HOT SWITCHING

Hot switching is a term used to describe operations where a relay is either opened or closed while carrying a user signal. It is a parameter that can have a major impact on relay life, a relay used in a hot switching environment will experience contact erosion and heating that does not occur in a cold switching environment where the user signal is removed before changing relay state.

Relay vendors do provide information on ratings, but they have to provide these ratings under reproducible conditions which usually means they are specified with resistive source and loads. When relays are placed in switching systems other issues can arise, the following describes some of those issues.

Capacitive Hot Switching

It is not always obvious to users what level of hot switching is experienced by relays - even in relatively low current or voltage conditions. If a low impedance source is connected to a high impedance load but the cabling or load contain significant parasitic capacitance then on contact closure the relay can experience a high surge current as the source charges the capacitor. High surges can also be experienced if the relay connects a source to a capacitive load that is carrying a charge from a previous state. This might occur for example in a system where polarity reversal is required to be made by a relay system, or if a previous operation has left a charge on a high impedance load. For this reason many systems that test cable assemblies provide a mechanism for discharging any residual charge on the cable assemblies.

Switching modules normally include a maximum hot switch voltage which is characterized into a resistive load. It should be noted that if long cables or other capacitive loads are attached the rating maybe degraded.

Power Supply Charge Exchange

One potential misunderstanding on hot switch ratings is when a power supply is used to connect a power supply to a load with the power supply already generating voltage. The load will commonly have local decoupling capacitors and the sudden connection of the power supply can result in high inrush currents. These current are NOT limited by a current limit on the power supply since they usually arise from exchange of charge from the power supply output decoupling to the load decoupling. Some relays do have ratings for these high inrush events which are above the normal rating of the relay, these relays will be typically designed with contacts which have a large wiping action on closure and use high temperature

materials in their contact construction. Solid state relays are generally considered to be more robust for hot switching power supplies since their ability to handle inrush currents between capacitors is often more than an order of magnitude greater than their steady state current handling.

Hot Switch Failure on Closure Mechanism

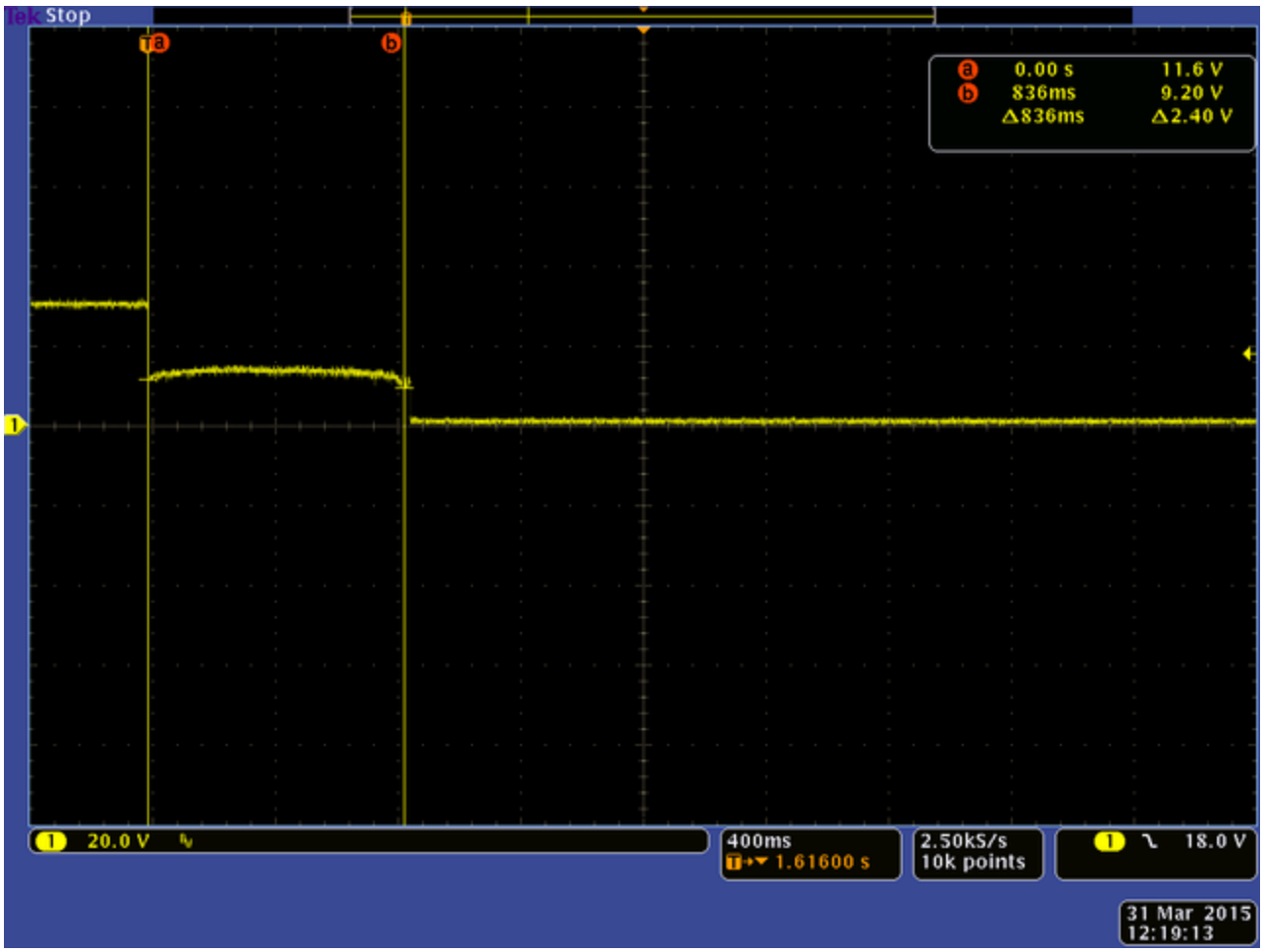
The most common mechanical relay hot switching failure mechanism is either welded contacts or contacts having variable or intermittent contact resistance, particularly at low currents, because of erosion of the contact materials. Welded contacts are usually caused by high inrush currents as the contacts are closed creating molten or soft metal in the contact area. Failure to close can be caused by severe erosion of the contacts and the build up debris on the contacts.

Hot Switch Failure on Opening

In applications where high powers are being switched an arc (plasma) can be generated which increases the time during which contact erosion can occur. The arc is particularly damaging if the load or source contains a significant inductive component as it can create multiple arc's over a period of time as the contact opens.

Operating a power relay frequently in a short space of time can cause additional problems as the arc generated leads to a general increase in the relay temperature, the more often the arc is generated in a given time the more erosion occurs and the more heat is generated. For this reason many high power mechanical relays are life tested at relatively low cycle rates, particularly as they are used towards their maximum rating. The more frequent an arc is generated the higher the temperatures that are reached leading to more rapid contact erosion and the damaging of mechanical parts in the relay, particular the plastic parts that hold the contacts in place. Some relays require the package to include a vent which is open to the environment when used to break a high current/voltage signal at regular intervals to help dissipate the plasma that forms in the relay case.

Arcing is particularly a problem on DC signals because the arc can be sustained for a long time. The trace below was taken by loading a relay with 30V and an excess carry current, the relay has then broken the connection. An arc is created as the relay opens (on very high current relays this creates a visual arc even thru the packaging), in this example the arc endured for 1 second before cooling enough to be extinguish.



While the arc was in progress and intermediate current flows, implying the relay package has to dissipate significant power during the arc duration.

RF Hot Switching

A slightly different problem can occur when hot switching RF signals. If the source VSWR is high then a relay in the open position could have very high voltages appearing across an open contact before it closes or a high voltage is created as the relay is opened. The source VSWR being high allows reflected signals to build up a high voltage, insertion loss will reduce the maximum voltage by attenuating the reflected signals.

As the operating conditions have a large impact on the hot switching conditions for RF signals the hot switch power is normally quoted with a low source VSWR unless otherwise stated. If the relay is operated with poor source/load VSWR the hot switch performance will degrade, the degree to which it degrades

being highly dependent on the conditions.

Power Limit

The relay specification often contains a power limit number. In the case of DC signals it should be noted that this often is limited to a single voltage/current. As voltage increases beyond this the DC power the relay can handle may decrease rapidly.

Difference Between AC and DC

The hot switch rating of power relays is often different between DC and AC switching, the AC power ratings being higher. In DC switching metal transfer tends to be in one direction so erosion occurs more quickly. In AC applications the erosion occurs in both directions and arcs may be suppressed as the signal voltage falls towards zero.

When handling AC signals derived form the AC supply reactive components (inductors and capacitors) can be problematic and reduce the relay hot switch capacity. AC supply systems typically have many reactive components in them (filters, transformers) which can create issues. Inductive sources or loads can create prolonged arcing when breaking a signal, capacitive loads can create high inrush currents on path closure.

Minimum Capacity

It should also be noted that hot switching some types of EMR is required to achieve the best contact resistance stability where there is a minimum switching capacity stated. The minimum switch capacity can be quite low and for example residual cable charges and capacitance in a system can provide the required surge to clean contacts.

Relays intended primarily for RF switching can also exhibit problems after frequent DC hot switch operations. The operation can remove gold from the contacts and make low level RF switching more variable in loss and frequency dependency, especially at lower frequencies. Where possible it is best to avoid DC switching in RF applications.

Solid State Relays

Solid state relays can offer "infinite" lifetimes when used within their ratings, they are not subject to the arcs and contact problems that are found on mechanical relays. Frequent operation of these relays

(above hundreds of Hz) can generate additional heat in the switching process. The faster the switching occurs the less heat that is generated. Solid state relays are a good solution for applications where long life is needed in a hot switch environment.

Source : http://wiki.pickeringtest.net/Hot+switching+relays