REEDHOLM

SUPPORT NOTE

SN-139

Stuck Relays and Scrambling

Dry Reed Relay Contact Resistance increases over time.

Under normal operating conditions, the expected life of dry reed relays used in Reedholm instrumentation modules should exceed 15-20 years. However, experience has shown that hot switching relays under heavy loaded signal conditions can increase the static contact resistance and thus effectively shorten the useful life of these components.

Key specifications and performance overview.

A reed switch consists of two ferromagnetic blades (generally composed of iron and nickel) hermetically sealed in a glass capsule. The contact area of the blades are sputtered with a very hard material, usually Rhodium or Ruthenium. These very hard materials give rise to the potential of very long life times if the contacts are not switched with heavy loads, i.e., hot switching.

Static contact resistance is the resistance across the contact terminals of the relay after it has been closed for a sufficient period of time to allow for complete settling.

Experiment description.

Figures 1 and 2 show the result of an experiment that was conducted to measure and compare the voltage drop on the Node and Pin side relay contacts. These measurements were taken on the Force and Sense lines. A total of 4 CPM boards were used for this experiment, one of which was a customer board that had been in use for 16 years. The other boards used for comparison came from a Reedholm demonstration system and from manufacturing spares (2). They ranged in age from 10 to 18 years.

CPM Tests - Matrix Only diagnostics were run on pins 5 thru 8, pausing on each pin test for voltage drop measurements. The measurements were taken on the node and pin side of the relay contacts. This was done for both the Force and Sense lines. The delta in voltage drop provides an indication of the static contact resistance and was plotted in a histogram

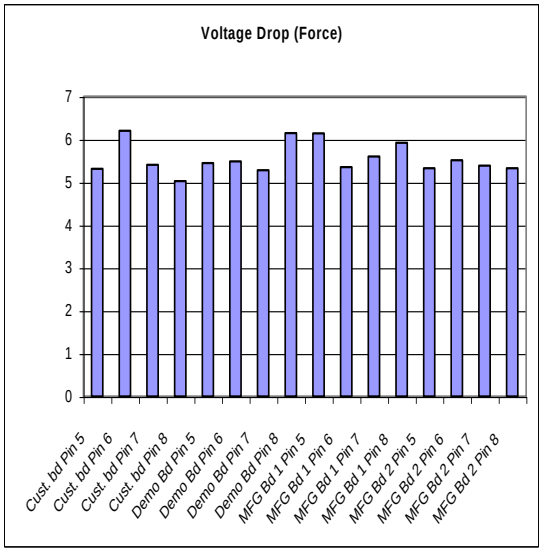

Figure 1

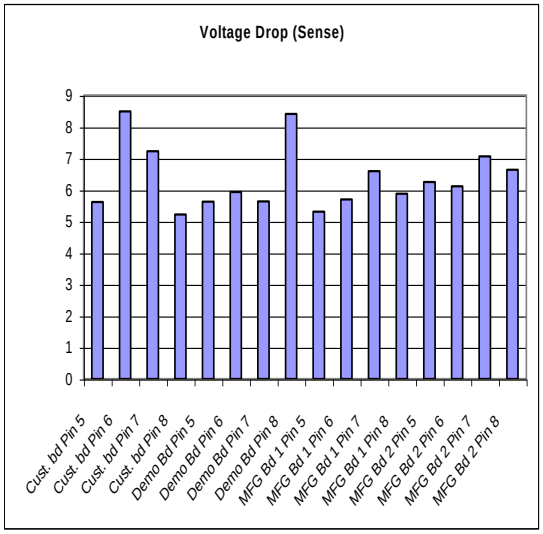

Figure 2

Conclusion.

Contact resistance of dry reed relays used in Reedholm instrumentation will not significantly increase if the proper test conditions are followed. Hot switching can definitely impact the electrical characteristics of these components. However, it is difficult to quantify how often this occurs, and under what conditions.

One can expect the useful life of these relays to exceed 18-20 years and several billion open/close cycles. Furthermore the CPM diagnostic tests can be relied upon as a good indicator of the relay electrical performance.

Intermittent "stuck relay" failures are often a symptom that the real culprit has not been identified.

Failures in the 30V range are a symptom that current is being clamped by a guard amplifier whose output is shorted to ground. If that is the case, the guard switch in a relay has welded. In previous software versions, the VFIF current limit bit was not checked, so the shorted relay switch was not detected. The shorted guard switch does not have to be in the CPM; it could be in the DMM as well.

Without hot switching, dry reed relays of the type used by Reedholm have lifetimes of 10^9 operations, with end of life defined by contact resistance increasing by two or three times the initial resistance, or ~100 milliohms. Even if operated continuously, which never happens, a relay would last >20 years. That is why we say there is no wear out. We have not experienced any shelf life related issues with the dry reed relays.

We make hardware and software changes in an ongoing attempt to eradicate chances of hot switching. One recent one was a change to the power control logic (PCL) board to prevent turn-on of the 120V supplies when ac power is applied to the instrumentation. Doing so eliminates possible hot switching during software initialization.

This can be a needle in the haystack problem. Stuck relays and scrambling are typically highly intermittent events that can bring testing to a halt, even though the problem tests can vary from wafer to wafer or week to week.

Once an abort occurs again, test conditions should be examined for that test, and the prior tests, along with the test structure documentation/layout for sneak paths and unexplainable pin connections. If either of those tests are not grounding unused pins, ground them. If that results in errant data, it is necessary to find out why. Such investigations are described in this support note:
http://www.reedholm.com/support/suppnotes/supportnotes.htm#SN-136.

The following software capabilities should be implemented in order to help reduce the incidents:

- In RDS DOS Setup, make sure BKD Protect is set to "Always"
- In RDS DOS Setup, make sure Ground Pins is set to "N"
- Start using Resume on Abort again in RDS Intranet Acquire

With this, events are simply logged to the database and testing continues without interruption. Before this scramble detection was introduced, most scramble events went undetected and/or resulted in other instrumentation aborts (such as FindDACrange errors). In addition, many hot switching events do not result in scrambling, only potential relay damage.

Examining Lot Abort reports can also help identify problem tests (either the test that aborted or test prior to it that conditioned the matrix for a hot switching event). Of course, finding and correcting for sneak paths is not a quick task and will require engineering resources, but it is needed to get to the root of the problem.

In some cases, evaluation of test conditions does not point to a specific problem test or test type. And when modules are sent in for checkout, frequently no problems are found. Yet some companies are able to run for years without node 0 failures. What is the difference?

The cause has to be hot switching. Relays can run for billions of operation at full current without welding, as long as current is brought to zero before switching. Even though identifying structures and tests that cause hot switching is not a trivial task, this is the only way to assure trouble-free operation.

Given the relatively low voltages used for most parametric testing, most hot switching is due to sneak paths that charge unspecified cables during testing. If left charged, subsequent testing could damage devices or relays when connections are made. That is why the software was modified to automatically grounds all paths after power is removed in a controlled manner.

In some cases, this software change led to a rash of stuck relays and scrambling. And some don't have the time or manpower to review and modify historic test conditions. In such cases, one possible fix is to install a software patch.

Node 0 Software Patch

To minimize the impact of node 0 stuck relays and scrambling, a software patch was released to make grounding all pins between tests optional (see node 0 patch at:
http://www.reedholm.com/ecrs/E0505201101.pdf

Obviously, this can result in cables or the chuck being left in charged states and lead to device and relay damage. In effect, the consequences of not controlling test connections will be transferred from mainly being node 0 problems to mainly being other problems.