Glossary of Terms

This Glossary of Terms was compiled from NARM Standard RS-436, MIL STD 202, and MIL STD R5757. They have been modified to pertain to Coto Reed Relays. The use of bold text within a definition indicates that a term is cross-referenced elsewhere in the glossary.

ACTUATE TIME: The time measured from coil energization to the stable contact closure (From-A) or stable contact opening (Form-B) of the contact under test. (See also: OPERATE TIME)

AMPERE-TURNS (AT): The product of the number of turns in an electromagnetic coil winding and the current in amperes passing through the winding.

BANDWIDTH: The frequency at which the RF power insertion loss of a relay = 50%, or 3dB

BIAS, MAGNETIC: A steady magnetic field applied to the magnetic circuit of a switch to aid or impede its operation in relation to the coil's magnetic field.

BOUNCE, CONTACT: Intermittent and undesired opening of closed contacts or closing of opened contacts usually occurring during operate or release transition.

BREAKDOWN VOLTAGE: The breakdown voltage is the maximum voltage that can be applied across the open switch contacts before electrical breakdown occurs. It is primarily dependent on the gap between the reed switch contacts and the type of gas fill used. High AT switches within a given switch family have larger gaps and higher breakdown voltage. It is also affected by the shape of the contacts, since pitting or whiskering of the contact surfaces can develop regions of high electric field gradient that promote electron emission and avalanche breakdown. Since such pitting can be asymmetric, breakdown voltage tests should be performed with forward and reverse polarity. When testing bare switches, ambient light can affect the point of avalanche and should be controlled or eliminated for consistent testing. Breakdown voltage measurements can be used to detect reed switch capsule damage. See **Paschen Test.**

CARRY CURRENT: The maximum continuous current that can be carried by a closed relay without exceeding its rating.

COAXIAL SHIELD: Copper alloy material that is terminated to two pins within the relay on each side of the switch. Used to simulate the outer conductor of a coaxial cable for high frequency transmission.

COIL: An assembly consisting of one or more turns of wire around a common form. In reed relays, current applied to this winding generates a magnetic field which operated the reed switch.

COIL AT: The coil ampere.turns (AT) is the product of the current flowing through the coil (and therefore directly related to coil power), and the number of turns. The coil AT exceeds the switch AT by an appropriate design margin, to ensure reliable switch closure and adequate switch **overdrive**. Sometimes abbreviated as NI, where N = number of turns and I = coil current.

COIL POWER: The product, in watts, of the relay's nominal voltage and current drawn at that voltage. Most Coto relays have coil powers in the 20 –100 mW range.

COLD SWITCHING: A circuit design that ensures the relay contacts are fully closed before the switched load is applied. Must take into account **bounce, operate** and **release time.** If technically feasible, cold switching is the best method for maximizing contact life at higher loads.

CONTACT RESISTANCE, DYNAMIC: Variation in contact resistance during the period in which contacts are in motion after closing.

CONTACT RESISTANCE, STATIC: The DC resistance of closed contacts as measured at their associated contact terminals. Measurement is made after stable contact closure is achieved.

CONTACT: The ferromagnetic blades of a reed switch usually plated with Rhodium, Ruthenium or Tungsten material.

CROSSTALK (CROSSTALK COUPLING) When applied to multichannel relays, the ratio, expressed in dB, of the signal power being emitted from a relay output contact to the power being applied to an

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adjacent input channel, at a specified frequency.

DIELECTRIC STRENGTH: When applied to the dielectric strength across open switch contacts, this term is synonymous with **breakdown voltage**.

DUTY CYCLE: A ratio of energized to de-energized time.

ELECTROSTATIC SHIELD: Copper alloy material terminated to one pin within the reed relay. Used to minimize coupling and electrostatic noise between the coil and contacts.

FORM-A: Contact configuration which has one Single Pole-Single Throw normally open (SPST n.o.) contact.

FORM-B: Contact configuration which has one Single Pole-Single Throw normally closed (SPST n.c.) contact.

FORM-C: Contact configuration which has one Single Pole-Double Throw (SPDT) contact. (One common point connected to one normally open and one normally closed contact.) Sometimes referred to as a Transfer Contact.

HARD FAILURE: Permanent failure of the contact being tested.

HERMETIC SEAL: An enclosure that is sealed by fusion to ensure a low rate of gas leakage. In a reed switch, a glass-to-metal seal is employed.

HOT SWITCHING: A circuit design that applies the switched load to the switch contacts at the time of opening and closure.

HYSTERESIS: When applied to reed relays, the difference between the electrical power required to initially close the relay and the power required to just maintain it in a closed state. (Usually expressed in terms of the relay's **pull-in voltage** and **drop-out voltage**) Some degree of hysteresis is desirable to prevent chatter, and is also an indicator of adequate switch contact force.

IMPEDANCE (Z): The combined DC resistance and AC reactance of a relay, at a specified frequency.

$$\text{Impedance}(Z) = R + jX$$

Where R = DC resistance and
$X = (2\pi fL - 1/(2\pi fC))$, f = frequency

Coto Technology's RF relays are designed to have a broadband impedance as close as possible to 50 ohms.

*Technical Note: Because of the small residual capacitance across the open contacts of a reed relay, the impedance decreases at higher frequencies, resulting in lower **isolation** (q.v.) at higher frequencies. Conversely, increasing inductive reactance at higher frequencies causes the impedance of a closed relay to rise, increasing the **insertion loss** (q.v.) at higher frequencies.*

IMPEDANCE DISCONTINUITY: A deviation from the nominal RF impedance of 50 ohms at a point inside the relay. Impedance discontinuities cause signal absorption and reflectance problems resulting in higher signal losses. They are minimized by designing the relay to have ideal **transmission line** characteristics.

INSERTION LOSS: The ratio of the power delivered from an AC source to a load via a relay with closed contacts, compared to the power delivered directly, at a specified frequency.
If V_i = incident voltage, and V_t = transmitted voltage, then insertion loss can be expressed in decibel format as: Insertion loss (dB) = $-20 \log10(V_t/V_i)$
Note: Insertion Loss, Isolation and Return Loss (q.v) are often expressed with the sign reversed; for example, the frequency at which 50% power loss occurs maybe quoted as the "-3dB" point. Since relays are passive and always produce net losses, this does not normally cause confusion.

INRUSH CURRENT: Generally, the current waveform immediately after a load is connected to a source. Inrush current can form a surge flowing through a relay switching a low impedance source load - typically a highly reactive circuit, or one with a non-linear load characteristic such as a tungsten lamp load. Such abusive load surges are sometimes encountered when reed relays are inadvertently connected to test loads containing undischarged capacitors, or to long transmission lines with appreciable amounts of stored capacitive energy. Excessive inrush currents can cause switch contact welding or premature contact failure.

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Coto Technology routinely tests relays with inrush current loads and can offer technical advice on this issue.

INSULATION RESISTANCE: The DC resistance between two specified test points.

ISOLATION: The ratio of the power delivered from a source to a load via a relay with open contacts, compared to the power delivered directly, at a specified frequency. If V_i = incident voltage, and V_t = transmitted voltage, then isolation can be expressed in decibel format as: Isolation (dB) = $-20 \log10(V_t/V_i)$

LATCHING RELAY: A bi-stable relay, typically with two coils, which requires a voltage pulse to change state. When pulse is removed from the coil, the relay stays in the state in which it was last set.

LIFE EXPECTANCY: The average number of cycles that a relay will achieve under specified load conditions before the contacts fail due to sticking, missing or excessive contact resistance. Expressed as Mean Cycles Before failure (MCBF). See *Reliability Testing* section for a detailed discussion on how coto Technology uses reliability testing and Weibull failure analysis to predict relay life. Life expectancy depends on many factors, including type of switch and contact coating used, the switch AT, % overdrive, steady state and inrush current and load voltage.

LOW THERMAL EMF RELAY: A relay designed specifically for switching low voltage level signals such as thermocouples. These types of relays use a thermally compensating ceramic chip to minimize the thermal offset voltage generated by the relay.

MAGNETIC INTERACTION: The tendency of a relay to be influenced by the magnetic field from an adjacent, energized relay. This influence can result in depression or elevation of the pull-in and drop out voltage of the affected relay, possibly causing them to fall outside their specification. Magnetic interaction can be minimized by alternating the polarity of adjacent relay coils, by magnetic shielding, or by placing two relays at right angles to each other. See *Magnetic Interaction* Section for more details.

MAGNETIC SHIELD: A ferromagnetic material used to minimize magnetic coupling between the relay and external magnetic fields.

MERCURY WETTED CONTACT: A form of reed switch in which the reeds and contacts are wetted by a film of Mercury obtained by a capillary action from a Mercury pool encapsulated within the reed switch. The switch in this type of relay must be mounted vertically to ensure proper operation.

MISSING (CONTACTS): A reed switch failure mechanism, whereby a open contact fails to close by a specified time after relay energization.

NOMINAL VOLTAGE: The normal operating voltage of the relay.

OPERATE TIME: The time value measured from the energization of the coil to the first contact closure (Form-A) or the first contact open (Form-B). [See also: ACTUATE TIME.]

OPERATE VOLTAGE: The coil voltage measured at which a contact changes state from its un-energized state.

OVERDRIVE : The fraction or percentage by which the voltage applied to the coil of relay exceeds its pull-in voltage. An overdrive of at least 25% ensures adequate closed contact force, and well-controlled bounce times, which result in optimum contact life. Coto Technology's relays are designed for a minimum of 36% overdrive. (For example, a relay with a nominal coil voltage of 5V will pull-in at no greater than 3.75V) *Technical Note: The circuit designer intending to use reed relays should ensure that, if possible, the overdrive applied to the relay does not drop below 25% under field conditions. Issues such as power supply droop and voltage drops across relay drivers can cause a nominally acceptable power supply voltage to drop to a level where adequate overdrive is not maintained.*

PASCHEN TEST: Coto Technology uses this test to detect reed switch capsule damage. In the case of a cracked switch capsule or damaged switch seal, atmospheric oxygen can leak into the switch and eventually oxidize the switch contacts, causing increased contact resistance and possible contact

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failure. The presence of oxygen causes the breakdown avalanche voltage to increase, due the ability of the electronegative oxygen to scavenge free electrons. The Paschen test observes the variation and magnitude of the breakdown voltage as a switch is opened, and the recorded waveform is use to diagnose the presence of oxygen.

RELEASE TIME: The time value measured from coil de-energization to the time of the contact opening (Form-A) or first contact closure (Form-B).

RELEASE VOLTAGE: The coil voltage measured at which the contact returns to its de-energized state.

RETURN LOSS: The ratio of the power reflected from a relay to that incident on the relay, at a specified frequency. If Vi = incident voltage, and Vr = reflected voltage, then return loss can be expressed in decibel format as:

$$\text{Isolation (dB)} = -20 \log10(V_r/V_i)$$

Return loss plots shown in this catalog were measures with the relay closed, and terminated with a 50 ohm impedance

SIGNAL RISE TIME: The rise time of a relay is the time required for its output signal to rise from 10% to 90% of its final value, when the input is changed abruptly by a step function signal. Can be estimated from the f_{-3dB} **bandwidth**, using the expression

$$T_r = 0.35/f_{-3dB}$$

where T_r = 10%-90% rise time (sec) and
f_{-3dB} = bandwidth (Hz)

*Note: See Section on **RF Parameter Measurement** for details on how Coto measures rise time.*

SHIELD, COAXIAL: A conductive metallic sheath surrounding the relay's reed switch, appropriately connected to external pins by multiple internal connections, and designed to preserve a 50 ohm impedance environment within the relay. Used in relays designed for high frequency service, to minimize **impedance discontinuities**.

SHIELD, ELECTROSTATIC: A conductive metallic sheath surrounding the relay's reed switch, connected to at least one external relay pin, and designed to minimize capacitive coupling between the switch and other relay components, thus reducing high frequency noise pickup. Similar to a **coaxial shield**, but not necessarily designed to maintain a 50 ohm RF impedance environment.

SHIELD, MAGNETIC: An optional plate or shell constructed of magnetically permeable material such as nickel-iron or mu-metal, fitted external to the relay's coil. Its function is to reduce the effects of **magnetic interaction** between adjacent relays, and to improve the efficiency of the relay coil. A magnetic shell also reduces the influence of external magnetic fields, which is useful in security applications. Magnetic shields can be fitted externally, or may be buried inside the relay housing.

SOFT FAILURE: Intermittent, self-recovering failure of a contact.

STICKING (CONTACTS): A reed switch failure mechanism, whereby a closed contact fails to open by a specified time after relay de-energization. Can be subclassified as hard or soft failures.

SWITCH AT: The ampere turns required to close a reed switch (pull-in AT) or just to maintain it closed (drop-out AT). Must be specified with a specific type and design of coil. Switch AT depends on the length of the switch leads, and increases when the reed switch leads are cropped. This must be taken into account when specifying a switch for a particular application.

SWITCHING CURRENT: The maximum current that can be **hot-switched** by a relay at a specified voltage without exceeding its rating.

SWITCHING VOLTAGE: The maximum voltage that can be **hot-switched** by a relay at a specified current without exceeding its rating. Generally lower than **breakdown voltage**, since it has to allow for any possible arcing at the time of contact breaking.

TIME DOMAIN REFLECTOMETRY (TDR): An alternative to **return loss** for measuring the degree of impedance mismatch of a relay at a specific frequency. TDR data can be computed from return loss data using Fourier Transform techniques, or measured directly with specialized TDR equipment.

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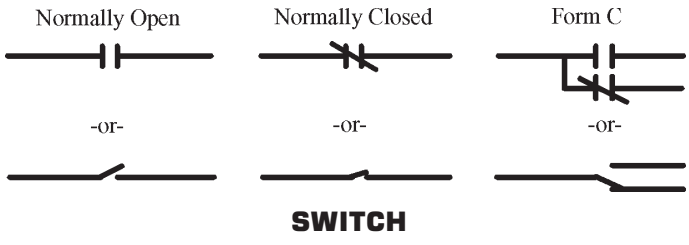
TRANSMISSION LINE: In relay terms: an interruptable waveguide consisting of two or more conductors, designed to have a well-controlled characteristic RF impedance and to efficiently transmit RF power from source to load with minimum losses, or to block RF energy with minimum leakage. Structures useful within RF relays include microstrips, coplanar waveguides and coaxial transmission line elements.

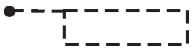
VSWR (VOLTAGE STANDING WAVE RATIO): The ratio of the maximum RF voltage in a relay to the minimum voltage at a specified frequency, and calculated from $(1+\rho)/(1-\rho)$, where ρ= the voltage reflected back from a closed relay terminated at its output with a standard reference impedance, normally 50 ohms. A VSWR of 1 indicates a perfect impedance match and zero reflection losses at a specific frequency. VSWR is normally computed from S_{11} parameter data via the reflectance coefficient.

SYMBOLS USED IN REED RELAY SCHEMATICS



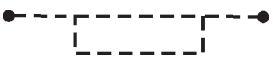
SWITCH

COIL



ELECTROSTATIC SHIELD

MAGNET



COAXIAL SHIELD

CONNECTED PIN

UNCONNECTED PIN

AGENCY APPROVALS

Coto's Reed Relays and Switches are designed with the highest level of quality and reliability in mind. In addition, each model is 100% tested to ensure compliance with specified limits. Because of our commitment to quality and reliability, many models have been recognized by international safety organizations such as Underwriters Laboratories (UL) and Canadian Standards Association (CSA). Reed Relays are recognized in UL file # E-67117 and CSA File # LR-28537. Switches are recognized on UL File # E-125629. Copies of Coto UL Recognized "Yellow Cards" are available on request.

In addition to the approvals mentioned Coto's Professional grade reed switches have been tested and meet the requirements of the following:

- IEC Publication 68-2-27 Shock
- IEC Publication 68-2-6 Vibration
- IEC Publication 68-2-21 Mechanical Strength
- IEC Publication 68-2-20 Solderability

For other approval or compliance information, please contact the factory.