

Measuring Reed Switch Sensitivity and Contact Resistance

The purpose of this application note is to document the preferred method of reading the sensitivity and contact resistance of Hamlin reed switches.

Terminology:

- Contact resistance or CR is the resistance of the reed switch when the contacts are closed. It is measured in the units of Ohm or mOhm (0.1 Ohm = 100 mOhm).
- Pull-In or PI is the magnetization level at which the Form A SPST reed switch closes. Other terms sometimes used are Pick-Up (PU) or Operate Point. Pull-In is measured in the units of AT (Ampere-turn). This is also sometimes written as At or NI, the latter representing number of turns (N) and current (I).
- Drop-Out or DO is the magnetization level at which the Form A SPST reed switch opens. It is sometimes referred to as the Release Point. Like Pull-In, this is measured in units of AT.

Standards related to reed switches:

- ANSI/EIA/NARM RS-421 Standard for Dry Reed Switches
- MIL-S-55433 Military Specification - General Specification for Switch Capsules, Dry Reed Type
- EIA RS-407-A Testing Procedures for Relays for Electrical and Electronic Equipment
- ANSI C83.16-1971 Definitions and Terminology for Relays for Electronic Equipment
- IEC 255 Electrical Relays

Test Coils

Reed switches are activated by magnetic fields. The magnetic field can be produced by a magnet or a coil. For reasons of history and accuracy, reed switches are tested by placing the reed switch inside a standard test coil. If a different coil is used, the readings may be different. The more the coil length or coil diameter differs, the more the readings are likely to differ. It is common practice to correlate one coil with another by measuring a set of reed switches with a range of sensitivities in both coils.

Sources of Error

There are several sources of variation or error that are important to consider in obtaining accurate, stable Pull-In and Drop-Out readings.

1. Since the reed switch responds to a magnetic field and a coil's magnetic field is directly proportional to the current through it, the coil's current needs to be carefully controlled or measured. Measuring the coil's voltage does not work well because of temperature effects. Copper has a temperature coefficient of resistivity of about $-0.4\%/^{\circ}\text{C}$, so ambient temperature or coil self-heating can easily affect measurements made using the coil's voltage.
2. Position of the reed switch inside the coil should be controlled. It is standard practice to center the reed switch contact gap in the center of the coil. If the center of the contact cannot be determined visually or by measurement, the reed switch can be centered by measuring and repositioning until the lowest Pull-In is achieved.
3. External magnetic fields need to be considered. The earth's magnetic field can cause reading errors of up to about 1 AT. Static magnetic fields can be compensated for using techniques described below. Dynamic magnetic fields can be produced by nearby fans, motors, or moving magnets and should be avoided.
4. Ferrous material near a test coil can cause errors by altering the magnetic field. Possible ferrous items include screws, brackets, connectors, and tabletops if they are near enough.

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5. Large stresses on the reed switch glass or leads can affect the sensitivity readings of the switch by slightly changing the reed switch contact gap.
6. There is a small (0.5-2 AT) amount of magnetic memory associated with the wire in the reed switch. The previous magnetic memory of the wire can be erased by degaussing or by saturating. Saturating is the standard method because it is much simpler.
7. When measuring CR, use of a 4-wire (Kelvin) connection is greatly preferred in order to minimize the effects of the test connections to the reed switch. The Hamlin standard for contact spacing is 1.0 inch (25.4 mm). The nickel-iron reed switch wire has a significant resistance. Depending on the wire diameter, reed switch lead wires have a resistance of about 30-60 mOhm/inch (1.2-2.4 mOhm/mm). Therefore a test contact spacing error of 0.1inch (2.5 mm) can effect contact resistance by 3-6 mOhm.

Compensation for External Fields

There are several techniques to compensate for external unchanging magnetic fields such as that generated by the earth. To determine if an external magnetic field is influencing the readings, simply reverse the polarity of the coil by swapping its connections. If the readings do not significantly change, then there is not significant external field influence. If there is a significant change, there are several techniques to compensate for the external field.

1. Rotate the coil's axis and retest until there is no longer a significant change in readings between normal and reversed coil polarities. This places the coil and reed switch axis perpendicular to the external magnetic field, thereby preventing interference.
2. Add an offset current to the coil to compensate for the external field.
3. Add or subtract an appropriate amount to the measured readings.
4. Always perform the test with both coil polarities and average the results.

Test Procedure

The following test sequence is listed in chronological order and applies to SPST (Form A) reed switches.

1. Apply a relatively large pulse to the coil to saturate the reed switch wire and remove any magnetic memory in it. An appropriate level for most reed switches is 100 AT. The minimum pulse width is that which allows the rise time of the current to reach a suitably high level. The rise time will be limited due to the inductance of the coil with the reed switch acting as a ferrous core. A saturation pulse width of 10 ms is suitable for standard small coils.
2. After applying the current pulse, wait a small time for the current to fall to zero and the reed switch to open. For standard small coils, 10 ms is adequate.
3. Linearly increase (ramp) the coil current until the reed switch closes. When the reed switch closes, measure the current through the coil and multiply by the coil's number of turns to calculate the Pull-In of the switch in ampere-turns (AT). The ramp rate must be slow enough that the reed switch has time to react. Also, coil inductance can cause the current to lag behind the applied voltage and result in offset errors. Hamlin's standard for ramp rate is 100 AT/s although slower or somewhat faster can also work. A manual ramp of a power supply, preferably in current drive mode, can be done, but accuracy will be limited by the precision at which an operator reacts to the contact closure.
4. Apply an additional drive level to the coil to measure the contact resistance. The standard value that Hamlin uses is 10 AT. Allow the coil drive and switch to settle for a small amount of time, such as 10 ms, after applying this additional coil drive. Then measure the contact resistance using a 4-wire Kelvin connection. Hamlin uses contact spacing of one inch (25,4 mm) as a standard.
5. Linearly decrease (ramp) the coil current as in step 3 until the reed switch opens. As in step 3, measure the coil current and multiply by the number of turns to determine the Drop-Out of the switch. Then set the coil drive to zero.