

4 Best Practices to Prolong Relay Life in NI Switches

Laura Moody Product Marketing Engineer

Nikita Prasad Staff Analog Engineer

**Flora Yoon** Senior Technical Product Manager



# 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 Basics

# 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 <sup>[4]</sup>	1 ms, typical 3.4 ms, maximum
Expected relay life <sup>[5]</sup>	
Mechanical	1×10 <sup>8</sup> cycles
Electrical	
10 VDC, 100 mADC resistive	$2.5 \times 10^6$ cycles
10 VDC, 1 ADC resistive	1×10 <sup>6</sup> cycles
30 VDC, 1 ADC resistive	$5 \times 10^5$ cycles
60 VDC, 1 ADC resistive	1×10 <sup>5</sup> cycles







Know the Strength & Limitations of Each Relay Type

2

Avoid Hot Switching



Use Protective Resistance to Combat Inrush Current



4

Use NI Software to Monitor Relay Health





Know the Strength & Limitations of Each Relay Type

**4 Best Practices** 



**Avoid Hot Switching** 

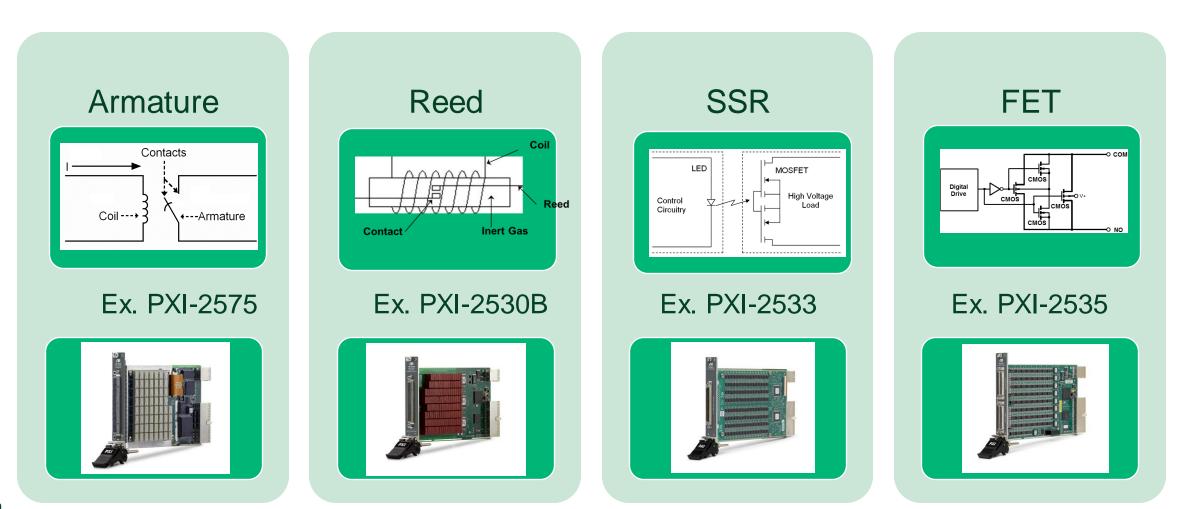


Use Protective Resistance to Combat Inrush Current



Use NI Software to Monitor Relay Health Π

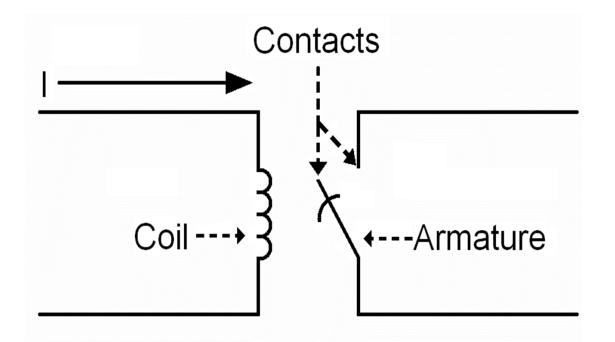
## Relay Types Overview



### Electromechanical Armature



- 2. Reed
- 3. SSR
- 4. FET



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

#### Relay Types

# Armature High Contact Resistance Remediation

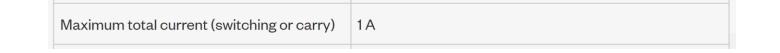
If switching very low currents with armature relays is unavoidable, there are still things that can be done:

#### 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



1. Armature

2. Reed

3. SSR

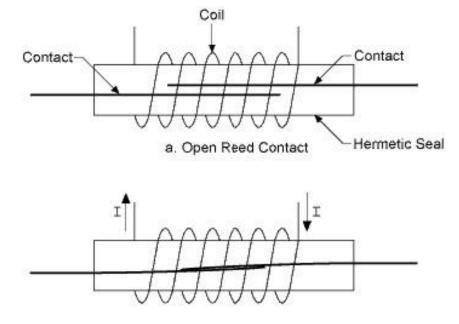
4.

FET

### Electromechanical Reed

#### . Armature

- 2. Reed
- 3. SSR
- 4. FET



b. Closed Reed Contact

Two reeds physically contact when coils are energized Inside a vacuum glass bead -> Resistant to contact polymerization Advantage:

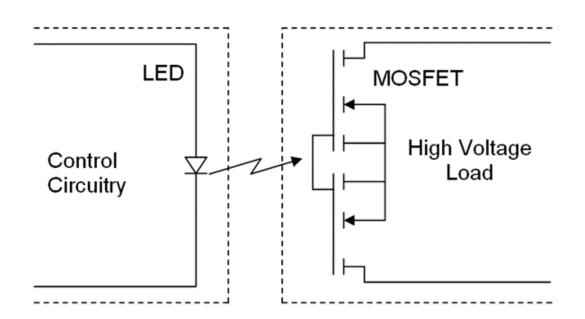
- Smaller than armature relays
- Low power consumption
- Faster than armature relays (higher switching speed)
- Longer lifespan

Disadvantage:

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

Failure Mechanism: Welded Shut

ni.com



- 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

Armature

Reed

SSR

FET

2

3.

4.

#### 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

ni.com



## FET Switch

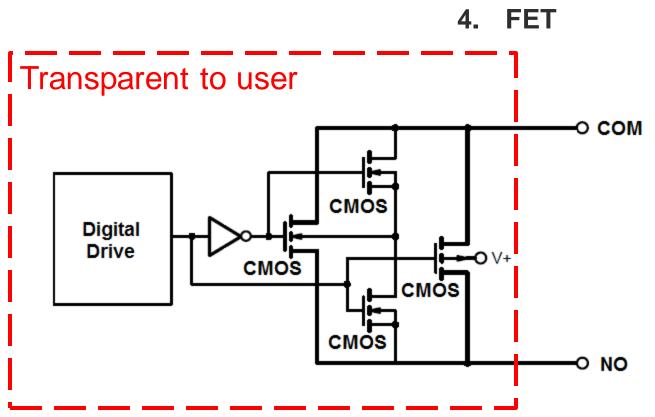
Recommended to check the voltage across the relay with a DMM first to avoid damage.

#### 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



Armature

Reed

SSR

2

3.

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

Relay Life Basics

# 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 <1Ω	Better	<b>Better</b> <1 Ω to 100 Ω	<b>Good</b> 8 Ω to 15 Ω
Relay Life	Good 1X10 <sup>6</sup> Cycles	Better 1X10 <sup>9</sup> Cycles	Best Unlimited mechanical life	Best Unlimited mechanical life
Cost	Best	Best	Good	Good







Know the Strength & Limitations of Each Relay Type



Avoid Hot Switching



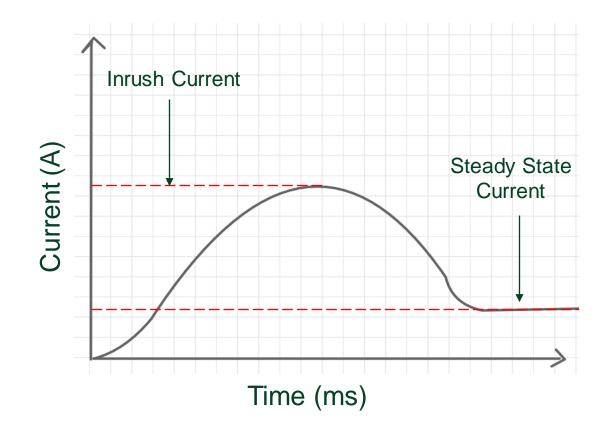
Use Protective Resistance to Combat Inrush Current

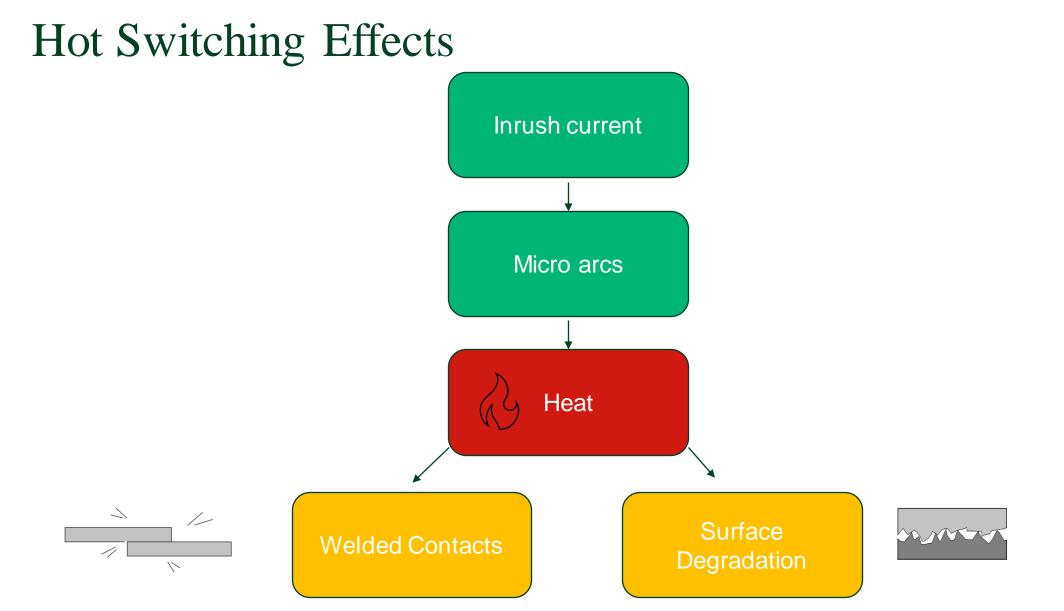


Use NI Software to Monitor Relay Health

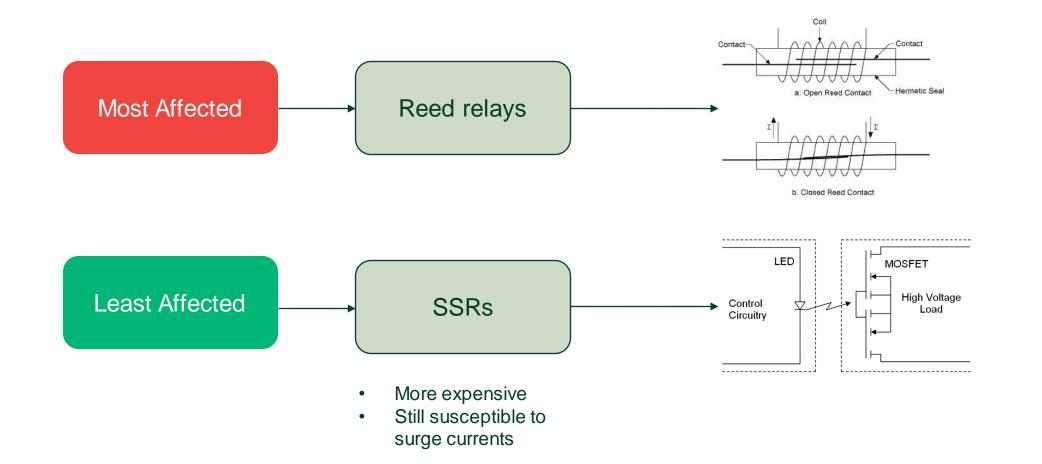
# What is Hot Switching?

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





# Hot Switching & Relay Type



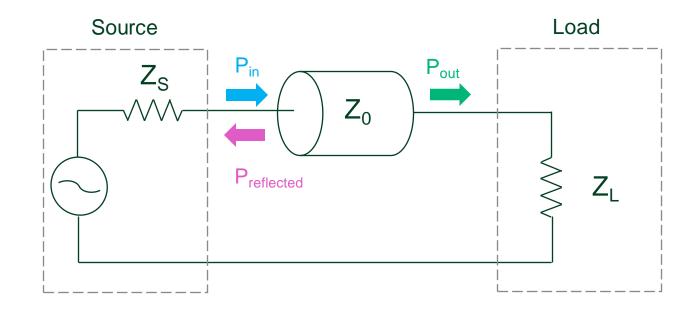
# Damage to Relays—DC vs. AC

- 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  $\Omega$  loads
- Avoid switching during transmission



# How to Avoid Hot Switching



Carefully coordinate switching sequence using:



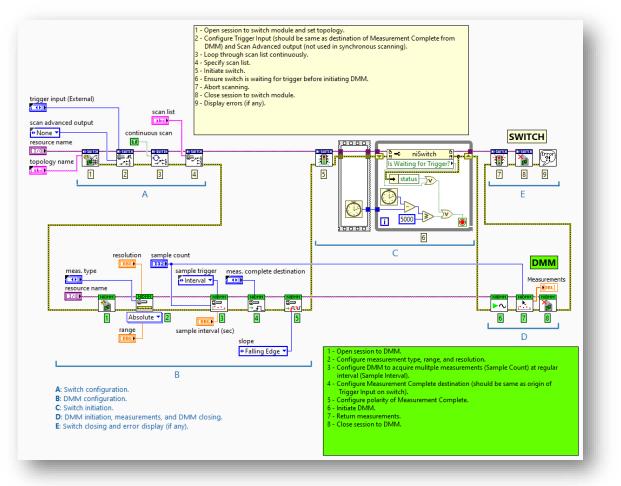
Time delays between switching operations

- ✓ 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









Know the Strength & Limitations of Each Relay Type

2

Avoid Hot Switching



Use Protective Resistance to Combat Inrush Current

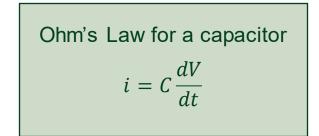


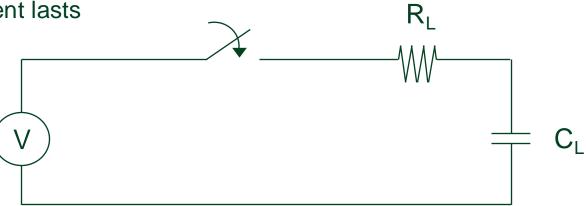


Use NI Software to Monitor Relay Health

# 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

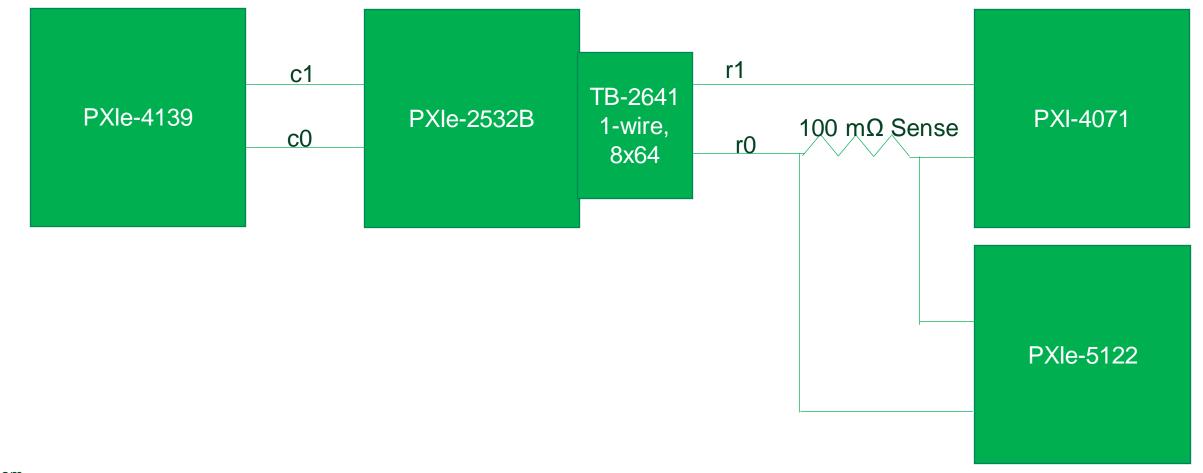




# Demo

#### Observing Inrush Current in Real Time

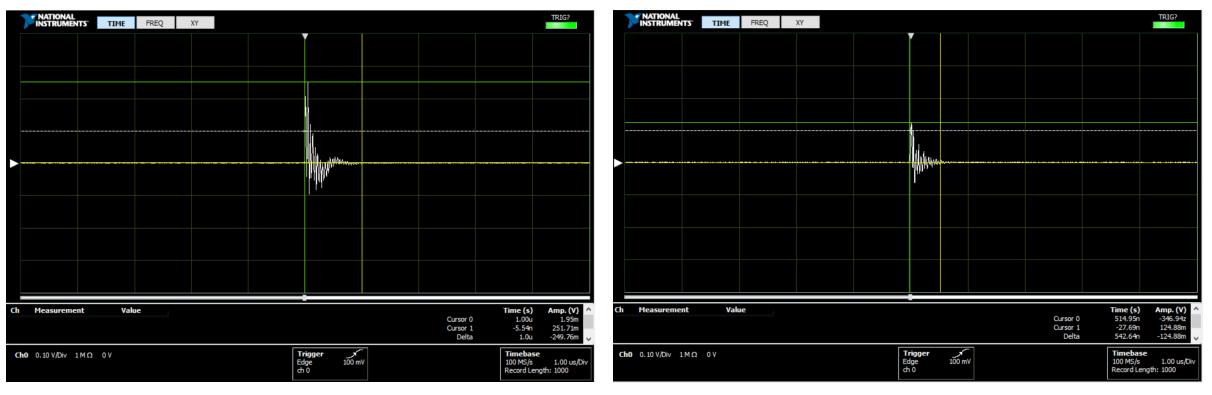
# Demo Set Up



Π

#### Without $100\Omega$ Protection

# With $100\Omega$ Protection



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





ni.com



Know the Strength & Limitations of Each Relay Type



**Avoid Hot Switching** 



Use Protective Resistance to Combat Inrush Current

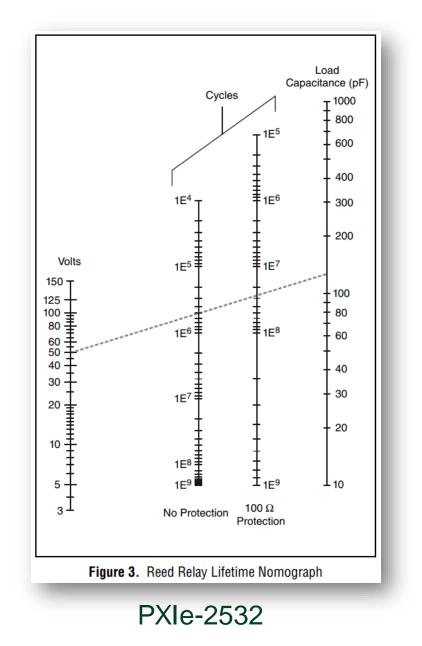


Use NI Software to Monitor Relay Health

#### Use NI Software to Monitor Relay Health

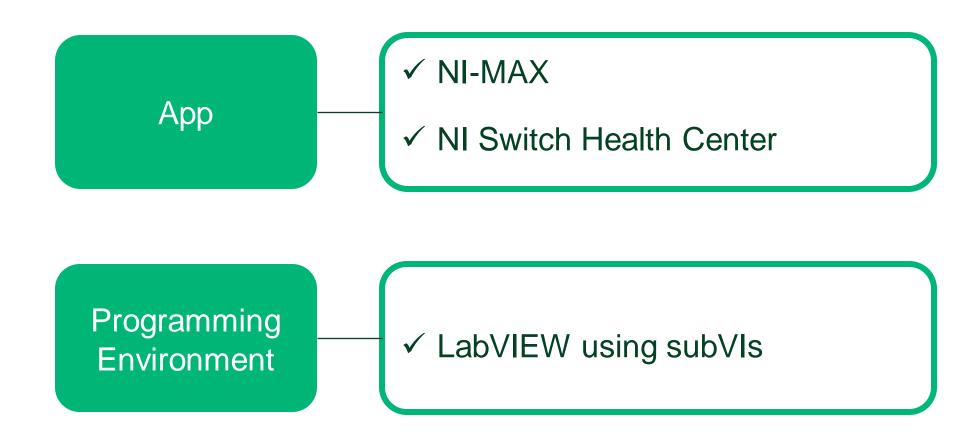
# Predicting Relay Life

- 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



Π

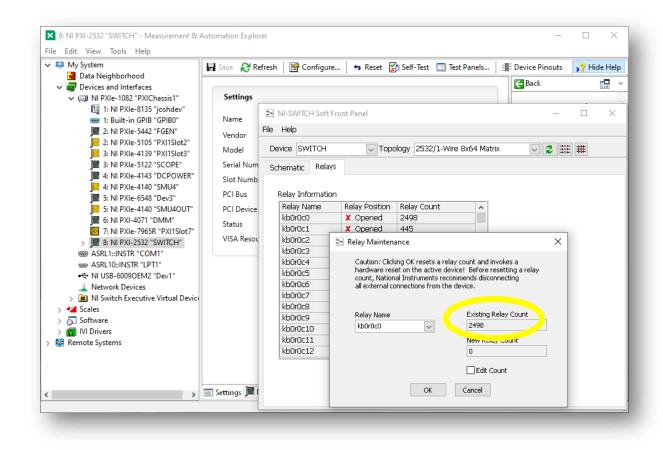
## NI Software for Relay Monitoring



#### Use NI Software to Monitor Relay Health

# 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

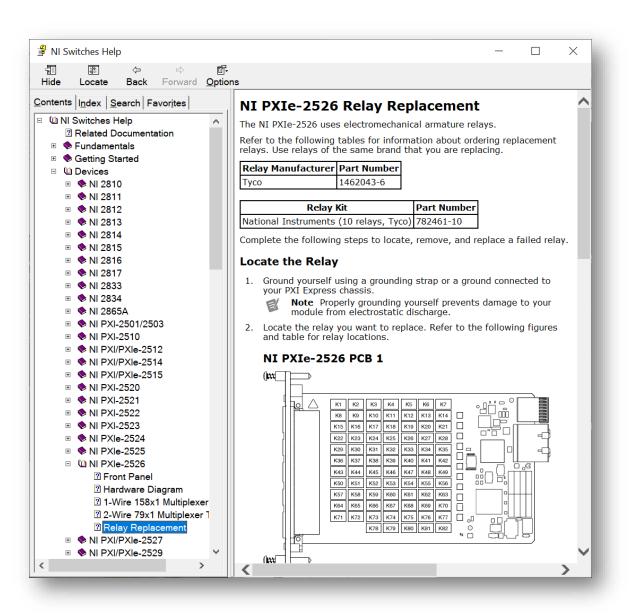


**N** 

#### Use NI Software to Monitor Relay Health

# 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 <u>https://www.ni.com/en/contact-us.html</u>
- For more information visit <u>How to</u> <u>Replace a Relay on Your Switch</u>
- Eliminate hassle with <u>system return</u> material authorization (RMA)



**N** 

## NI Switch Health Center

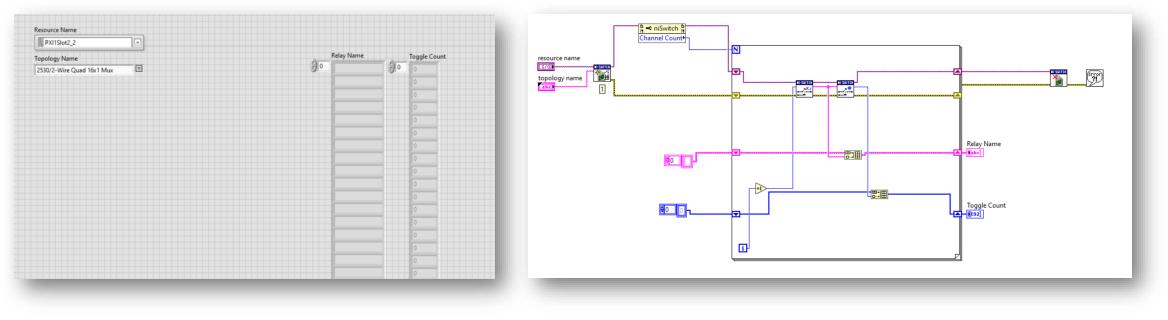
- Monitor relay health and failure modes through integrated relay test:
  - ✓ Basic functional test
  - ✓ Test to determine change in resistance
- HTML Report is generated along with a detailed diagram
- Shipped on all NI SwitchBlock modules and select PXI Switch Modules

odel: rial No.:	NI 281 0×0	1A												
	K1	K2	K3	K4	K5	KG	17	KS		Relay	SW Name	Condition	Count	
•	K9	K10	K11	K12	K13	K14	K15	K16		K41	kcard1r2c20	Pass	0	
	K18	K19	K20	K21	K22	K2.3	K24	K25		K42	kcard1r1c2	Pass	0	
	K26 K34	K27 K35	K28 K36	K29 K37	K30 K38	K31 K39	K32 K40	K33 K41		K43	kcard1r1c5	Pass	0	
	K42	K43	K44	K45	K46	K47	K48	K49	8.60	K44	kcard1r1c8	Pass	0	
1	K50	K51	K52	K53	K54	K55	K56	K57		K45	kcard1r1c11	Pass	0	=
	K59	<b>K</b> 60	K61	K62	K63	K64	K65	K66		K46	kcard1r1c14	Pass	0	
	K67 K75	K68 K76	K69 K77	K70 K78	K71 K79	K72 K80	K73 K81	K74 K82		K47	kcard1r1c17	Pass	0	
	K84	K85	K36	K/8 K87	K/9 K88	K80 K89	K90	K82 K91					-	
- <u>-</u>	K92	K93	K94	K95	K96	K97	K98	K99		K48	kcard1r2c19	Pass	0	
	K100	K101	K102	K103	K104	K105	K106	K107		K49	kcard1ab2	Stuck closed	0	
	K108	K109	K110	K111	K112	K113	K114	K115	Ac	K50	kcard1r2c0	Stuck open	0	
	K117 K125	K118 K126	K119 K127	K120 K128	K121 K129	K122 K130	K123 K131	K124	N114	K51	kcard1r2c3	Pass	0	
	K125 K132	K120	K127 K134	K128 K135	K129 K136	K130 K137	K131 K138	_ [] "	PARTICIAL DE	K52	kcard1r2c6	Pass	0	
	K139	K140	K141	K142	K143	K144	K145	NI 2811	10	K53	kcard1r2c9	Pass	0	
-	K146	K147	K148	K149	K150	K151	K152	1085 N		K54	kcard1r2c12	Pass	0	
ET .	K153	K154	K155	K156	K157	K158	K159			K55	kcard1r2c15	Pass	0	
	K160 K167	K161 K168	K162 K169	K163 K170	K164 K171	K165 K172	K166 K173	I¤∟ L		K56	kcard1r3c18	Pass	0	
	K174	K175	K176	K177	K178	K179	K180	₽IC Ē	68 8					-
Pas				K177	K178	K179	K180	]' <b>©'( €</b>	98 B	K57	kcard1ab3	Pass	0	-

# Use NI Software to Monitor Relay Health

**Front Panel** 

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



**Block Diagram** 

#### ni.com

# Demo

#### Get Relay Count

- NI MAX
- LabVIEW

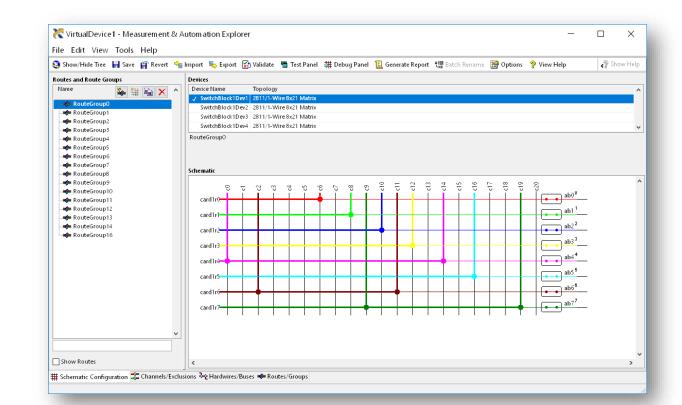
# NI Switch Executive

Management & Routing App Software

ni.com

# 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 <u>Here</u>

# 

#### 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 <u>this guide</u> 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



#### 10:15 AM Multichannel RF Data Recording 11:15 AM and Analysis

Meeting Room 19A

Aerospace & Defense •
 Technical Session

10:15 AM Optimizing Validation Processes: 11:15 AM Building Complex Test Systems with Distributed I/O

- Meeting Room 19B
- Aerospace & Defense •
  Technical Session

10:15 AM Panel: Continuous Integration (Cl/ 11:15 AM CD)—Don't Leave Home without It

- Meeting Room 12A
- Programming Essentials Technical Session

10:15 AM Using Python and TestStand to 11:15 AM Boost Your Test Development

Ballroom G

 Product & Technology • Technical Session

10:15 AM What Does Left Shifting Test 11:15 AM Mean in the NI Ecosystem?

Meeting Room 18A
 Transportation - Technical Session

#### **〈** Tue May 23

#### 🛨 Add to Schedule 🛛 🏥 iCal 🛛 👤 Check In

Optimizing Validation Processes: Building Complex Test Systems with Distributed I/O

#### Tue May 23 10:15 AM - 11:15 AM

Map Meeting Room 19B
 Aerospace & Defense • Technical Session

#### C Surveys

#### **Take Session Survey**

In this session, learn to improve efficiency and reduce non-recurring engineering costs in validation labs by connecting multiple distributed line-replaceable unit (LRU) test systems. Also learn how to abstract LRUs and construct complex test systems faster and more efficiently using existing distributed I/O and edge computation technology.

# Click "Take the Session Survey"

ni.com

