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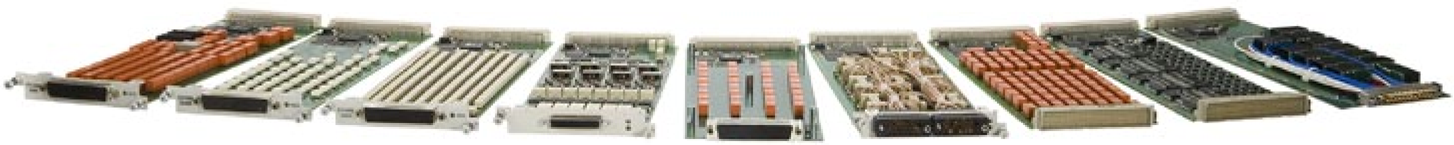


AUTOMATED SIGNAL SWITCHING

"A primer"

VTI Instruments

RELIABLE DATA FIRST TIME EVERY TIME

Overview

Routing electrical and even optical signals from one source to another requires an overall understanding of the application, signals being switched and finally an understanding of how to select a switching solution that helps maintain signal integrity at a reasonable cost. Some of the main issues to consider are:

- Types of relays
- Types of relay topologies
- Selecting appropriate switching configurations to minimize size and cost while maintaining signal integrity
- Communicating with the switching system to maximize overall system throughput
- Cabling and wiring to/from one source to another
- The ability to easily configure and expand the switching system for several applications

The intent of this switching primer is to provide our customers with a step-by-step guide to help configure a switching system for their application, without being tied to the constraints of typical switching systems on the market. Although the focus is for test and measurement, the same principles also apply for any automated switching task. Configuring a switching system is application-specific. Help in configuring an optimum solution to your application is available by contacting our applications department. (949 • 955 • 1894)

Types of Relays used in Test & Measurement

DRY REED RELAYS

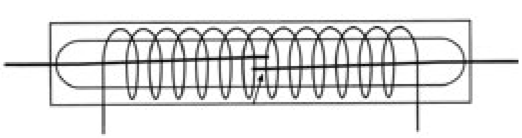
Contacts are made from ferromagnetic material (reeds). These contacts are encapsulated in glass. An energizing coil is wrapped around the glass and an EMF brings the two reeds together, closing the contacts.

Main Advantages

- Hermetically sealed, reduces oxidation build-up
- High Isolation (about 1014 ohms)

Main Disadvantages

- EMFs affect adjacent relays – requires shielding of relays in high-density applications.
- Inconsistent contact resistances



MERCURY WETTED REED RELAYS

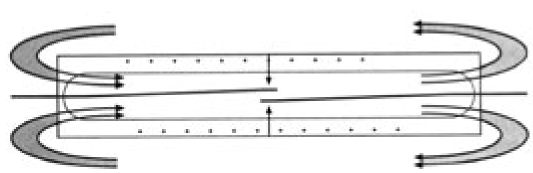
Similar in construction and operation to dry reed relays except that a small amount of mercury is added inside the glass tube to provide more consistent contact resistances.

Main Advantages

- More power handling than a dry reed
- Consistent and low contact resistances

Main Disadvantages

- Position sensitive
- Mercury is a sensitive material
- Expensive relays



ELECTROMECHANICAL RELAYS

An electromechanical relay uses an armature to bring two electrical contacts (i.e., gold over silver) together. This method provides consistent contact resistances. There are many different types of armature controlled electro-mechanical relays such as contactor for high power, bifurcated contacts for better general purpose switching, coaxial switches for microwave applications.

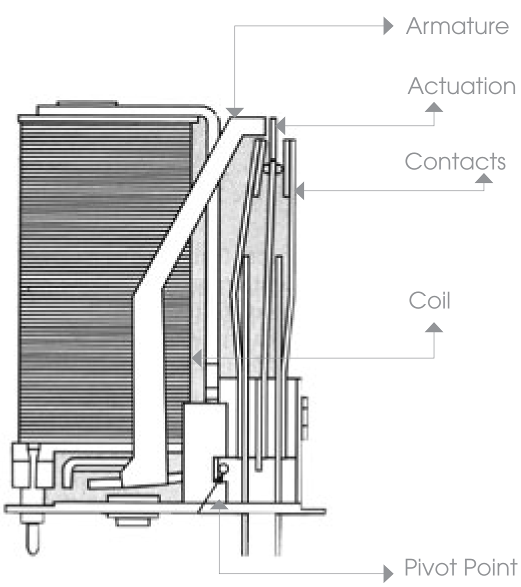
Main Advantages

- Ideal for general purpose switching
- Good consistent contact resistance
- Many variations available
- Allows switching of high power
- Allows for RF/microwave switching

Main Disadvantages

- Not ideal for low thermal, very low voltage switching

ELECTROMECHANICAL RELAY



SOLID STATE RELAYS

In a solid state relay an opto isolator is typically used to control FETs, SCRs or triac types of solid state devices.

Main Advantages

- Offers long mean time between failures (MTBFs)
- Very fast switching times (typically in microseconds)
- Allows for high density signal switching

Main Disadvantages

- Degrades signal integrity
- Typically not bi-directional
- Not useful for high voltage swings
- Typically application specific

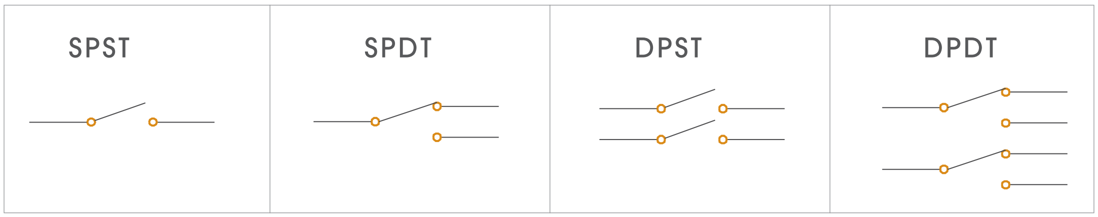
Switch Card Types

The types of relays used determines the application of the switch card. The types of switch cards can be divided into the following categories:

- POWER SWITCHING CARDS that use highpower electro-mechanical relays that can handle high voltage signal switching or those above 2 A - the EX1200-2000 series
- GENERAL PURPOSE SWITCHING CARDS designed for low-level and low-frequency applications (less than 2 Amps, and typically less than 40 MHz) - the EX1200-3000, EX1200-4000, EX1200-5000 series.
- RF SWITCHING CARDS that are controlled impedance (typically 50 ohms or 75 ohms. These modules are typically designed to handle RF signals under 1 GHz - the EX1200-6000 series.
- MICROWAVE SWITCHING SOLUTIONS designed for switching frequencies between 1 GHz and up to 40GHz - the EX7000 or EX1200-7000 series.

Relay Topologies

Each switch card provided by a switching system manufacturer will typically consist of relays that have one of the following topologies:

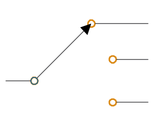


An SPST relay simply opens or closes a signal path. This relay is typically normally open when power is removed, and the relay needs to be energized in order to close the signal path. A normally open relay is sometimes also referred to as a Form A relay. A normally closed SPST (i.e., closed when no power is applied) is referred to as a Form B relay. A DPST relay is in essence two SPST relays, but energized from the same coil. An SPDT relay has one normally open and one normally closed path, and a DPDT relay is in essence two SPDT relays which are energized from the same coil. An SPDT relay is also referred to as a Form C relay.

Switching Configurations

VTI INSTRUMENTS HAS YEARS OF EXPERIENCE IN HELPING CONFIGURE SWITCHING SYSTEMS, OPTIMIZING PERFORMANCE AND COST.

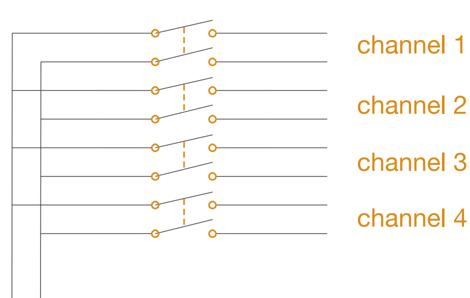
A typical automated switching system consists of several switch cards/configurations combined together to achieve the final result. The flexibility, modularity and mixture of different switch cards/configurations from a manufacturer play an important role in selecting the correct switching system for a particular application. Care needs to be applied to how these building blocks are used and combined since a bad configuration can affect the size, cost and signal integrity of the system. The main types of switch configurations are tree, multiplexer, and matrix.



TREE

MULTIPLEXER AND TREE SCANNERS

The tree only allows one channel to be selected at a time, whereas the multiplexer can allow all channels to be selected simultaneously. The multiplexer configuration, however, has limited bandwidths due to unterminated stubs hanging onto the selected channel. The tree configuration is typically used in RF applications, whereas the multiplexer is used for general purpose switching.

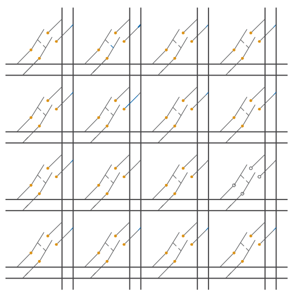


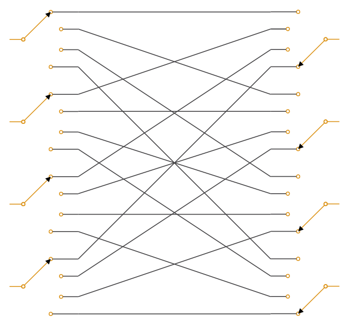
MULTIPLEXER

MATRIX

The matrix is the most flexible type of switch topology, since any input can be connected to any output. However, it is also the most expensive, and affects overall signal integrity more than other configurations.

A low frequency matrix has large unterminated stubs, whereas a matrix designed for RF applications has no unterminated stub effects. Although the matrix is the easiest topology to specify for a complete switching solution, it is best to break the switch solution into smaller building blocks that consist of each of the switching topologies described. This will considerably improve the size, cost and integrity of the overall solution.





Programming

Traditional software models for instrumentation have historically been applied to switching products and ignore the fact that the system switch is a conduit between test instrument I/O and the device under test. Test sequences often require multiple relays on multiple modules to be closed to establish paths between stimuli and measurement channels.

The traditional software model for switching, such as SCPI or plug&play, targets a relay or group of relays on a single module with no knowledge of how these relays connect to each other or to other relays on other modules to form a path. This puts a significant burden on the application developer who must have an intimate understanding of how individual relays are wired together through the mass interconnect and test adapter. Measurement paths are made by making a series of discrete relay calls, and path states must be maintained within the software application creating a potentially complex management structure when multiple tests using multiple combinations of relay states are required.

When the LXI consortium mandated IVI as the required application programmer's interface, developers were presented software drivers that address signal switching as paths that connect input channels to output channels and removed the concept of controlling individual relay coils.

A more intuitive approach implemented in the VTI switch API allows for the creation of switch subsystems that span multiple modules in which a single session handle is created to communicate to multiple switch modules that would otherwise be controlled through dedicated sessions. Furthermore, logical channel names can be easily defined to represent the overall system architecture.

VTI's system level approach to switch drivers provides a common communication interface spanning modular switch cards and switch platforms alike. One switch driver allows for concurrent control multiple switching hardware platforms including the modular EX1200 and custom microwave EX7000 for seamless integration of LF and HF switching, regardless of requirements. By creating a single entry-point into a switch subsystem, true end-to-end path level switching can be achieved with minimal calls creating a more elegant development environment with code that is more efficient to debug and maintain.

Cabling/Wiring to/from the Switching System

A switching system is merely an extension of the cabling/wiring from one point to the next. The choice of cable used is as important in the overall system integrity as the method of cabling/wiring to the switching system. For example, if twisted pair shielded cabling is to be used to wire between the unit-under-test (UUT) and an instrument via the switching system, the switching card employed needs to be an extension of the twisted shielded pair cable. In such a case a switch module with a balanced line pair (2 lines/channel) should be used. This same switch module should have isolated shielding that would be an extension of the shield on the twisted pair cable (eg. EX1200-3001).

A universal switching system also needs to provide the user with the capability to wire up to the switching system in a variety of methods, allowing the user to determine the simplest approach for cabling/wiring the switch to the rest of the system. If the switching system is to be used in an application where the switch cards will be wired and re-wired several times (i.e. in R&D, engineering or scientific applications), the user should consider wiring to/from the switch card using a screw-down terminal block approach. If the switching system is to be used in an ATE application and wired once for a long period of time, crimp type pins and connectors are recommended.

The connector kits available on the EX1200 family give the user several options for cabling and wiring to the switching system.

Specifications to Consider and What They Mean

The following is a brief definition of specifications found for switching cards. The specifications defined by a manufacturer are normally only for a switch card and not the complete switch system, since this would consist of several switch cards combined

- Maximum Switching Voltage is the maximum open circuit voltage which can safely be switched by the contacts. AC and DC voltage maximums will differ in most cases.

- Maximum Switching Current is the maximum current which can safely be switched by the contacts. AC and DC current maximums may differ.

- Maximum Switching Power is the upper limit of power which can be switched by the contacts. Care should be taken not to exceed this value.

Specifications to Consider and What They Mean

- MAXIMUM CARRYING CURRENT is the maximum current that can safely pass after closing or prior to opening the contacts.
- Path Resistance is the resistance of the worst-case signal path and includes relay contact resistance, trace resistance, and connector resistance.
- Breakdown Voltage is the maximum voltage that can be tolerated by the relay without damage for a specified period of time.
- Relay Settling Time is the time it takes the relay to close or open and settle from all bounce.
- Mechanical Life is the minimum number of times the relay can be operated under normal conditions with no load on the contacts.
- Electrical Life is the minimum number of times the relay can be operated under nominal conditions with a specific load being switched by the contacts.
- Isolation. High frequency signals leak through the stray capacitance across contacts. This is called isolation and is specified in dB to express the magnitude of the leak signal. The larger the dB the better the isolation. Isolation will typically be expressed from input to output of the worst case channel, with the relay open. The isolation specification is important to consider since it determines the amount of noise that is induced to the output of a channel from the input of that channel when the channel is open.
- Crosstalk is used to express the stray capacitance between adjacent channels on a switch card and is specified in dB. The larger the dB, the better. The crosstalk specification is important to consider since it determines the amount of noise that is induced to the signal switched from an adjacent channel.
- Insertion Loss. At high frequencies signal disturbance occurs from self-induction, path resistance, dielectric loss, as well as from reflection due to impedance mismatch in circuits. This type of loss is called insertion loss and is expressed in dB, and refers to the magnitude of the loss of the input signal on the output. The lower the magnitude of the insertion loss, the better the signal path.
- VSWR (Voltage Standing Wave Ratio). At high frequencies resonance is generated from the interference between the input signal and the reflected signal. VSWR is specified as the ratio of the maximum value to the minimum value of the waveform. The lower the VSWR, the less the reflected wave.

Conclusion

When selecting a switching system, it is strongly recommended that the user understand the application and test philosophy before configuring the system in order to optimize the solution. However, since test stations today are sometimes designed concurrently with the product to be tested, it is not always easy to determine the exact configuration. Selecting a switching system, therefore, that is modular and easily expandable should be key, putting particular focus on the selection of the correct building blocks.