

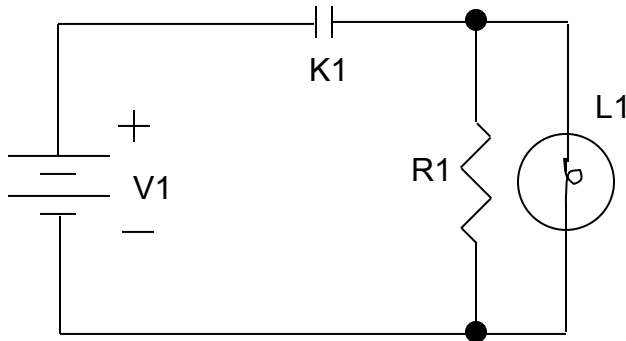
Verification and Diagnosis of Suspected Relay Failures
(Field, Production Line, Repair Area, Quality Assurance or Receiving Inspection)

Generic Notes:

- **New relays** (right out of the package) may be tested for functionality at “minimum specified contact load” or above.
- **Used relays** (that have been installed or have switched any load current) must be tested for functionality at much higher voltages and currents - typically about 12V, 100 mA (or 500mA). Consult Quality or Product Engineering for advice.
- **New relays** (right out of the package) must pass the contact resistance test at the load voltage and current specified in the datasheet for that contact resistance.
- **Used relays** (that have been installed or have switched any load current) **cannot** be reliably tested for contact resistance after installation or use due to the pitting that results from normal switching and the arc residue that accumulates on the surface of the contacts. A functionality test only can be performed per above.
- **Relays and Contactors with large contacts** require higher levels for functional testing and typically do not have “new” contact resistance specified. Consult Product Engineering for advice.

In-circuit relay verification - If relay fails to close (or open) the contacts, etc.:

- Verify contact performance (do they close(NO) or open(NC))
 - Monitor contacts with at least 6Vdc and 100ma (preferably use 12 Vdc and 500ma on all except “signal” level relays).
 - Do not monitor contacts using an ohm-meter or digital logic levels (digital logic levels can be used in automated testers to screen for good relays and proper control operation, but **a contact failure under logic level conditions may not indicate a problem** in the relay or control being tested (i.e. false errors) **so a backup means of screening at greater than minimum load rating must also be provided**).



Typical contact verification circuit.

K1 = Relay contact tested.
V1 = Minimum rated voltage.
R1 = Select R to set minimum rated current (include lamp) thru K1 contact.
L1 = Indicator lamp (rated @ V1).

- Verify coil drive circuit
 - Measure voltage applied to coil terminals of the relay
 - Is it at or above minimum voltage?
 - If yes, can you hear (or see) armature move?
 - Does it buzz?
 - DC coil types:
 - If buzzing, is applied coil voltage smoothly filtered DC?
 - If yes, carefully remove relay from PCB and evaluate using the “off PCB” methods below.
 - AC coil types:
 - If buzzing, is applied coil voltage normal 50 or 60 hZ line power at nominal rated value?
 - If yes, carefully remove relay from PCB and evaluate using the “off PCB” methods below.
 - If all above OK, go to “off PCB” methods below.

Out of Circuit (Off PCB) relay verification:

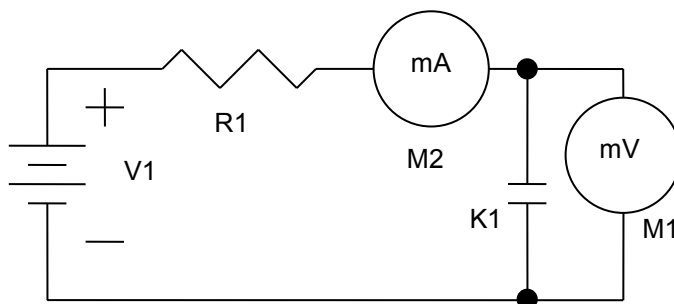
- If relay failed to operate or if it was buzzing: (AC or DC coils)
 - Measure coil resistance (ohmmeter OK here) and compare to specification.
 - If open coil (infinite resistance) – return for evaluation
 - If coil resistance is out of specification, let stand 1 hour and retest to make sure coil was not heated by removal process or applied voltage.
 - If still out of spec., return for evaluation.
 - If resistance in spec., proceed as below.

- Do not monitor contacts using an ohm-meter or digital logic levels (digital logic levels can be used in automated testers to screen for good relays and proper control operation, but **a contact failure under logic level conditions may not indicate a problem** in the relay or control being tested (i.e. false errors) **so a backup means of screening at greater than minimum load rating must also be provided**).
- **DC relays**
 - Apply well-filtered DC voltage at nominal specified level
 - Monitor contacts with at least 6Vdc and 100ma (preferably use 12Vdc and 500ma on all except “signal” level relays)
 - Do not monitor contacts using an ohm-meter or digital logic levels (digital logic levels can be used in automated testers to screen for good relays and proper control operation, but **a contact failure under logic level conditions may not indicate a problem** in the relay or control being tested (i.e. false errors) **so a backup means of screening at greater than minimum load rating must also be provided**).
 - Do contacts operate properly?
 - If OK, repeat test several times to check for an intermittent condition
 - If still OK:
 - There may be a problem in the control under test
 - There may be a problem in the tester being used
 - Possibly it was an intermittent condition in the relay that disappeared during de-soldering and handling.
 - If possible, place the relay back in the control under test and retest.
 - If it now passes, it may have been an intermittent relay, control or tester problem.
 - If it still fails in the tester, there must be some control or tester problem.
 - Investigate control and tester problems. If none found, return the relay for evaluation.
 - If contacts do not operate properly or if the relay buzzes, return for evaluation.
- **AC relays**
 - Apply a stable AC voltage at nominal specified level
 - Monitor contacts with at least 6Vdc and 100ma (preferably use 12 Vdc and 500ma on all except “signal” level relays)
 - Do not monitor contacts using an ohm-meter or digital logic levels (digital logic levels can be used in automated testers to screen for good relays and proper control operation, but **a contact failure under logic level conditions may not indicate a problem** in the relay or control being tested (i.e. false errors) **so a backup means of screening at greater than minimum load rating must also be provided**).
 - Do contacts operate properly?
 - If OK, repeat test several times to check for an intermittent condition
 - If still OK:
 - There may be a problem in the control under test
 - There may be a problem in the tester being used
 - Possibly it was an intermittent condition in the relay that disappeared during de-soldering and handling.
 - If possible, place the relay back in the control under test and retest.
 - If it now passes, it may have been an intermittent relay, control or tester problem.
 - If it still fails in the tester, there must be some control or tester problem.
 - Investigate control and tester problems. If none found, return the relay for evaluation.
 - If contacts do not operate properly or if the relay buzzes, return for evaluation.

Commonly used Specialized Tests and Testing Considerations:

- **AC relays (and DC relays on unfiltered or partially filtered power):**
 - AC relays may also “hum” (as opposed to “buzz”)
 - Buzzing (as above) usually makes the contacts chatter (intermittently make)
 - Nearly all AC relays hum at some level.
 - Humming is normally just aggravating to the user depending upon the background sound level.
 - The hum level may even vary between successive operations of the same relay because the internal parts always move slightly from one operation to the next.
 - The typical hum level also varies from relay to relay.

- Relays with consistently excessive hum should be returned for evaluation.
- DC relays driven from half/full-wave rectified and incompletely filtered power sources may also hum. Again this is normal. The same considerations as on AC relays above apply.
- **Measuring - Operate or “Pull-In” Voltage**
 - Using the proper coil power source (stable AC or filtered and regulated DC)
 - Monitor contact state using the proper voltage and current defined above.
 - Slowly increase the voltage applied to the coil
 - Relay will begin to “chatter”
 - Keep increasing until the contacts transfer state
 - If the contacts are bouncing (switching back and forth) at that time, keep increasing the voltage until they no longer bounce.
 - Voltage at that time is the “Pull-In voltage”
 - It should be the specified value or less
- **Measuring - Release or “Drop-Out” Voltage**
 - Using the proper coil power source (stable AC or filtered and regulated DC)
 - Monitor contact state using the proper voltage and current defined above.
 - Apply nominal coil voltage, then slowly decrease the voltage applied to the coil
 - Relay may begin to “chatter”
 - Keep decreasing until the contacts transfer state
 - If the contacts are bouncing (switching back and forth) at that time, keep decreasing the voltage until they no longer bounce.
 - Voltage at that time is the “Drop-Out voltage”
 - It should be the specified value or more
- **Measuring – Contact Resistance**
 - Specified only for “new” (unused) relay contacts
 - Specified at Minimum Contact Load (voltage and current)



Typical contact resistance circuit.

K1 = Relay contact tested.
 V1 = Minimum rated voltage.
 R1 = Select R1 to get minimum rated current.
 M1 = milli-volt meter.
 M2 = milli-amp meter.

- Usually specified for “load switching” state (i.e. contact “makes” specified rated load voltage + current for contact resistance rating before measurement). This value is nearly always some value in excess of the “minimum contact load rating”. **Consult the datasheet or Product Engineering for required test parameters.**
 - “Dry circuit” contact resistance is not to be used unless the relay is rated for “dry-circuit” operation. (i.e. “Dry circuit” means closing the contact with no voltage and current applied, then applying voltage and current - usually at very low levels.)
- Simple test method:
 - Using a regulated DC power supply and a series resistor, set the voltage to the contact resistance test voltage specified in the datasheet and select a resistor to limit the current to the specified current. ($\pm 10\%$ for voltage and current is OK)
 - Break the circuit and insert the relay contact in series.
 - Make sure the contact you are measuring is open (i.e. – measure the NO contact with the coil power off and the NC contact with nominal coil power applied).
 - Insert an ammeter in series to measure the current
 - Insert a voltmeter in parallel with the relay contacts to measure the voltage drop across the contacts
 - With the power supply on:
 - Operate (or release) the relay coil at nominal voltage (i.e. close the contacts under test)

- Read the voltage drop (E) and the series current (I)
- Using the formula (Ohm's Law) $R = E \div I$
 - Calculate Contact resistance R in Ohms (Ω)
 - R should be equal to or less than the value specified in the datasheet.
 - R is usually 50 to 200 or so milli-Ohms (m Ω). It is lower for signal or dry-circuit rated relays and larger for power relays, contactors, etc.
- **Measuring – Initial Dielectric Strength (Hi-Pot Test)**
 - **(WARNING – Uses hazardous voltages. Proper training and safety controls required.)**
 - Tested at datasheet specified AC Voltage (Vrms)
 - Applies to “new” or unused relays only
 - Used relays have different limits
 - Tester is set to the rated voltage and the sensing level to the specified current (may be fixed in the tester – usually 10 or 20ma)
 - Specified test voltage is applied for one minute
 - Should not trip sensor (This is a Pass/Fail test – not a parametric test)
 - Test is usually applied to one or more of the following points (Each may have its own datasheet specified voltage level)
 - Coil to contacts
 - Pole to pole (on multi-pole relays)
 - Across open Contacts
 - Failures should be discarded or returned for evaluation

Miscellaneous Analysis

- Physical damage
 - If relays are dropped more than about 6 inches onto a hard surface, or exceeded the shipping damage rating of 10g during transit, the relay should be scrapped due to potential damage to the sealing of the relay and to internal adjustments critical to good performance. Just because the relay still works does not mean it is operating correctly.
 - Do not cut or saw off relay terminals. Doing so may cause damage to the seal causing leaks and/or move terminals causing improper operation or broken coil wires.
 - Seal integrity (sealed relays)
 - If relays are washed and seal is damaged, fluid may infiltrate relay
 - May cause failure to operate / release or intermittent operation
 - May cause contact resistance or dielectric failures
 - May not be apparent for several hours / days (takes time to form rust)
 - Damage may occur during any phase of cycle from initial shipment from supplier to final assembly into the end use product.
 - Movement of terminals
 - Drop on hard surface (bends or “jams” terminals)
 - Bending of terminals to hold in during handling and soldering
 - Forcing terminals into holes that are too tight or misaligned
 - Terminals pulled out or pushed in
 - May cause improper operation, open coils, etc.
 - Compression, warpage or puncture of case
 - May affect seal integrity
 - May jam or restrict internal components
 - To prevent damage above
 - Review assembly, handling, soldering and cleaning processes
 - Consult supplier Applications Engineering and Quality personnel

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