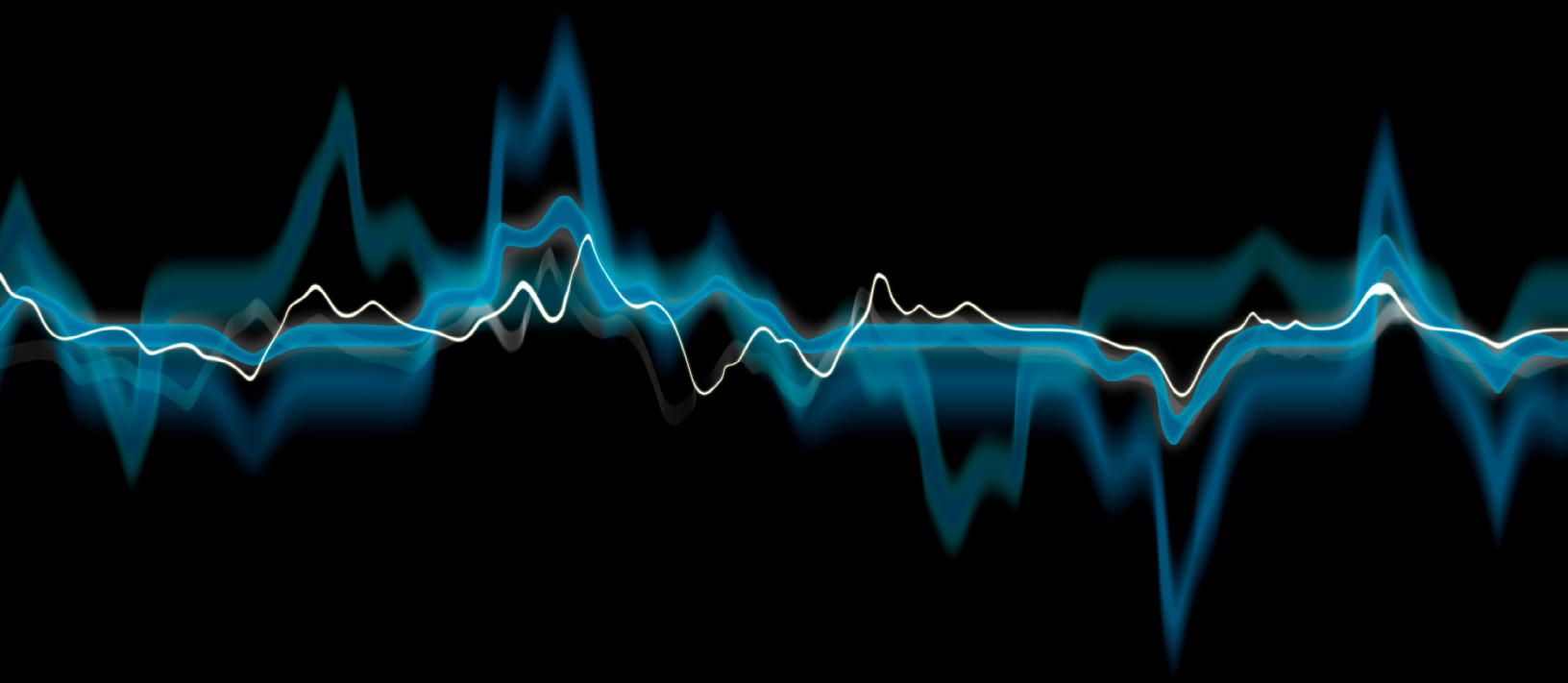
WHITE PAPER



Recognizing and Reducing Data Acquisition Switching Transients

KEYSIGHT

Introduction

If you make sequential measurements with a data acquisition/switch unit or data logger, you could have problems and not even realize it. Transients in your switching system can disrupt your measurement results, cause cross talk between channels, and damage your relays.

This white paper will help you recognize, understand, and resolve problems associated with switching transients. We use the Keysight DAQ970A data acquisition system in our examples, but the principles we discuss apply to data acquisition/switch units and switch cards from any test equipment vendor.

Symptoms of Transients in Switching Systems

How do you know if you are experiencing transient voltage or current in your switching system? Here are some common symptoms that could be caused by transients:

- Digital logic connected to the switch card resets or is erratic
- Voltage from the previous channel appears unexpectedly as an output on the next channel
- Your data acquisition/switch system resets or hangs
- Voltages across the relay/switch are twice the applied voltage
- The life of your relay/switch is unexpectedly low
- Sensitive devices in the device under test (DUT) are damaged

Methods to reduce fast current transients that are harmful to the circuits and mechanical relays:

- Place a resistor of 100 Ω in series with the Hi or Lo channel terminal connected to a low impedance source or to ground
- Prevent the voltage of one channel from transferring to a subsequent channel by setting up an intermediate channel that has the Lo and Hi tied to ground through a 100 Ω resistor to discharge stray capacitance

What Causes Transients?

When you use a data acquisition / switch unit with a switch card such as the DAQ970A with the DAQM901A, low-impedance sources can produce large and fast current transients. Simultaneous contact closure may appear to cause these high-current transients, but the actual cause is stray capacitances in the measurement circuitry.

The current transients may cause problems with adjacent channels, create transients in the ground circuit that upset digital logic connected to the DUT, or cause the data acquisition system to reset or hang in some cases.

To understand these transients, we must consider the source of stray capacitance found in measurement circuitry. Figure 1 shows connections that can cause this unwanted effect. It depicts the stray capacitances C1 (~120 pF) and C2 (~70 pF) associated with the inputs of the digital multimeter to ground. Channel 1 is connected to measure a low-value resistor that connects to ground. Channel 2 is connected to measure the current of a load connected to a 25 Vdc power supply. The sense resistor is 0.1 Ω. Channel 3 represents a resistor measurement.

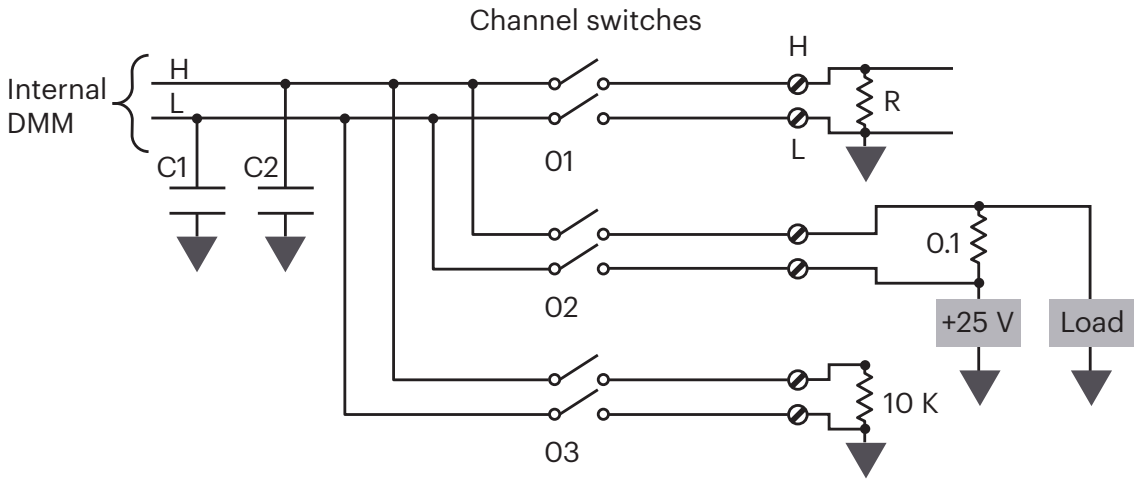


Figure 1. C1, C2 represent stray capacitance that can create transient currents and voltages

Example 1

Now we will look at what happens when we scan through channels 1, 2, and 3.

Channel 1 switch closes

Closing the channel 1 switch discharges the voltages on capacitors C1 and C2, and the voltages across both capacitors rapidly approach zero.

Channel 1 switch opens, then Channel 2 switch closes

When the channel 1 switch opens and the channel 2 switch closes, the 25 Vdc from the channel 2 power supply quickly charges both capacitors. The series resistance of the circuit is:

- The output resistance of the power supply (< 0.1 Ω)
- The shunt resistor (for C2 only)
- The resistance of the traces on the PC board
- The relay contact resistance (< 0.1 Ω)
- The ground path back to the power supply

The total resistance will be < 1 Ω. **From Ohm's law, the initial surge current will be more than 25 A through each contact (25 V/1 Ω = 25 A)**. These large, fast transient currents cause havoc with digital circuits. Power supply voltages greater than 100 V may create transients that interfere with the proper operation of the data acquisition system.

The large transient currents create arcing across the relay/switch contacts as they close. Arcing causes movement of metal from one relay contact to the other or some other deterioration of the contact surface, reducing the life of the relay. To make things more difficult, these transients have a short duration and are difficult to measure.

Channel 2 switch opens, then channel 3 switch closes

When channel 2 reaches steady state, and finally opens, C1 and C2 are charged at approximately + 25 V by the channel 2 power supply

When channel 3 closes, C1 will discharge a large current pulse through the ground circuit creating large currents similar to those that occurred when channel 2 closed. As a result, the channel 3 Lo relay will likely wear out faster than channel 3 Hi. The + 25 V on C2 will initially appear across the 10 K Ω resistor. The voltage will be across the 10k Ω resistor as a transient until it gets discharged. You will see it as an output from the high to low terminals of the channel, and you may even interpret it as a failure of channel 2.

This symptom is similar to having channel 3 close before channel 2 opens; however, channel 2 does open before channel 3 closes.

Example 2

An unexpected voltage also manifests itself when the source is floating (very high impedance to ground — see Figure 2). After channel 1 closes, C1 and C2 are in series and will charge such that 25 V is present between points A and B.

When channel 1 opens, the + 25 V at point A referenced to B remains.

When channel 2 closes, one contact will close before the other. Assume in this case the lower of the two contacts closes first. Point C will be –25 V referenced to point B, and the voltage across the upper channel 2 contact will be 50 V. In this case, the sum of both voltage sources (50 V) must be less than the rating of the relay or damage will occur.

A severe case occurs when you measure AC line voltage on two successive channels. The voltage across the relay of the second channel may be twice the peak voltage, creating large currents and arcing.

How to Solve Transient Problems

To reduce the current transients that create problems in the digital circuits associated with the measurement and reduce the life of the relay contacts, place a 100 Ω current limiting resistor in series with the Hi or Lo channel terminal that connects to a low-impedance source or ground. **The current limit resistor will not deteriorate the voltage measurement but will limit the peak current**. Placing the current sense resistor at the low side of the power supply will also avoid high voltages.

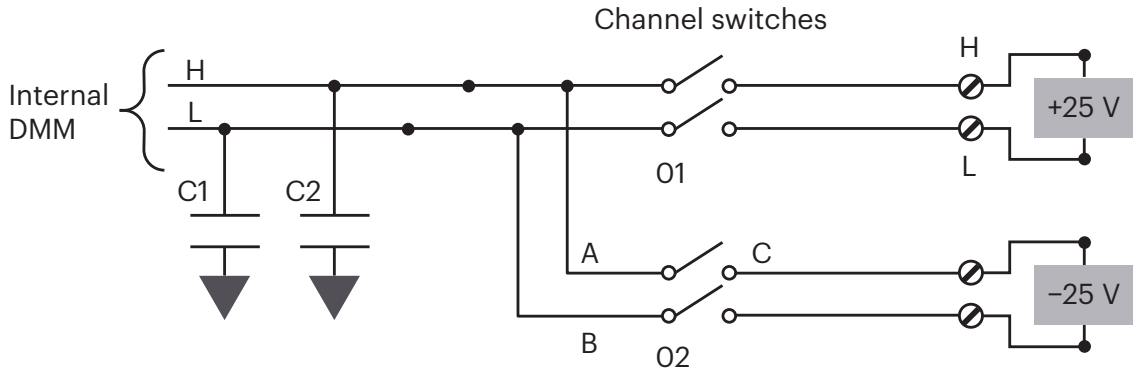


Figure 2. Floating Sources can create current and voltage transients in adjacent channels

You can prevent the voltage of one channel from transferring to a subsequent channel by setting up an intermediate channel that has the Lo and Hi tied to ground through a 100 Ω resistor to discharge C1 and C2. You can activate this channel after switching voltages higher than a subsequent measurement can tolerate.

Conclusion

Switching transient problems are common. Fortunately, you can reduce them using the techniques described in this white paper.

For more information regarding Keysight's DAQ970A data acquisition system, please visit our website at www.keysight.com/find/DAQ970A.

Glossary

Transient — transition behavior until a steady state is achieved, may be initiated by a contact closure.

Related Keysight Literature

DAQ970A Data Acquisition/System - Technical Overview, publication number, 5992-3168EN