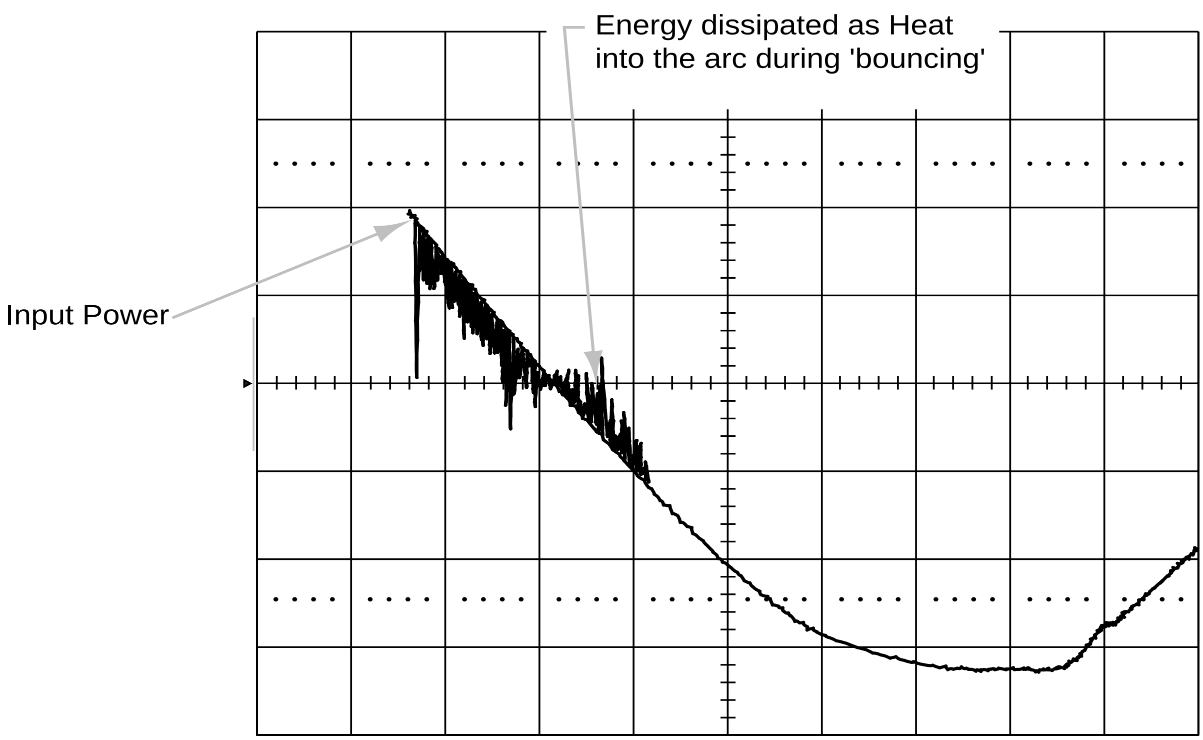
Background

Up until the early 1990's, relays needed to be concerned with only incandescent and inductive loads. The worst case inrush for these load types was 10X and the relays were designed accordingly.

Unfortunately, the advent of electronic ballasts changed the 'rules' as the inrush for these loads can be as high as 100X, more typically 30-50X. At these levels of inrush, the relays that were designed for 10X will typically experience a lower life. In some cases, this could be only weeks after initial operation.

The primary cause of relay failure is heat which is caused when the typical relay is closed during turn on. As the relay closes, an arc is created as the relay contacts close, 'bouncing' several times before finally closing. As Figure 1 shows, this results in wasted energy that is dissipated in the contacts of the relay as heat. The higher the inrush, the more heat is created. Ultimately, this heat causes the contacts to weld and become inoperative.

FIGURE 1

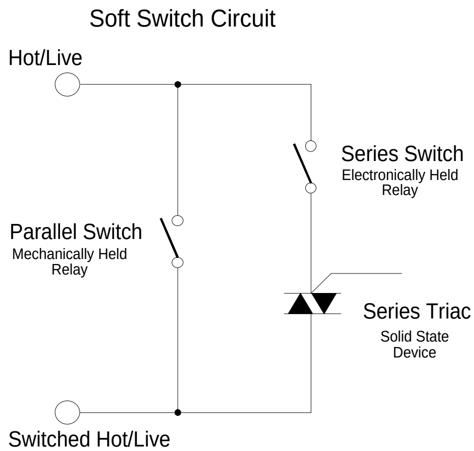


Lutron's Solution

Knowing that heat was the source of relay impairment, Lutron's approach was aimed at reducing the heat by eliminating the root cause - the arc.

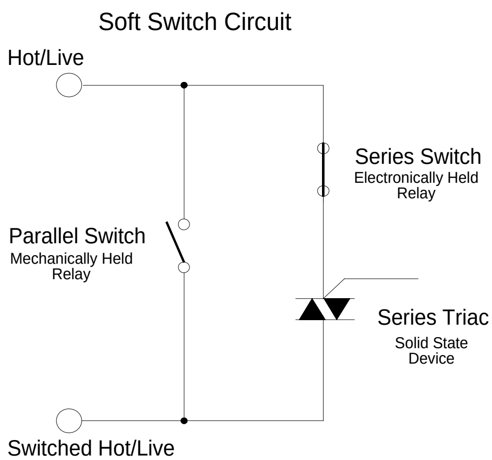
Figure 2A shows three components - a mechanically held relay (which is the primary component of other relays), an electronically held relay, and a solid-state triac. Upon being signalled to close (or turn on), the electronically held relay is closed before the triac is signalled to begin conducting (Figure 2B). Once the electronically held relay is closed, the triac begins conducting, energizing the load. Any inrush at this point is passed through the triac. (Triacs are inherently more capable of handling surges than relays because they have no moving parts and therefore no arc.) Since the electronic relay is already closed, it is not affected by any inrush.

FIGURE 2A



This is the circuit prior to activation. Three components are shown - a mechanically held relay, an electronically held relay, and a solid-state triac.

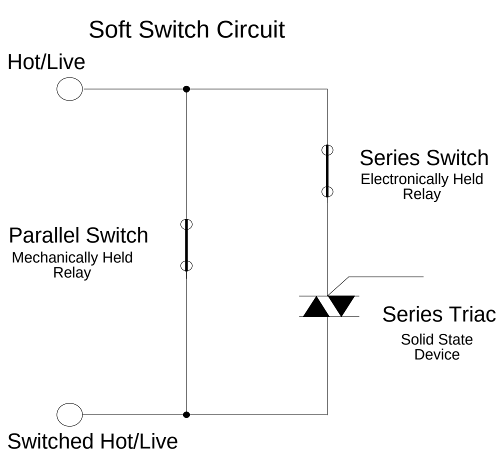
FIGURE 2B



Upon activation, the electronically held relay is closed and then the triac begins conducting. Once the load is energized, inrush is passed through the triac (the closed relay is not affected).

At this point, the mechanically held relay is closed (Figure 2C). When the contacts for this relay 'bounce', there is no current passing through the contacts because the 'bouncing' contacts have a higher resistance than the already completed circuit passing through the electronically held relay and triac. Accordingly, this relay closes without an arc. Figure 3 reflects this.

FIGURE 2C



Now the mechanically held relay closes as well. Because of the higher resistance than the electronically held relay, no current passes through the mechanically held relay, resulting in no arc.

Finally, the electronically held relay opens (Figure 2D) and takes the triac (and any heat or inefficiency - most triacs are 2-3% inefficient) out of the circuit. The notch in the waveform in Figure 3 is the triac remaining in the circuit. The electronically held relay opens after 10 line cycles, removing the triac from the circuit.

In turning off the circuit, both relays are opened using the same sequence in reverse, ensuring an air gap off that is consistent with all Lutron products.

FIGURE 2D

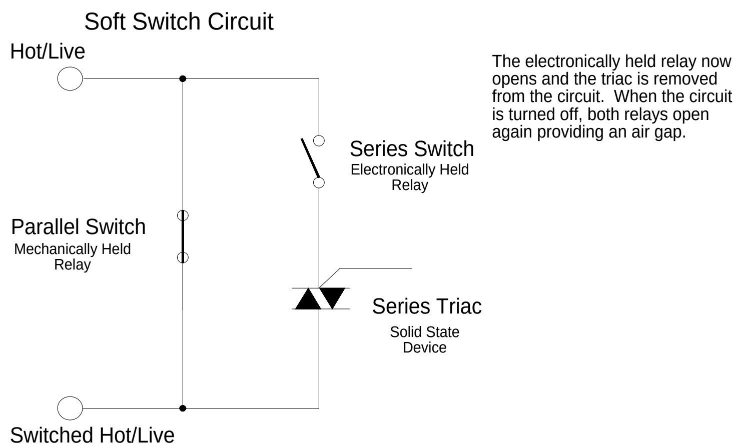
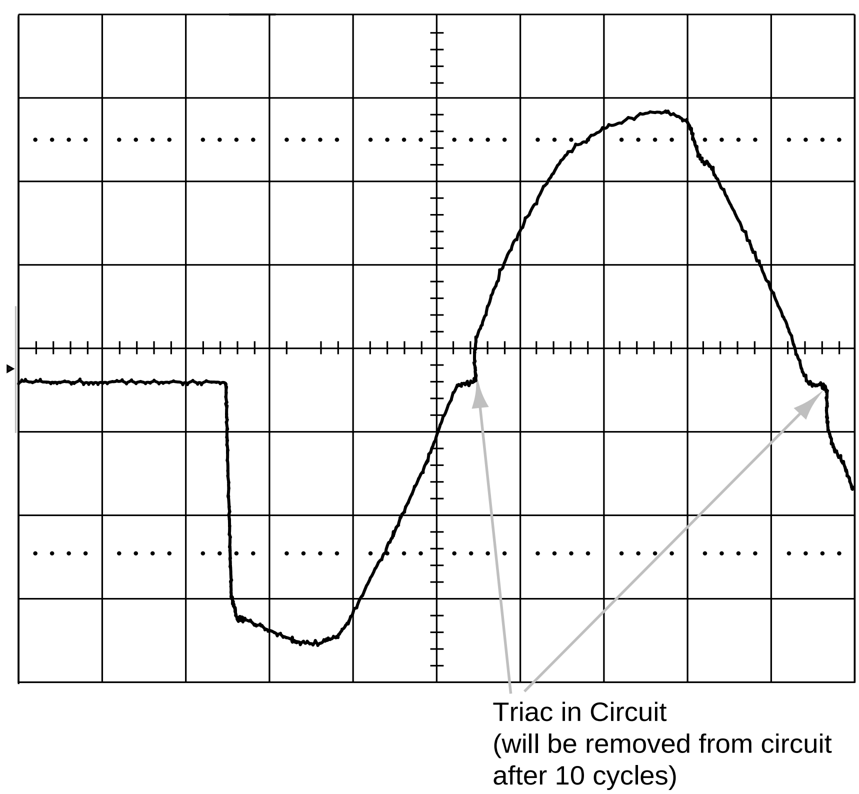


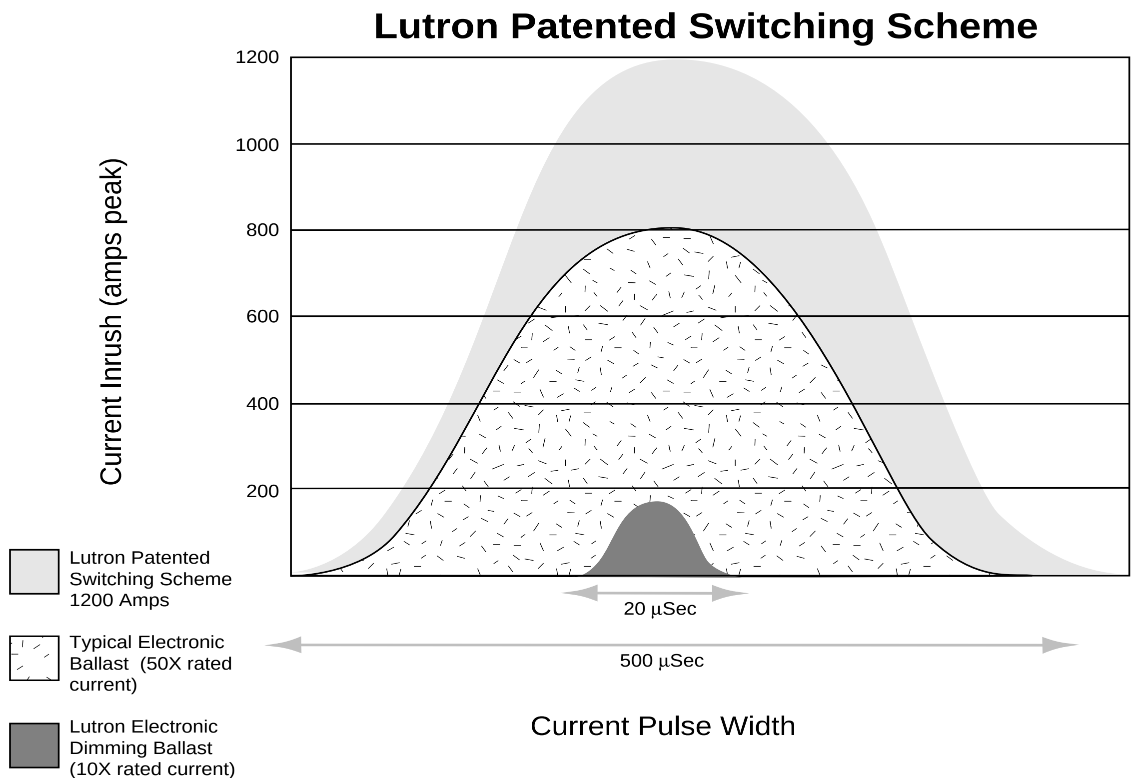
FIGURE 3



Summary

With this design, Lutron has verified relay cycles (on/off) in excess of 100,000 times without adverse effects on relay operation. It is also independent of source - resistive, inductive, or capacitive - where most other relays are rated for resistive only. Figure 4 shows the various levels of typical inrush and Lutron's solution which is capable of handling 75 times inrush.

FIGURE 4



Another 'new' relay circuit that has been introduced recently is what is called 'zero cross relays'. These relays are supposed to reduce the inrush by turning on where the power sine wave crosses zero. These relays do reduce the inrush but there is still inefficiency in this operation. Figure 1 is in fact a zero cross relay. Other common relays (i.e. GE's RR7) would be far worse. Zero cross switching is implemented in order to protect the relay contacts from the effects of arcing. With Lutron's Soft Switch technology there are no moving parts to protect, therefore zero cross switching is not necessary.

One last comment is that many facilities have not experienced a problem with traditional relay operation. There are several factors that can contribute to this - circuits that are not fully loaded and line impedance (longer wire runs as an example) being the two most common. It is important to note that we as a manufacturer had the same perspective four years ago. Because we do operate some circuits as nondim, we began to witness issues with our circuits (and components) that led us to this solution. With this solution in place, we have not experienced a problem.

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