

# Load Switching and Contact Protection

The Reed Switch contact rating is dependent on the switch size, gap size or ampere turn rating, contact material and atmosphere within the glass capsule. To receive the maximum life for a given load some precautions may be necessary.

Because a Reed Switch is a mechanical device and has moving parts, there are circumstances where life will be shortened due primarily to contact wear. Switching no load or loads where the voltage is less than 5 Volts @ 10 mA or less, the contacts undergo little or no wear. Here life times in excess of billions of operations are expected and realized. In the 10 Volt range, higher contact wear will take place. The amount of wear is dependent upon the current switched. Generally speaking, switching 10 Volts @ 10 mA, life times of 50 million to 200 million operations can be expected. If one is looking for more life under these circumstances and you can not eliminate the actual switching of the load, mercury wetted contacts may be the correct solution. Here the contacts actually have a small amount of mercury on them so that no net metal is ever transferred from contact to contact. Life for most 'hot' switching loads using mercury wetted contacts will also be in the billions of operations even when switching 100's of Volts at 10's of mA.

Switching pure DC loads is always advised. All the data shown in our life test section, has been taken under this condition. Avoid loads with a leading or trailing power factors.

Loads having a net overall inductance will play havoc when opening the contacts. Because the opening transition is so fast the  $di/dt$  term in Equation #1 becomes very large and the contacts will undergo sustained arcing.

$$L \frac{di}{dt} + i R = V \quad \text{Equation \# 1}$$

When the contacts see a net overall capacitive load, an inrush of current will occur when closing the contacts. Contact damage and even sticking will occur depending up the total capacitance, voltage present and series resistance.

Tungsten filament lamps, a very popular switching load for Reed Switches particularly in automotive, have inrush currents due to their cold filaments. Once the light is on the resistance in the filament rises rapidly reducing the current flow. Typically current surges in the order of 10 to 20 times the steady state current can be expected. Knowing the cold filament resistance is important to determine the size of the inrush current. Adding some series resistance to the same circuit can have a dramatic improvement on the life of the switch.

## Capacitive and Inductive Loads

Stray capacitance may be present, to some degree, when switching any voltage and current. When closing and switching a given voltage and current, the first 50 nanoSeconds are the most important (see Figure #46). This is where the exact amount of arcing will occur. If there is a significant amount (depends on the amount of voltage switched), of stray capacitance in the switching circuit, a much greater arc may occur and thereby reduce life. When switching any sizable voltage, it is always a smart idea to place a fast current probe in the circuit to see exactly what one is switching in the first 50 nanoSeconds. Generally speaking, when switching voltages over 50 Volts, 50 picoFarads or more can be very significant to the expected life times. If the Reed Switch is operated remotely with a long cable connection, that cable can act like a long distributed capacitance. Shields and other potentially capacitive components can also lend their capacitance to high inrush currents.

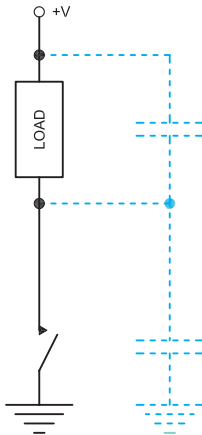


Figure #46. Surprisingly large inrush currents can be generated across the contact when stray capacitance is charged to compliance voltages. Contact life may be dramatically shortened.

Common mode voltages are also another area to be watchful of. They can have a significant effect on the life of a Reed Switch as well. Depending upon the circuit and the environment, common mode voltages can in effect, charge stray capacitances in the switching circuit and dramatically reduce Reed Switch life in an unexpected manner. (See Figure #47) Again, a fast current

probe can reveal a startlingly higher than expected voltage and current switched in that first 50 nanoSeconds, having no bearing on one's actual load. When line voltages are present in or near sensitive circuits, be cautious. Those voltages can be coupled into the circuit creating havoc with your life requirements. Typically, a faulty Reed Switch is blamed for this reduced life, when in actuality, it is a product of unforeseen conditions in the circuit.

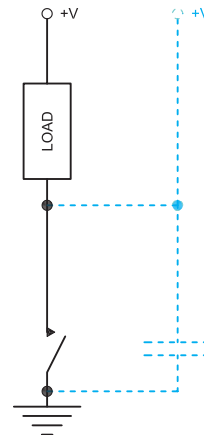
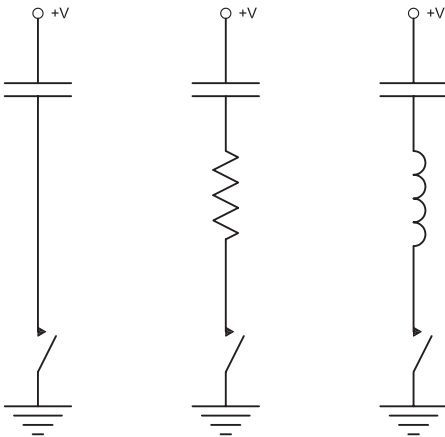


Figure #47. Common mode voltages charging stray capacitance and then be switched across the contacts will reduce life times rapidly. Avoiding this condition is important.

## Protection Circuitry

Under above conditions, protective circuitry can be added which will minimize the metal transfer at the time of the transitions, but not eliminate it.

Circuits shown in Figure #48 are very typical. The capacitance can be only a few pF attributed to stray capacitances or actual capacitive components in the mf range. Capacitors in an electronic circuit store charge. By their nature they like to give up their entire charge as quickly as possible. With no resistance or impedance to the flow of the current, that is exactly what will occur.



(Figure #48. Switching capacitance directly will damage the contacts rapidly with high inrush currents. Adding a resistor or an inductor will reduce the inrush current and reduce the contact wear.)

The voltage and current in a capacitive circuit are stated in Equation #2 and in Equation #3. The capacitive discharge rate is stated in Equation #3.

$$R \frac{dq}{dt} + \frac{q}{c} = V \quad \text{Equation \#2}$$

$$i = -\frac{V}{R} e^{-t/RC} \quad \text{Equation \#3}$$

R is the circuit resistance  
 q is the charge  
 t is the time  
 c is the capacitance  
 i is the current  
 v is the voltage

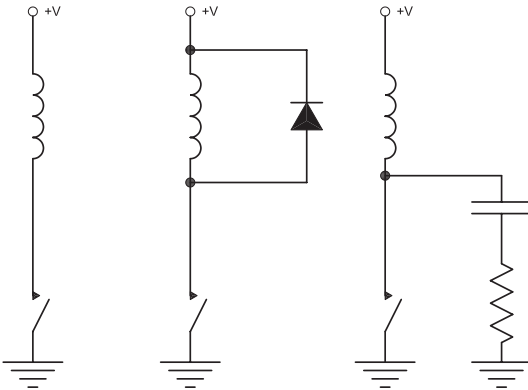
Inrush currents are to be avoided or minimized when closing the contacts of a Reed Switch. If your circuit allows series resistance to be added directly in line with the Reed Switch, that is generally the best choice. The higher the resistance the better as shown in Figure #48. Using an inductor or adding inductance in the circuit can be effective as well. Inductors initially impede the flow of current, thereby reducing inrush currents. Here a careful balance must be calculated such that too much inductance is not added, thwarting its effect and creating another problem when the contacts open.

Switching inductive loads such as relays, solenoids, coil driven counters, small motors or inductive circuits will all require protective circuitry to lengthen the life of the reed contacts (see Figure #49). Equation #1 describes the inductive relationship. Inductors, once current is flowing will tend to sustain that flow. If the current is suddenly terminated the term,  $di/dt$  in Equation #1, can become very large. The net effect can be a large voltage across the contacts. With the contacts in the stage of opening, arcing will ensue. If the arcing continues for any period of time, contact disruption will occur. Many times RC networks and diode suppression are added which both inhibit the inductive 'kick' (see Figure #49).

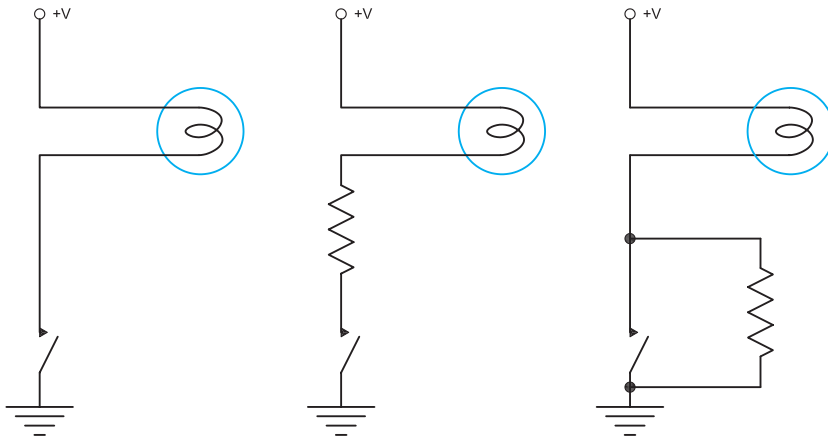
### Inrush Current Loads

Lamp loads can also produce high inrush currents when they are initially switched on. Here typically tungsten filaments are used in small bulbs which will have inrush currents as high as 10 times their normal operating current when initially switched on (see Figure #50). Adding resistance in series with the lamp can dramatically reduce the inrush current and play a major role in extending the life of the Reed Switch.

Another approach is to add a parallel resistor across the contacts as shown in Figure #50. In this case, a small current always flows through the filament keeping it hot and its resistance high. This current flow is balanced such that the filament is not 'glowing'. Now when the Reed Switch is activated, the current switched is close to its steady state current.



(Figure #49. Abruptly opening a circuit with an inductor can produce a very large back voltage. Adding a diode in parallel with the coil will dramatically reduce this voltage. An RC network across the contact will also help.)



(Figure #50. Lamps when first turned on have a high inrush current because of their cold filament. Adding series resistance will reduce the inrush. Having a resistor in parallel with the contacts will allow a trickle current to flow, heating the lamp filament below it. Then when the contacts close the filament is hot and does not draw an inrush current.)