|---|
| Q6012LTH1LEDTP | Q6012LTH1 | 2.2 g | Tube | 500 (50 per tube) |

## Part Numbering System

Q 60 12 L T H1 LED

**DEVICE TYPE**
Q: Quadrac

**VOLTAGE RATING**
60: 600V

**CURRENT RATING**
12: 12A

**LED LIGHTING APPLICATION**

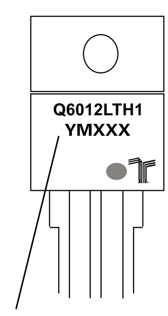
**TRIAC TYPE**
H1: Low Holding Current
Alternistor Quadrac

**Trigger**
T: Internal Diac (33V – 43V)

**PACKAGE TYPE**
L: TO-220 (Isolated)

## Part Marking System

TO-220 AB - (L Package)



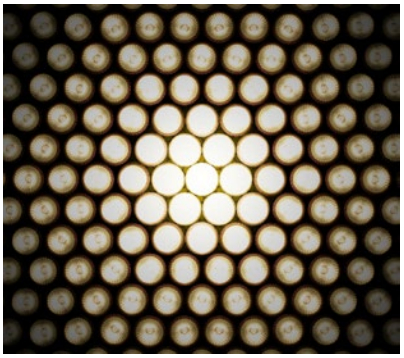

Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Expertise Applied | Answers Delivered

Application Note:

# Controlling LED Lighting Using Triacs and Quadracs

Light Emitting Diodes (LEDs) are fast becoming the most popular lighting option. Industry forecasts anticipate the market will continue to expand at an annual rate of 20% from 2011 to 2016, with the greatest growth coming in the commercial and industrial lighting sectors. As incandescent lamps have been made largely obsolete, given the U.S. government's mandate to save energy, they have frequently been replaced by LEDs due to their long life (typically 25,000 hrs.) and the ease of adapting them to many different socket and shape requirements. However, LED lighting control presents a few problems not encountered with incandescent lamps. For example, with much less current from the LED load, normal types of triacs may be challenged in terms of latching and holding current characteristics.



Triacs make up the heart of AC light dimming controls. Triacs used in dimmers have normally been characterized and specified for incandescent lamp loads, which have high current ratings for both steady-state conditions and initial high in-rush currents, as well as very high end-of-life surge current when a filament ruptures.

Because they are diodes, LEDs have much lower steady-state current than incandescent lamps, and their initial turn-on current can be much higher for a few microseconds of each half-cycle of AC line voltage. Therefore, a spike of current can be seen at the beginning of each AC half-cycle. ***Figure 1*** illustrates a typical spike of current. Typically, the current spike for an AC replacement lamp is 6–8 A peak; the steady-state follow current is less than 100 mA.

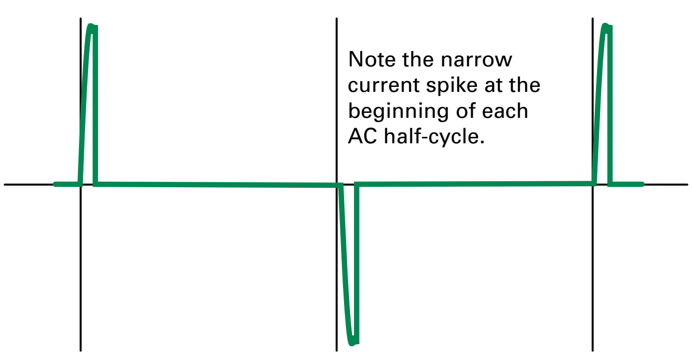



**Figure 1**

LED lamps for home lighting lamps might draw 7.5 W (A19 bulb-450 lumens) or higher, with a chandelier typically having from four to ten lamps. In contrast, a string of 50 decorative Christmas lights might draw only 4.8 W total. An LED flood lamp for a recessed ceiling fixture designed to replace a typical filament unit that produces 750 lumens consumes only 13 W (BR30) in contrast with the old filament unit, which normally draws 65 W.

Designing an AC circuit for controlling LED light output is very simple when using the new Q6008LH1LED or Q6012LH1LED Series Triacs because only a few components are required. All that is needed is a firing/triggering capacitor, a potentiometer, and a voltage breakover triggering device.

By using two inverse parallel sensitive gate silicon-controlled rectifiers (SCRs), S4X8ES1, as the voltage breakover triggering device, the controlling circuit can produce a wide range of light level outputs. Also, by using two inverse parallel sensitive gate SCRs as the triggering device, a low hysteresis control can be achieved because two SCRs form a full breakback trigger. ***Figure 2*** illustrates a circuit diagram for such a control that might be ideal for a recessed flood lamp (for example, a BR30 LED lamp), which can be dimmed to produce a low-level light output or turned up to nearly 180° full light output.

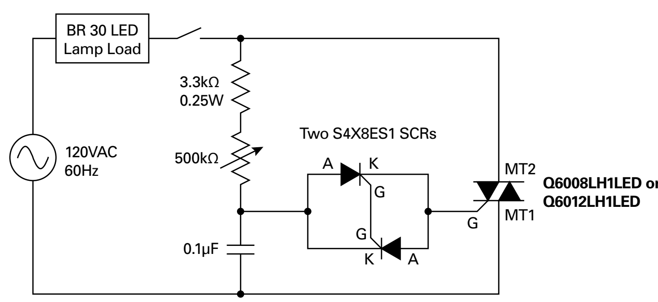



**Figure 2**

This circuit allows the lamp to turn on at nearly the full 180° on each AC half-cycle; in addition, the RC timed turn-on may be delayed to a small conduction angle on each half-cycle for very low light output. The Q60xxLH1LED Triac Series, with its low holding and latching current characteristics, allows the triac to remain on at very low current levels. Two inverse parallel sensitive gate SCRs (S4X8ES1) with their gates tied together produce a very low voltage triggering device with full breakback voltage, producing very low hysteresis. That allows the potentiometer to be set for a low conduction angle with turn-on being immediate when the line switch is turned off and on. For more information and an explanation of the hysteresis phenomenon, see Littelfuse Application Note AN1003: Phase Control Using Thyristors.

The circuit diagram in *Figure 3* improves upon older phase control/dimmer circuits that provided poor hysteresis. As *Figure 3* shows, with the addition of steering diodes around the $C_1$ firing capacitor, hysteresis may be eliminated, as presented in Littelfuse Application Note AN1003.

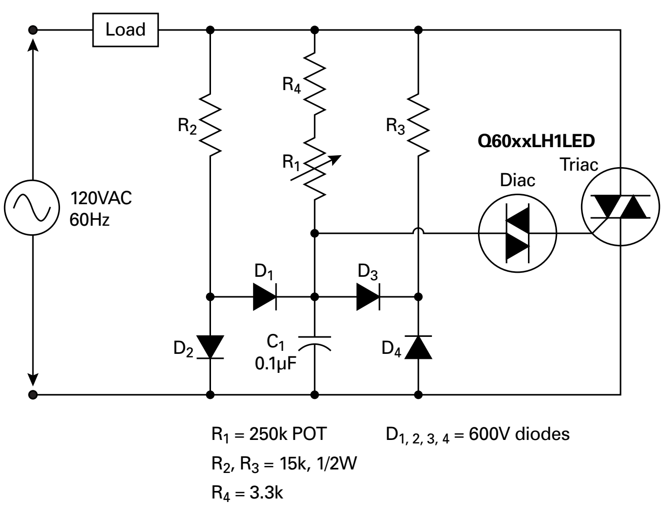



**Figure 3**

If a wide control range (full bright to very dim) and low hysteresis are not critical to the application, a simple variable light control may be designed using new Littelfuse Q6008LTH1LED or Q6012LTH1LED Series Quadrac devices. (A quadrac device is a special type of thyristor that combines a diac and a triac in a single package.) The circuit shown in

*Figure 4* further reduces the component count by combining the diac triggering device and an alternistor triac in a single TO-220 isolated mounting tab package. This control circuit allows a little lower full turn-on voltage due to higher $V_{BO}$ switching of the diac trigger device but offers a light dimming function that operates from 175° to <90° of each AC half-cycle.

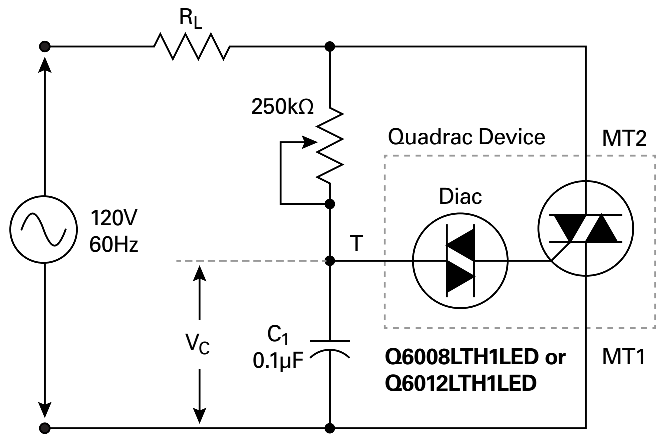



**Figure 4**

**Notes: Potentiometer is 250kΩ with built-in fixed end resistance of 3kΩ minimum. The quadrac device is QxxxxLTH1LED with more sensitive triac die (low gate and holding current characteristics). $R_L$ is a minimum LED load of 10 W. $V_C$ is the same as the triggering voltage of the built-in diac die.**

LED lamp loads for AC circuits may be very simple like the one shown in *Figure 5* or there may be extra elements for DC refinements, such as a filtering capacitor. The presence of added elements will determine if the LED lamp load is dimmable. The simpler the LED lamp load, the more likely it is to be dimmable because filtering capacitors may increase the minimum DC current to a level that thyristor devices latch on with no varying AC current reduction below the minimum thyristor holding current.

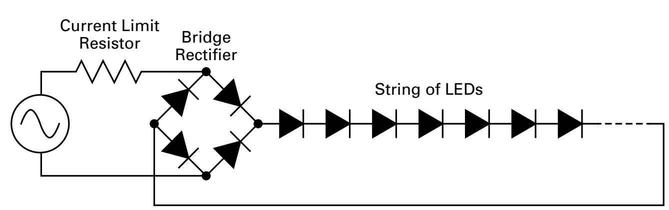



**Figure 5**

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AN1011

 