
WELCOME TO AUSTIN

4 Best Practices to Prolong Relay Life in NI Switches

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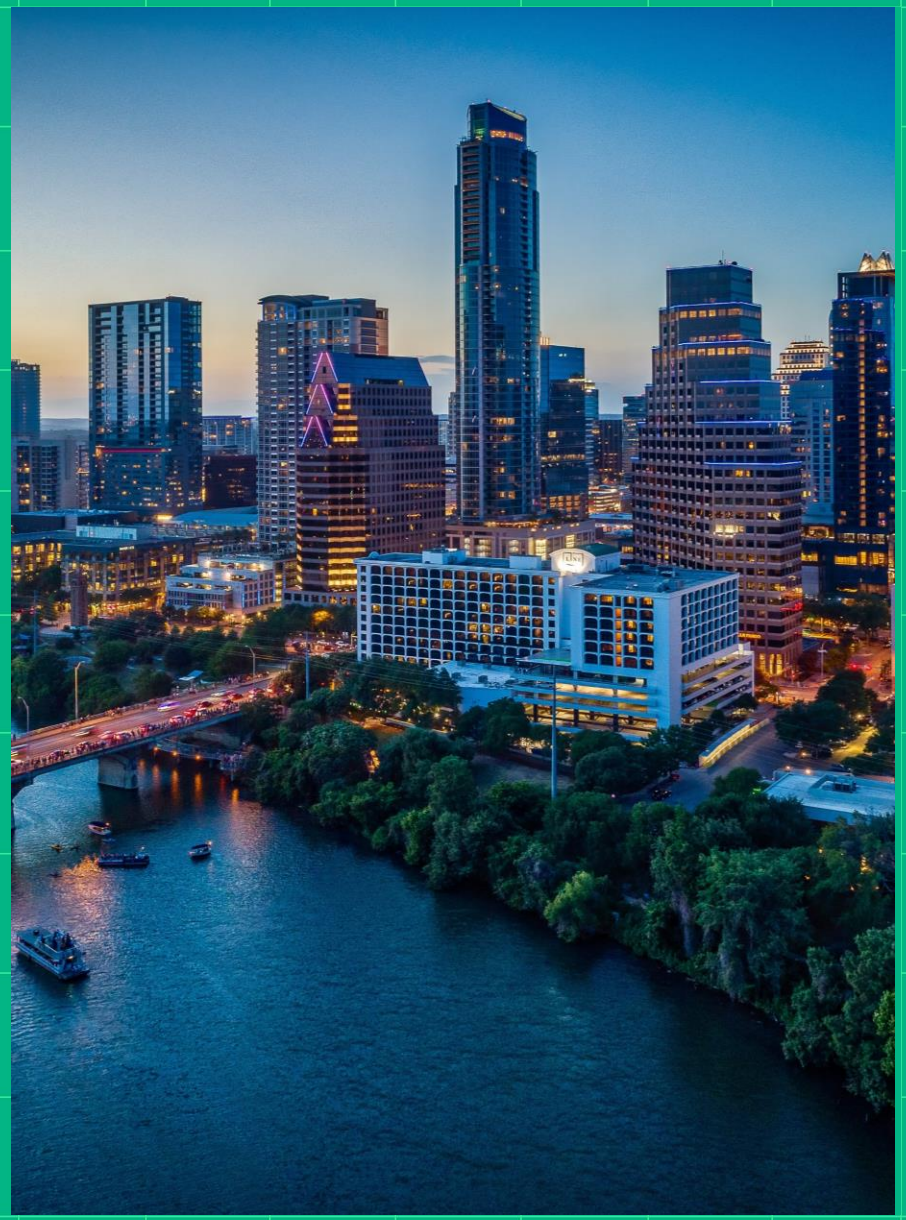


Agenda

- Introduction
- Relay Life Basics
- 4 Best Practices
- NI Switch Executive
- Summary
- Q&A

Switches

- Switches are the unsung hero of automation
- Responsible for signal routing
- Easy way to increase channel count
- Found in
  - General purpose functional test
  - Semiconductor parametric test
  - High –power fault insertion
  - Radar tests
  - And MORE
- Chief consideration—Relay Life

What is Relay Life?

The Basics
Variables Affecting Relay Life

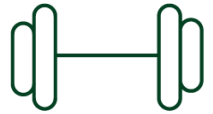
Relay Life

- Expected or actual duration of time that a relay can operate reliably under its specified conditions.
- Mechanical
  - Assumes no electrical load across contacts during actuation
- Electrical
  - Impacted by arcing
- Depend on several factors:
  - Relay Type
  - Operating environment
  - Load characteristics
  - System Capacitance
  - Stress
- Relay lifespan can affect the overall cost and reliability of the system

Dynamic	
Relay operate time[4]	1 ms, typical 3.4 ms, maximum
Expected relay life[5]	
Mechanical	1×10^8 cycles
Electrical	
10 VDC, 100 mADC resistive	2.5×10^6 cycles
10 VDC, 1 ADC resistive	1×10^6 cycles
30 VDC, 1 ADC resistive	5×10^5 cycles
60 VDC, 1 ADC resistive	1×10^5 cycles

4 Best Practices

1. Know the Strength & Limitations of Each Relay Type



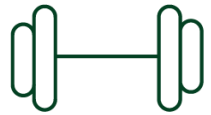
2. Avoid Hot Switching

3. Use Protective Resistance to Combat Inrush Current

4. Use NI Software to Monitor Relay Health

4 Best Practices

1. Know the Strength & Limitations of Each Relay Type



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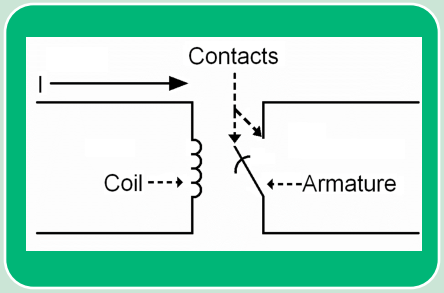
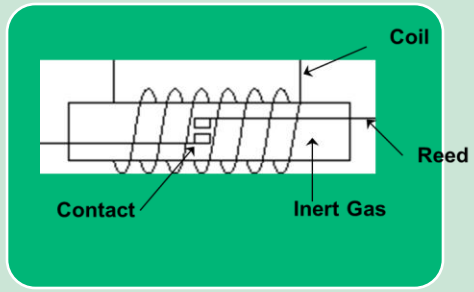
Relay Types Overview

Armature



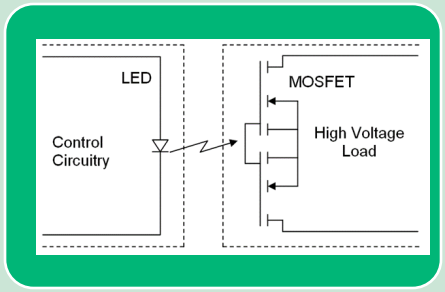
Ex. PXI-2575

Reed



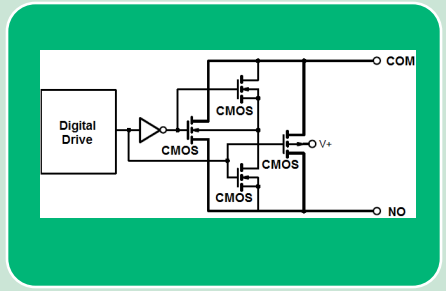
Ex. PXI-2530B

SSR



Ex. PXI-2533

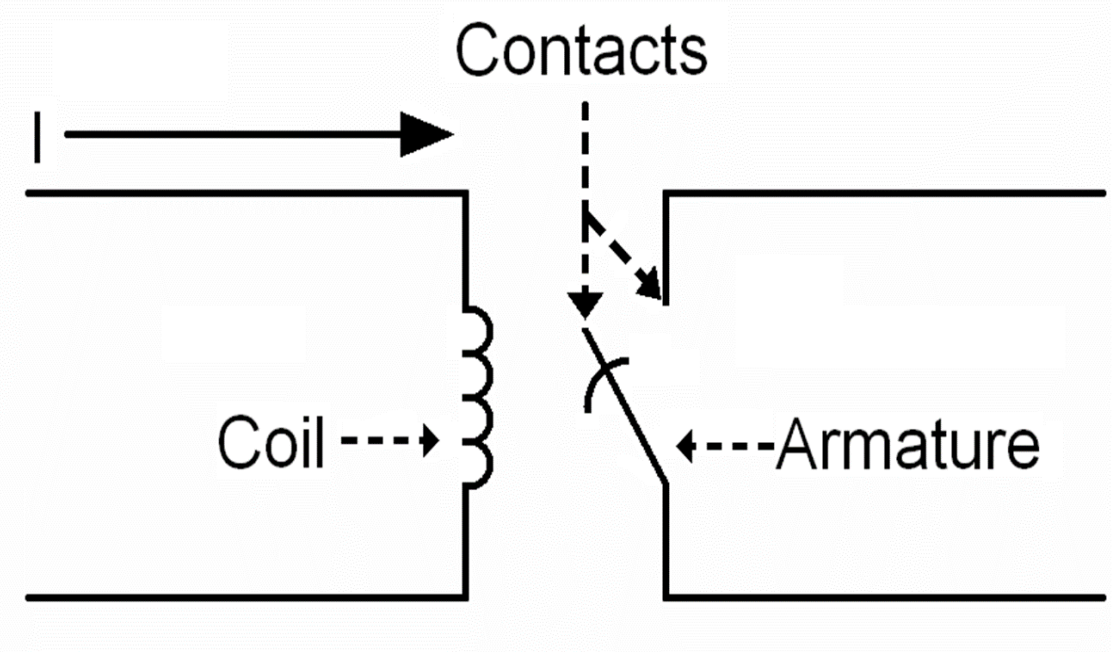
FET



Ex. PXI-2535

1. **Armature**
2. Reed
3. SSR
4. FET

Electromechanical Armature



Coil, when energized, creates a magnetic field to pull contacts closed

Advantages:

- Low cost
- Ease of Use
- High voltage and current loads

Disadvantages:

- Limited lifespan due to mechanical wear and tear
- Slower to switch
- Audible clicking sound

Failure Mechanism: Resistance build up, unable to close

1. **Armature**
2. Reed
3. SSR
4. FET

Armature High Contact Resistance Remediation

If switching very low currents with armature relays is unavoidable, there are still things that can be done:

1. Increase the Switching Current

- Clean the absorbed/polymerized material from the contacts
- Amount of current will vary depending on the relay size
  - Recommended to use max current reported in the specifications
  - Power level >0 Dbm
- Too high of current can also degrade the contact resistance

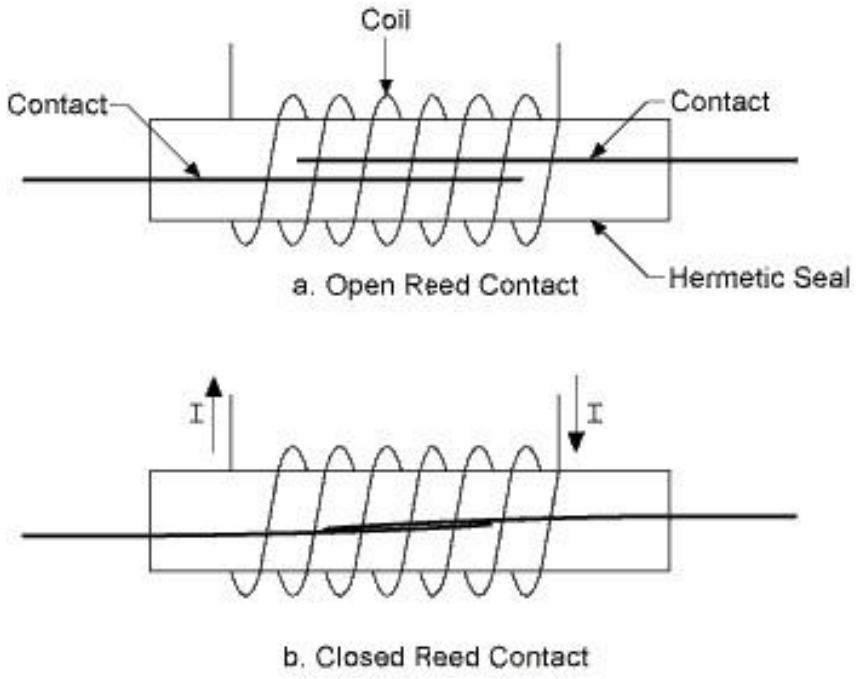
2. "Buzz" the Relay

- Rapid cycling the relay to knock deposits from relay contacts
  - Actuate the device for ~1second
- No fixtures or other measurement devices are needed
- Effective for shorter time than the first method
- Impacts relay life

Maximum total current (switching or carry)	1 A

1. Armature
2. **Reed**
3. SSR
4. FET

Electromechanical Reed



Two reeds physically contact when coils are energized

Inside a vacuum glass bead -> Resistant to contact polymerization

Advantage:

- Smaller than armature relays
- Low power consumption
- Faster than armature relays (higher switching speed)
- Longer lifespan

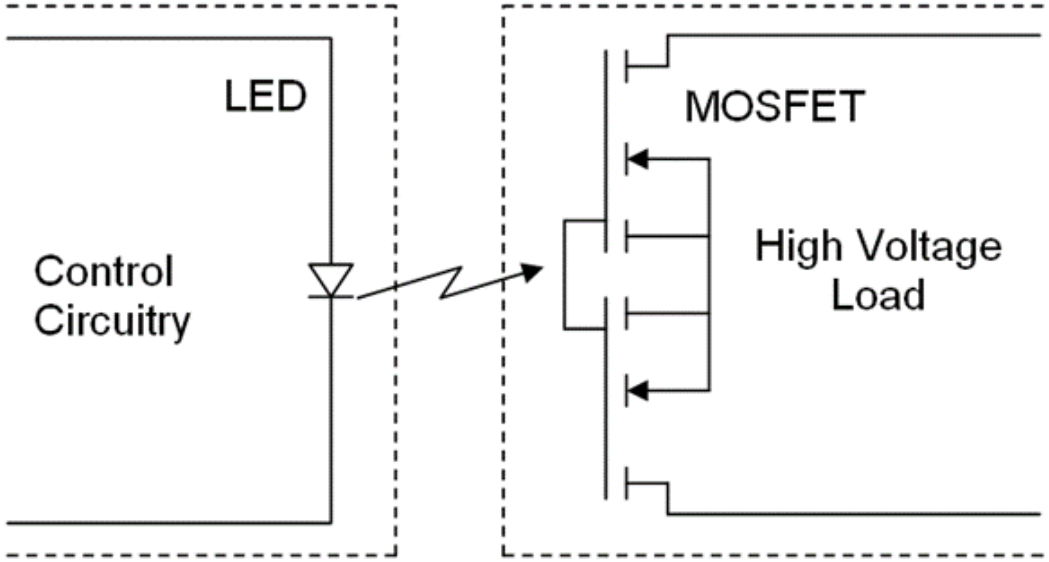
Disadvantage:

- Low load voltage and low current
- Susceptible to contact damage
- Prone to inrush currents

Failure Mechanism: Welded Shut

1. Armature
2. Reed
3. **SSR**
4. FET

Solid State Relay



- Photo-sensitive MOSFET responds to light from LED
- Isolation barrier allows relay to switch high voltages
- LED restricts switching speed

Advantage:

- Faster than electromechanical relays
- Quiet due to no moving parts
- Infinite life when used within specifications

Disadvantage:

- High cost
- Not as robust
- Susceptible to surge currents and damage

Leakage current might need to be addressed

Heat could be produced from the LED

1. Armature
2. Reed
3. SSR
4. **FET**

FET Switch

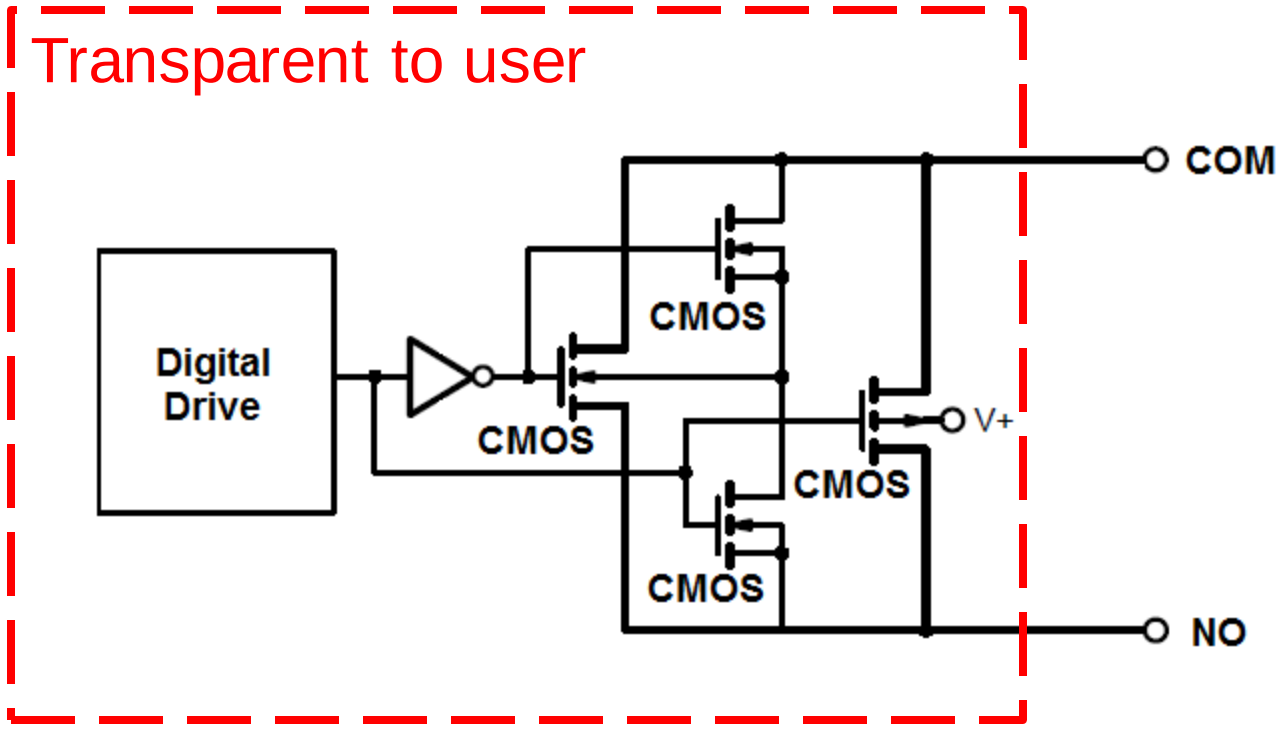
Recommended to check the voltage across the relay with a DMM first to avoid damage.

Advantage:

- Very fast switching rate
- Long switching lifespan

Disadvantage:

- Very easily damaged
- Only be used with low voltage (±10V)
  - Voltage of the system cannot be higher than the voltage that is allowed to pass through the relay



- CMOS transistors to implement the switching
- No additional isolation between the control circuitry and the signal path

Relay Types and Capabilities

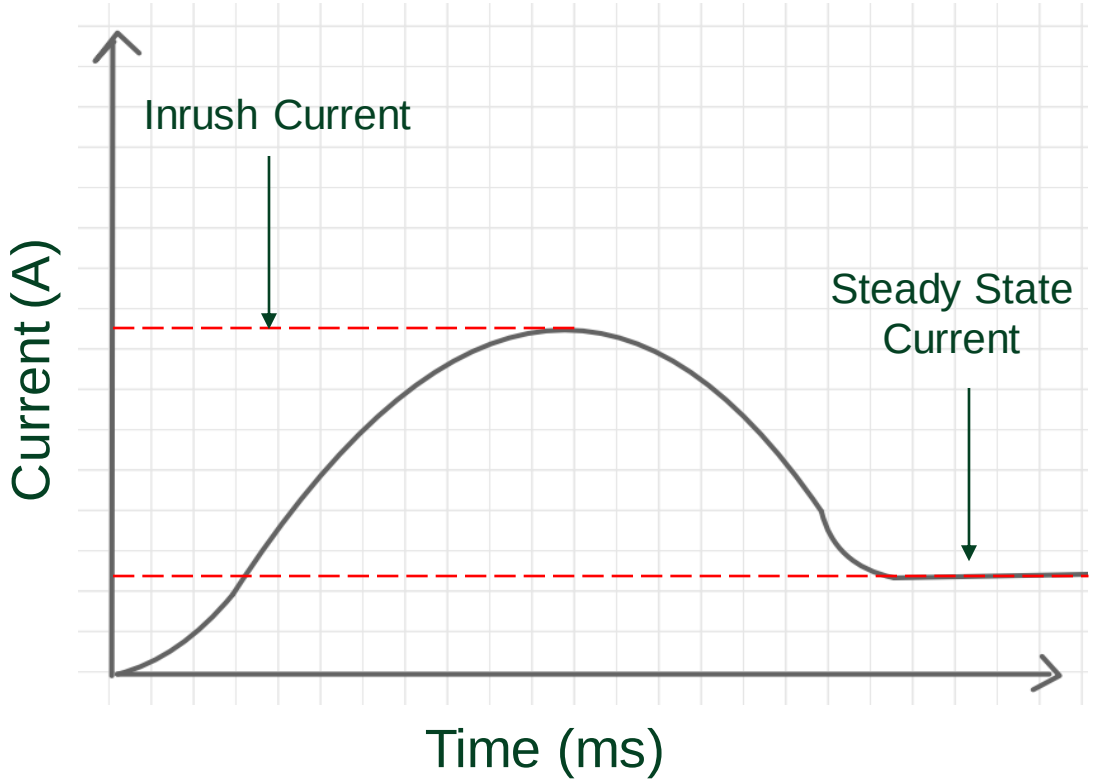
Capabilities	Armature	Reed	SSR	FET
High-Power	Best	Better	Better	Good
High-Speed	Good 150 cycles/s	Better 2000 cycles/s	Better+ 300 cycle/s	Best 60,000 cycles/s
Size	Better Smallest	Better+ About 10x smaller than armature	Best Smaller than Reed	Best Smaller than Reed
Low Path Resistance	Best < 1 Ω	Better	Better <1 Ω to 100 Ω	Good 8 Ω to 15 Ω
Relay Life	Good $1X10^6$ Cycles	Better $1X10^9$ Cycles	Best Unlimited mechanical life	Best Unlimited mechanical life
Cost	Best	Best	Good	Good

4 Best Practices

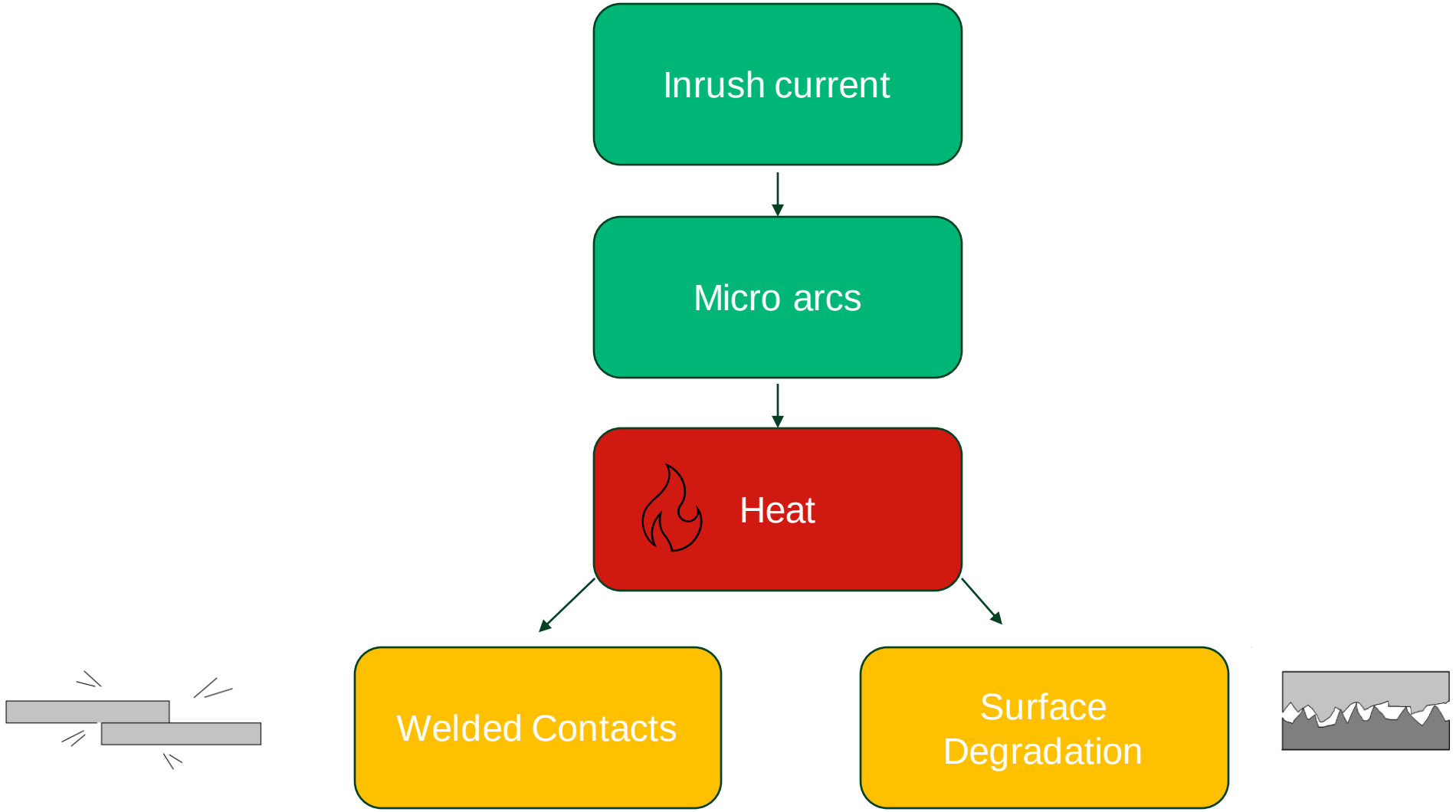
1. Know the Strength & Limitations of Each Relay Type
2. Avoid Hot Switching 
3. Use Protective Resistance to Combat Inrush Current
4. Use NI Software to Monitor Relay Health

What is Hot Switching?

- Definition of Hot Switching:
  - Moving the relay when current/voltage is applied
- What does hot switching lead to?
  - High inrush current

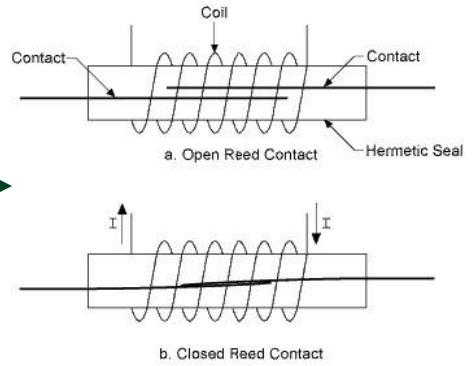


Hot Switching Effects

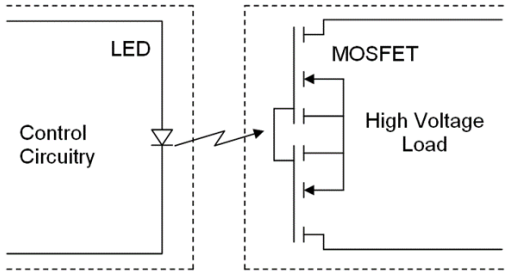


Hot Switching & Relay Type

Most Affected → Reed relays



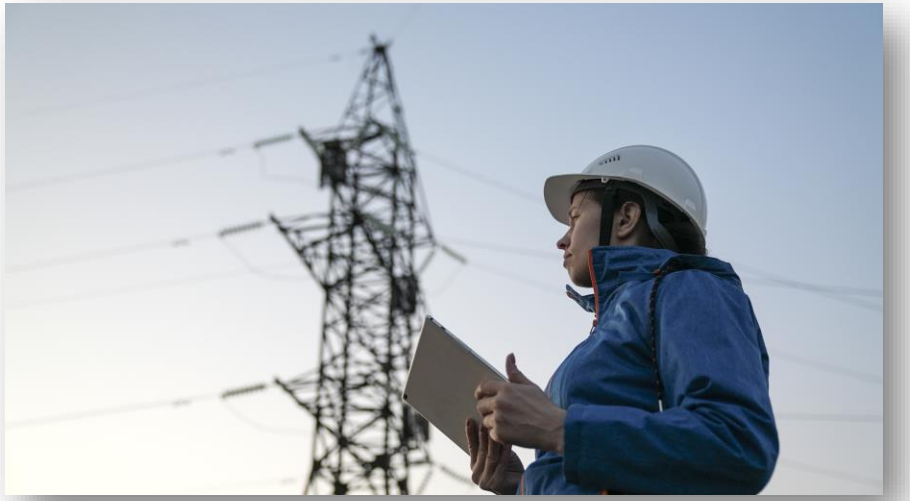
Least Affected → SSRs



- More expensive
- Still susceptible to surge currents

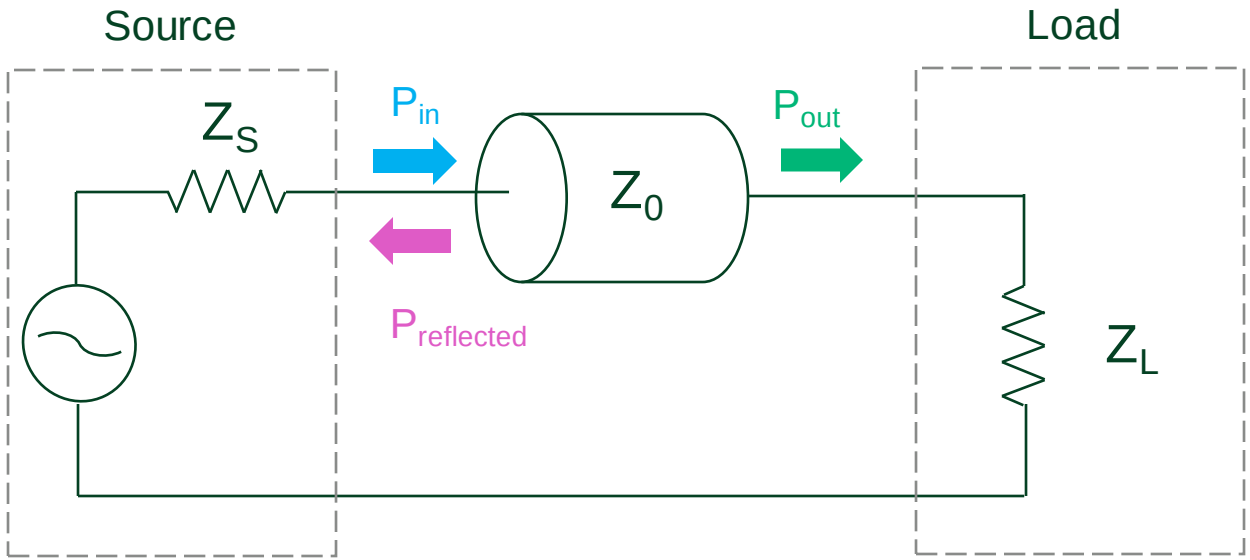
Damage to Relays—DC vs. AC

- Relay damage worse for DC signals
- Why?
  - Current flows continuously in one direction
    - Longer and stronger arcing
    - Greater heat and damage
- Consequence?
  - Max rated switching power is less for DC than AC



Hot Switching RF Signals

- Can damage the RF signal source due to reflected power
- Open relay leads to high impedance
  - Impedance mismatch leads to power loss because power is reflected
- Terminated switches ensure that when a selected path is closed all other paths are terminated with 50/75 Ω loads
- Avoid switching during transmission



How to Avoid Hot Switching

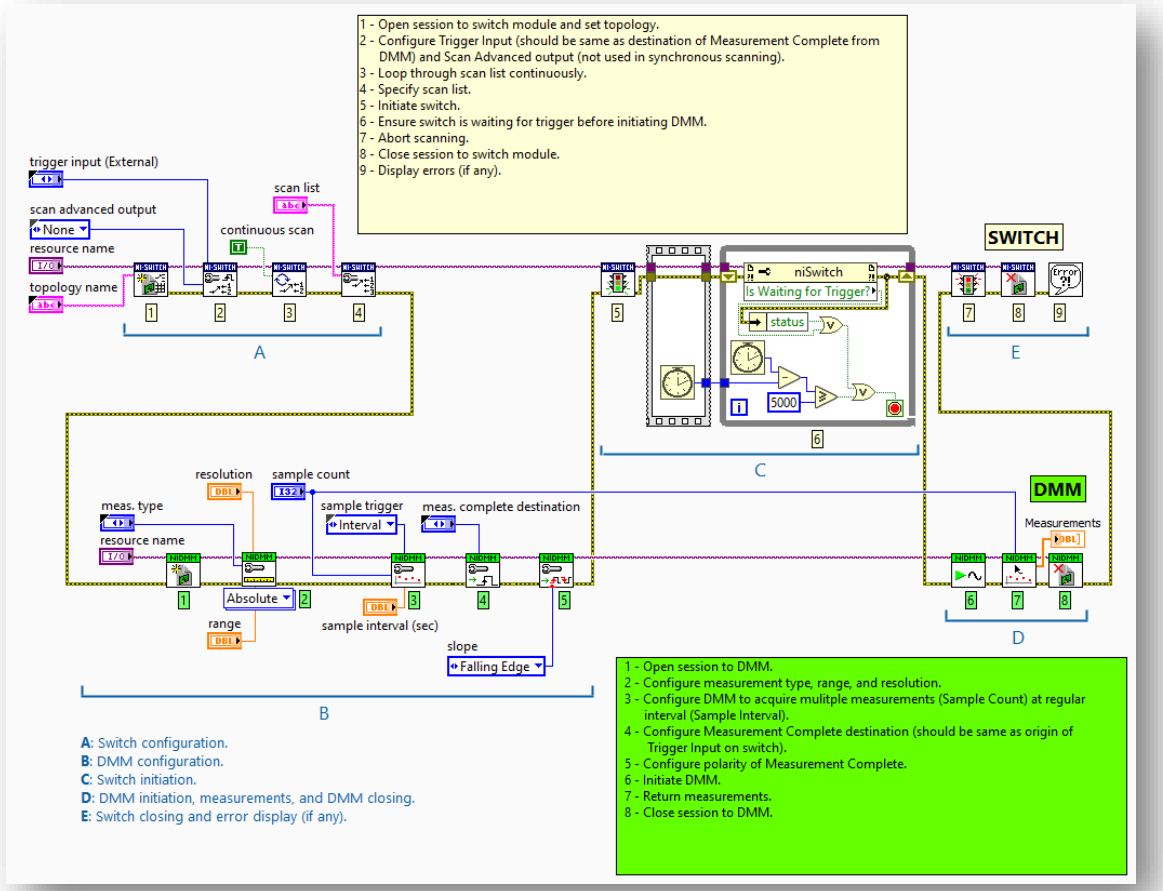
Carefully coordinate switching sequence using:

Time delays between switching operations

- ✓ Allow proper settling time
- ✓ Reduce instances of cross talk or interference
- ✓ Facilitate cooling

Overvoltage protection

- Receives input from voltage sensing circuits
- Disables power supply, shuts down system, or sends alerts when threshold is exceeded



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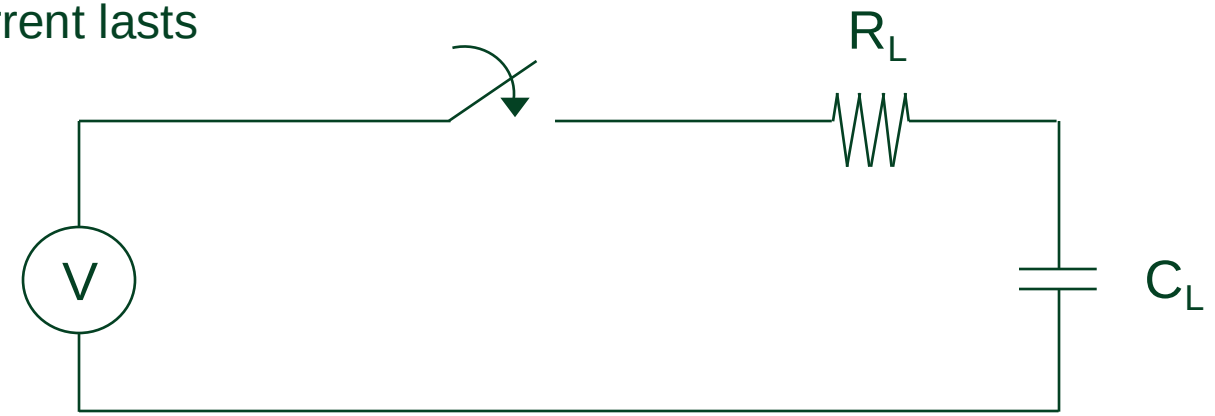
Switching Capacitive Loads

- Protective resistors limit inrush current due to switching in capacitive load
- Everything has capacitance:
  - DMM / Power Supplies / SMU / Cables
- High inrush can cause relay contacts to weld shut requiring relay replacement
- Inrush current is proportional to:
  (1) change in voltage
  (2) capacitance
- Resistance limits how long the inrush current lasts

Ohm's Law for a capacitor

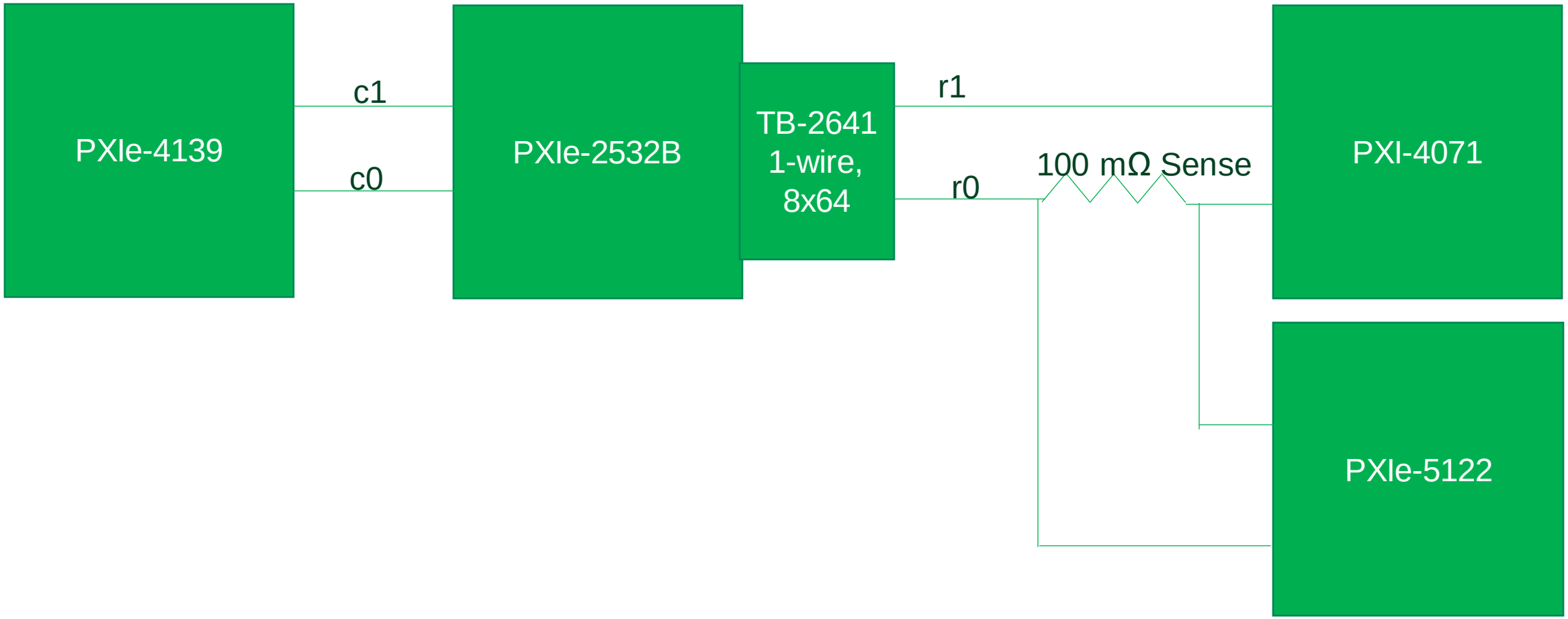
$$i = C\frac{dV}{dt}$$



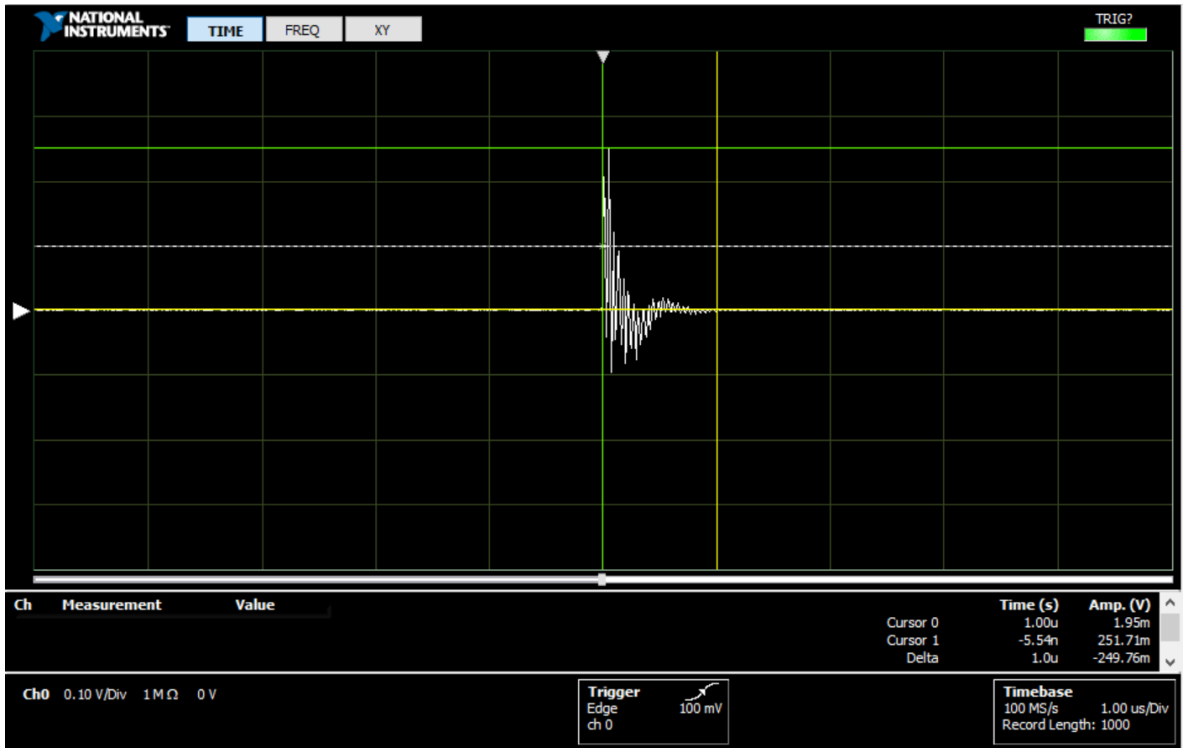
Demo

- Observing Inrush Current in Real Time

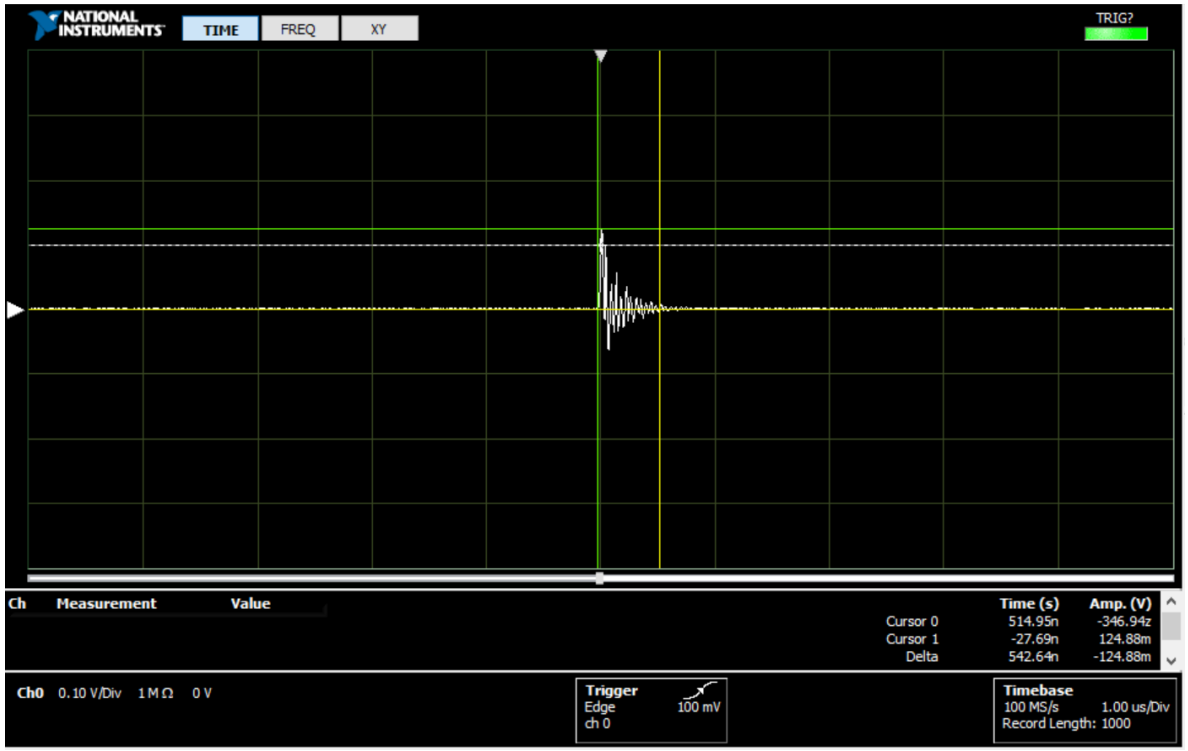
Demo Set Up


PXIe-4139
c1
c0
PXIe-2532B
TB-2641
1-wire,
8x64
r1
r0
100 mΩ Sense
PXI-4071
PXIe-5122

Without 100Ω Protection



With 100Ω Protection



- 250 mV spike w/o protection resistors, lasts 1 uS
- 125 mV spike w protection resistors, lasts 542 ns

4 Best Practices

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Predicting Relay Life

- Predicting relay life less straightforward and depends on the type of load
  - Purely resistive loads
  - Capacitive loads
- Must account for statistical variations on relays

✓ Predictive maintenance is key

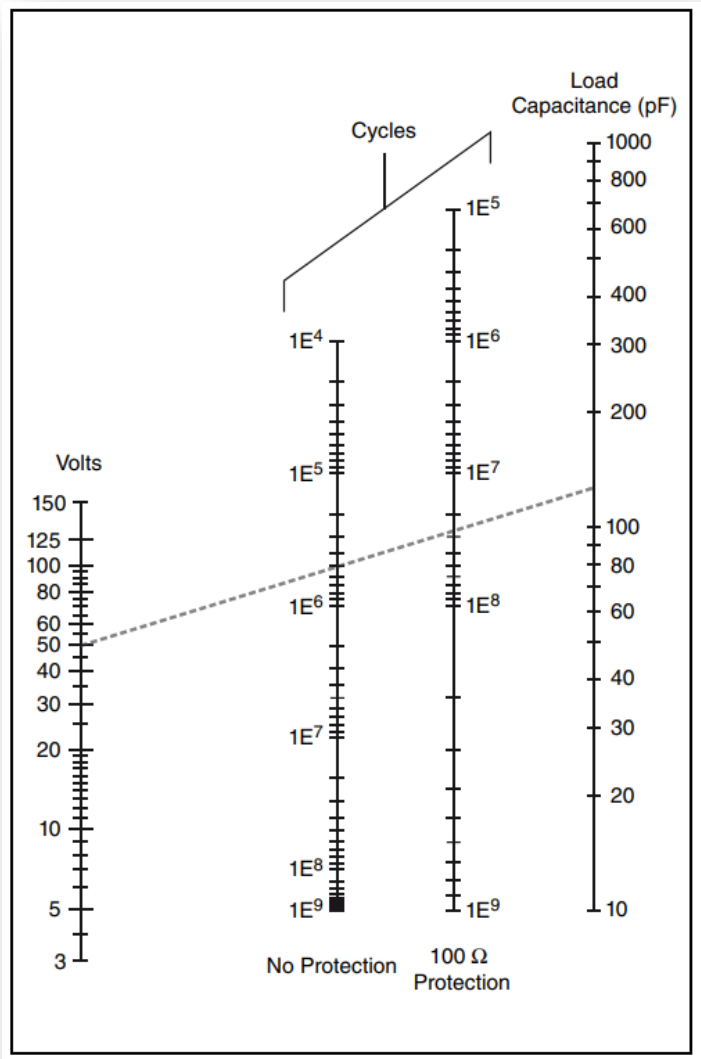
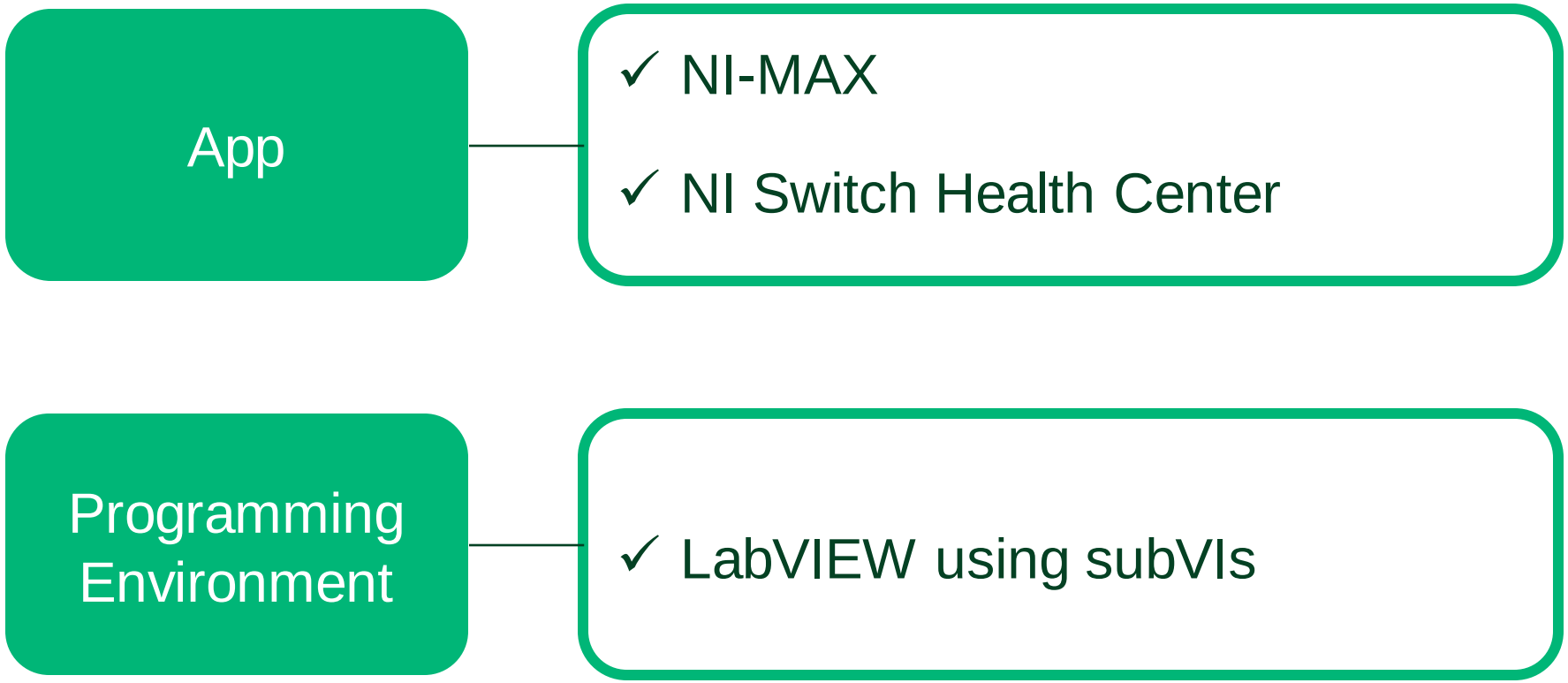


Figure 3. Reed Relay Lifetime Nomograph

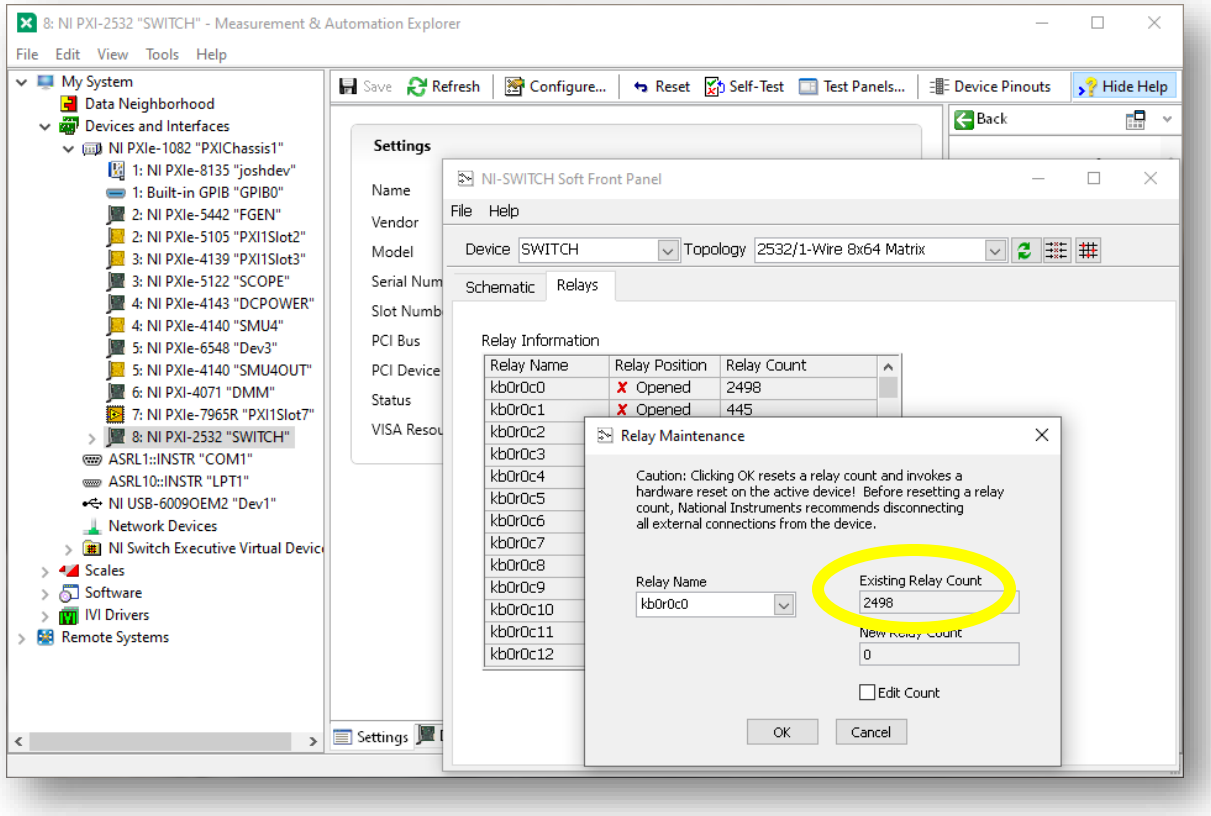
PXIe-2532

NI Software for Relay Monitoring



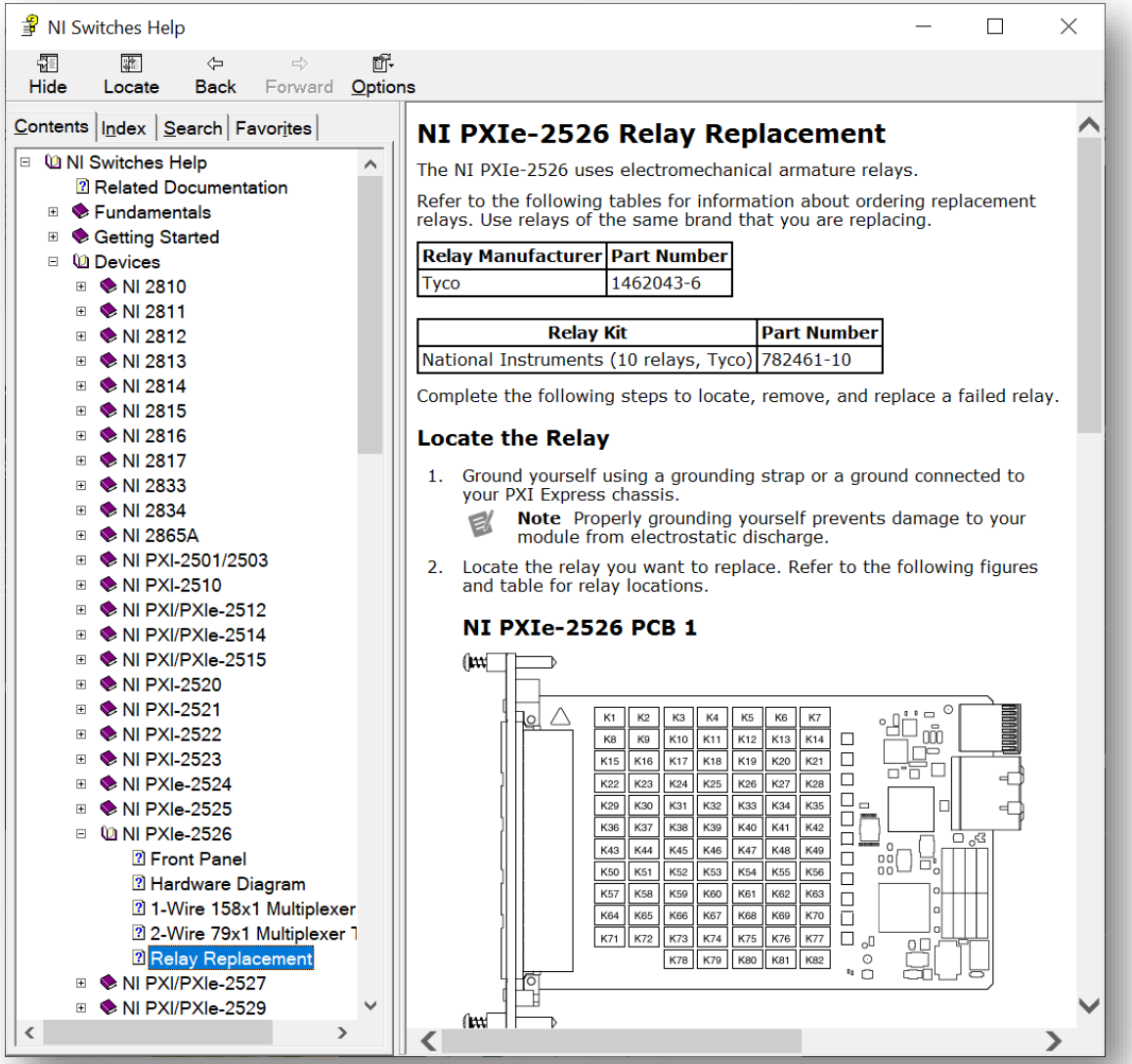
NI-MAX

- Check relay counts
  - Can search by name
- Reset count for new relays
- Cycle count = # of times relay has been closed and opened
- Counts stored on switch hardware in nonvolatile storage such as EEPROM or flash, and are backed up periodically as well as on system shutdown



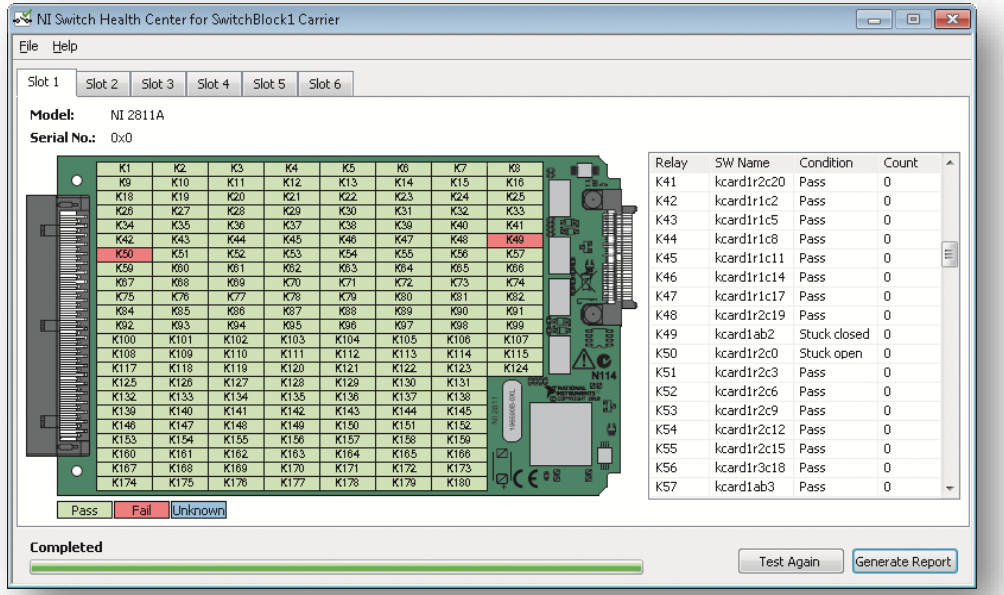
Replacing Your Relays

- Replacement instructions in **NI Switches Help** app
  - Includes instructions on resetting count in NI-MAX
- Replacement Kits contain 10 relays
- To order visit https://www.ni.com/en/contact-us.html
- For more information visit How to Replace a Relay on Your Switch
- Eliminate hassle with system return material authorization (RMA)



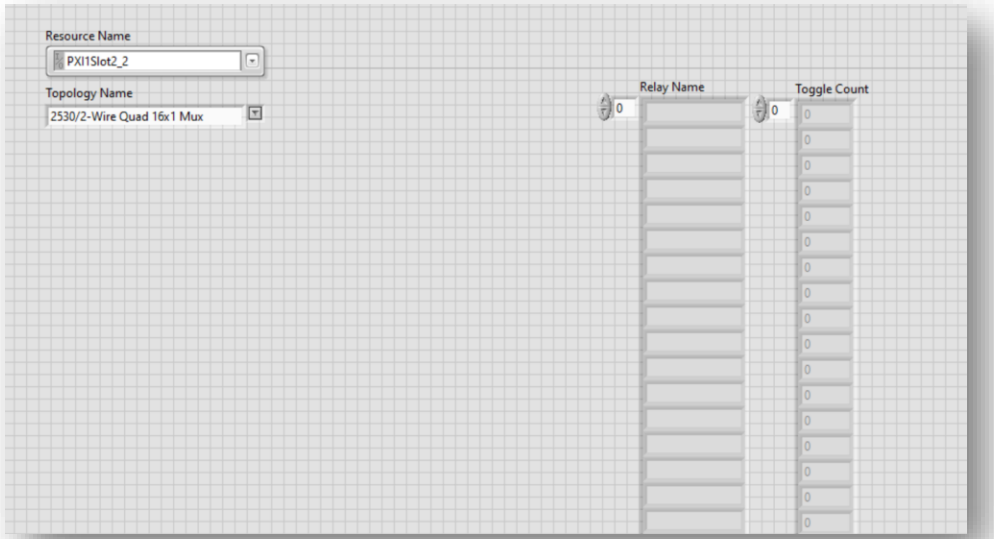
NI Switch Health Center

- Monitor relay health and failure modes through integrated relay test:
  - ✓ Basic functional test
  - ✓ Test to determine change in resistance
- HTML Report is generated along with a detailed diagram
- Shipped on all NI SwitchBlock modules and select PXI Switch Modules

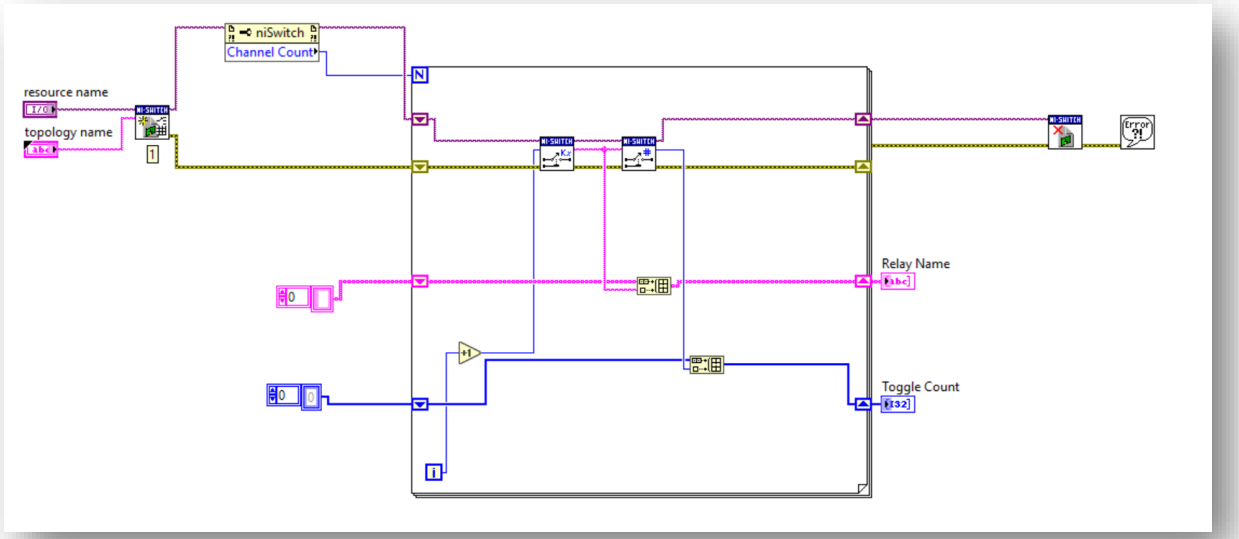


LabVIEW

- Use example VI from library (niSwitch Get Relay Count.vi)



Front Panel



Block Diagram

Demo

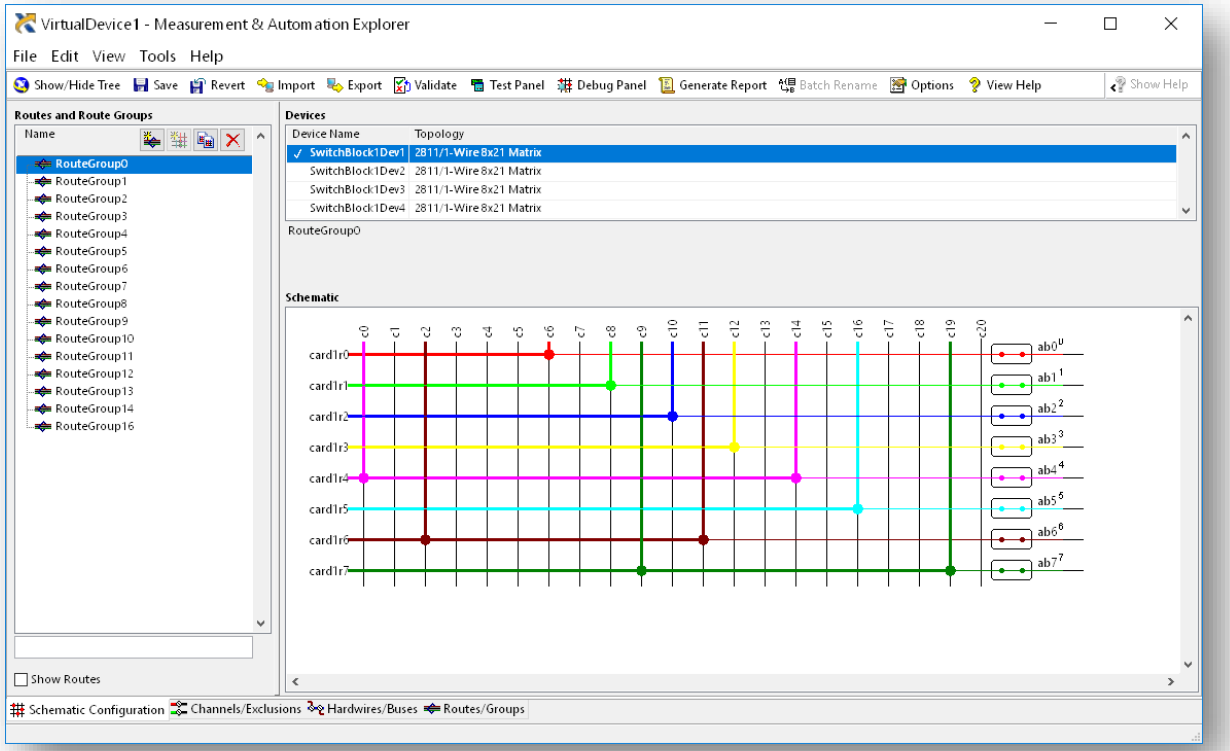
- Get Relay Count
  - NI MAX
  - LabVIEW

NI Switch Executive

Management & Routing App Software

NI-Switch Executive

- Switching software for automated test equipment (ATE) systems
- Provides interactive configuration and automatic routing capabilities that make it easier to design a switch system
- How does it work?
  - Create virtual device which serves as the software configuration of your switch
  - Rename channels & apply route exclusions
  - Validate in simulation mode
  - Export & edit configuration in Excel



✓ Reuse test code in LabVIEW, LabWindows™/CVI, Measurement Studio, & TestStand

→ Download Here

Summary

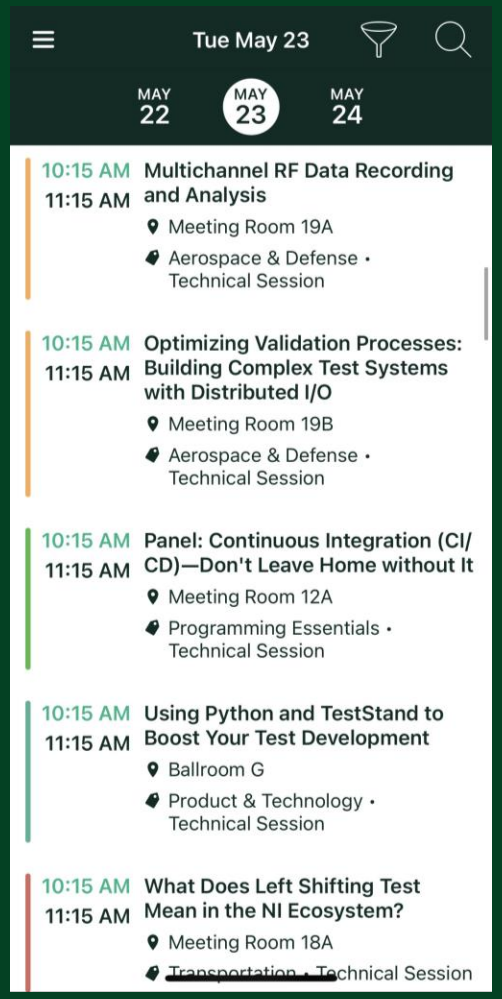
- 4 Best Practices:
  1. Know the strengths and limitations of each Relay type
  2. Avoid Hot Switching
  3. Use Protective Resistance to Combat Inrush Current
  4. Use NI Software to Monitor Relay Health
- Use NI Switch Executive for switch system configuration

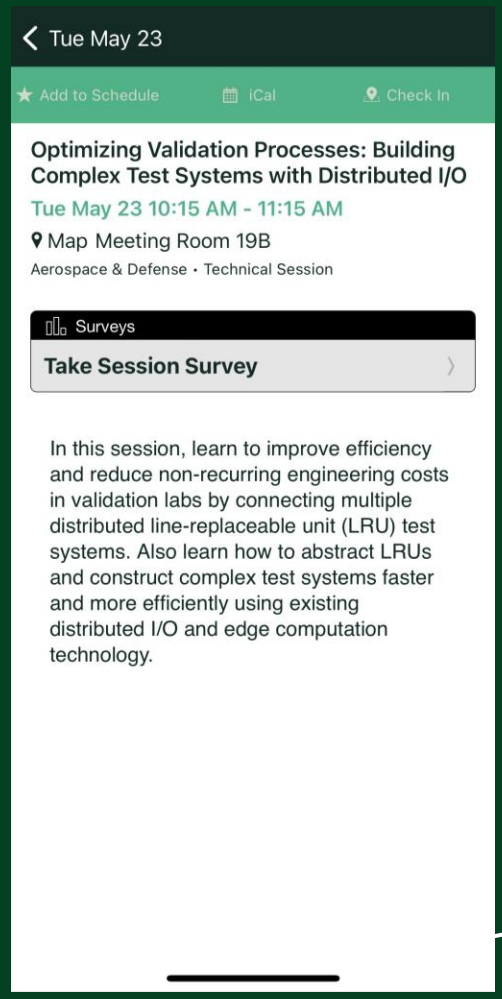
Check out this guide on Switching and Multiplexing to ensure you're creating a successful automated functional test system.

Q&A

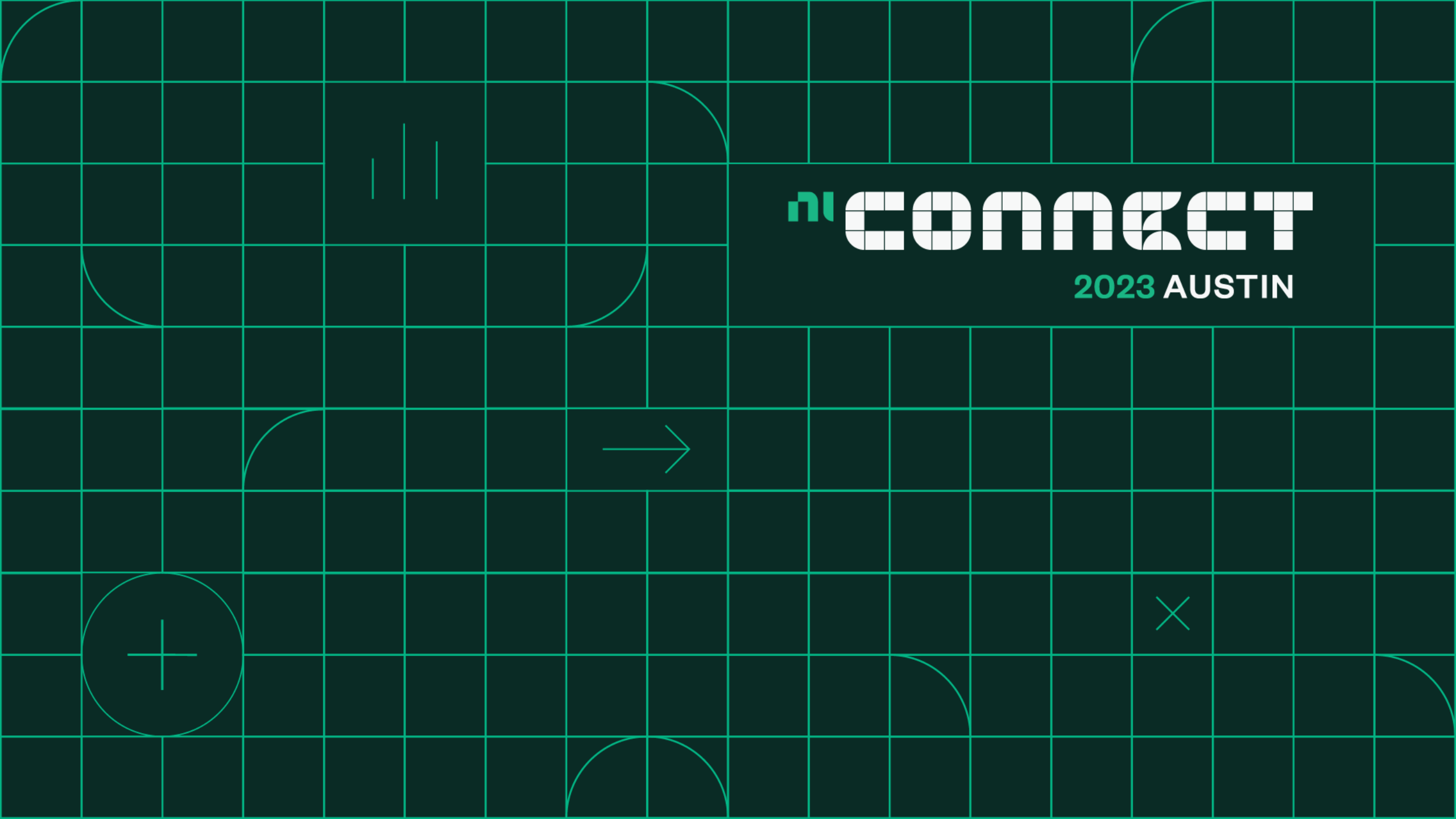
Give us your feedback!
Quick 2 Question Survey

In the mobile app, click into the session you would like to provide feedback for





Click “Take the Session Survey”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