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APPLICATION NOTE

Chroma 19501 Partial Discharge Test Guide – High Voltage Relay

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Chroma ATE Inc.

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APPLICATION NOTE

1. Objective

High voltage relay (HV Relay) is broadly used in automatic circuit control functioning as safety protection or switching circuit. However, has the general user ever thought that the relay used for the switching circuit should be or must be in an isolated state? But then again, is the HV relay really completely isolated?

There are many conditions causing the relay to fail. The common problems are poor withstand voltage of Contact to Coil, increased contact resistance of the reed switch, increased coil resistance, and glass tube dark crack on reed switch. Among them, the poor withstand voltage of Contact to Coil could endanger the user's safety and seriously affect the low-voltage digital control circuit. It is particularly important to use the relay with safety protection. This document explains the precautions of partial discharge (PD) detection and withstand voltage detection for HV relays during testing and production inspection.

2. Working Theory

2.1 Operational Principle

When an external coil is energized to form a magnetic field, the two magnetic reeds will contact and conduct. When the external coil is no longer conductive, the magnetic field disappears, and the reed switch will return to its original position.

2.2 Basic Structure

2.2.1 A HV relay is composed of reed switch, bobbin, coil and epoxy resin for insulation as Figure (1) shows.

2.2.2 A reed switch is composed of two reeds sealed in a glass tube. There is a small gap between the two reeds, and the glass tube is filled with nitrogen or equivalent inert gas to improve the high voltage isolation effect as shown in Figure (2).

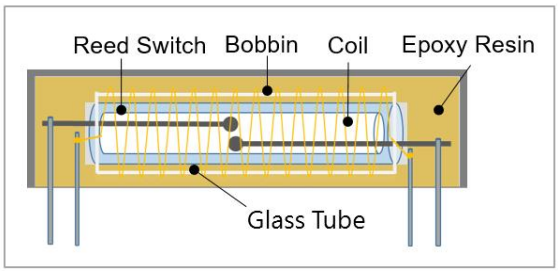


Figure (1) Basic Structure of HV Relay

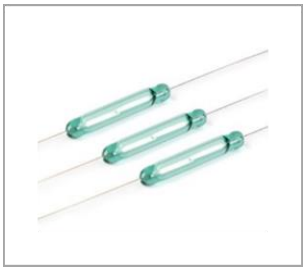


Figure (2) Reed Switch

3. Common Specifications

3.1 Basic Specifications of Relays

Coil Data at 20℃	Min.	Type	Max.	Unit
Coil Resistance	900	1,000	1,100	Ohm
Coil Voltage		24		VDC
Rate Power		576		mW

- Coil resistance: Defines the resistance value of the relay coil confirming that the coil turns are correct and well soldered.
- Coil voltage: Defines the voltage and current specifications required for relay operation.
- Rated power: Defines the rated working power of the relay.

3.2 Contact Specifications

Contact Data	Conditions	Min.	Type	Max.	Unit
Contact Rating	Any DC combination of V & A not to exceed their individual max.'s			50	W
Switching Voltage	DC or Peak AV			7,500	V
Switching Current	DC or Peak AV			3	A
Carry Current	DC or Peak AV			5	A
Contact Resistacne Static	Measured withb 40% overdrive Start Value			150	mOhm
Insulation Resistance	RH < 45% 100V Test Voltage	10			Gohm
Breakdown Voltage		10			kV DC

- Contact rating: Defines the maximum withstand power when the contact is on for work.
- Switching voltage: Defines the maximum working voltage for hot-swappable contact.
- Switching current: Defines the maximum working current for hot-swappable contact.
- Carry current: Defines the maximum current passing the contact.
- Contact resistance static: Defines the maximum resistance when the contact is on, the smaller the on-resistance the better.
- Insulation resistance: Defines the minimum insulation resistance of contact in the OPEN state under specific voltage conditions.
- Breakdown voltage: Defines the maximum withstand voltage of contact in the OPEN state.

3.3 Specifications between Contacts and Coils

Special Product Data	Conditions	Min.	Type	Max.	Unit
Dielectric Strength Coil/Contact		15			kV DC
Insulation Resistance Coil/Contact	RH < 45%, 200VDC Measuring Voltage	10			TOhm
Capacity Coil/Contact	@10 kHz		1.2		pF

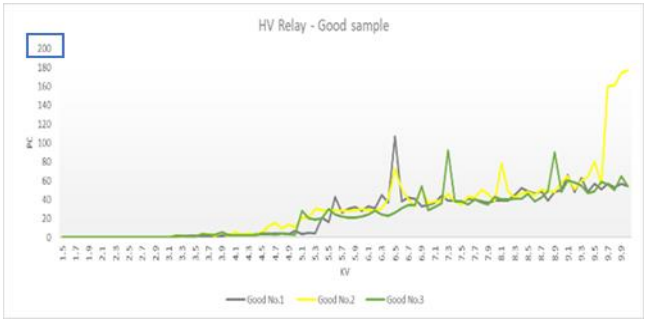
- Dielectric strength: Defines the maximum withstand voltage between the contact and the coil.
- Insulation resistance: Defines the minimum insulation resistance between contact and coil under a specific voltage.
- Parasitic Capacity: Defines the parasitic capacitance between the contact and the coil. Excessive parasitic capacitance will affect the leakage current of the product.

4. Deficiencies of Detecting Methods

In general, HV relay manufacturers only conduct DC withstand voltage tests according to the specifications without any partial discharge (PD) or electrical flashover test items. In light of the analysis and research, it is found that between the HV relay contact and the control coil, partial discharge or electrical flashover will occur to some relays within the working voltage, resulting in high-voltage control failure.

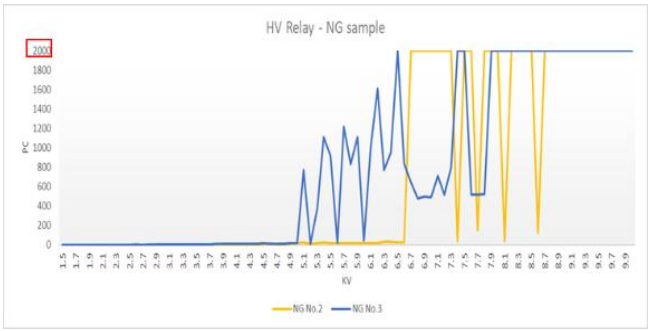
- Normal relay

  When the test voltage between the test contact and the coil climbs to 10KVac, the partial discharge inception voltage (PDIV) is high but no strong discharge (<200pC).



- Abnormal relay

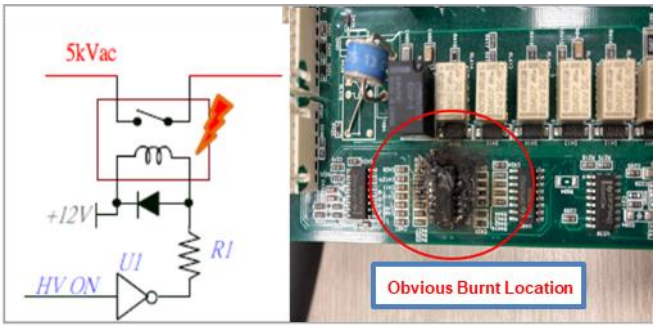
  When the test voltage between the test contact and the coil climbs to 10KVac, the PDIV is low and has strong discharge (>2000pC).



4.1 Case of Actual HV Relay Damage

4.1.1 HV relay control circuit and logic of failure

4.1.1.1 Control circuit error

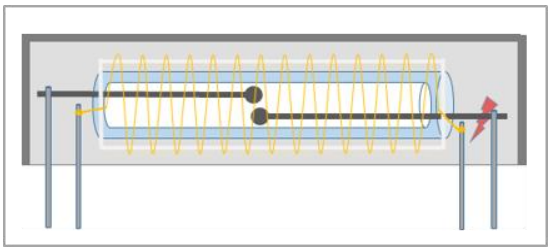


4.1.1.2 Symptom of fault

- Deterioration of current limiting resistor R1 (Ex: 10ohm → 9kohm)
- Driving IC U1 failed

4.1.1.3 Failure analysis

When partial discharge (PD) occurs inside the HV relay, though the relay does not fail due to incomplete insulation, the control circuit has deteriorated or failed due to abnormal high voltage pulses.



4.2 From the case described above, we can learn that if the withstand voltage marked on the HV relays in the market is actually used in the rated high voltage, most of them will generate accidental partial discharge.

4.2.1 Possible factors causing relay to partial discharge

- Air gaps or oil contamination on the surface of reed glass
- Air gaps or conductive impurities in the insulating glue
- Insufficient insulation distance between coil and reed switch contacts

5. Chroma Related Test Solutions

5.1 19501 Partial Discharge Tester

5.1.1 Objective: Partial discharge test between relay contact and coil.

5.1.2 Basic Specification

- Programmable AC withstand voltage output: 0.1kVac~10KVac
- High precision and high resolution ammeter: 0.01μA~300μA
- Partial discharge (PD) detection range: 1pC~2000pC
- High voltage contact check (HVCC) function

5.2 11890-8kV HF Hi-Pot Tester

5.2.1 Objective: Deterioration accelerated test to analyze the cause of partial discharge.

5.2.2 Basic specification

- Programmable AC withstand voltage output: 0.1kVac~8KVac (5kV/100mA or 8kV/60mA)
- Test frequency: 20KHz ~ 200KHz
- High frequency and high voltage durability test (CV and CC mode)
- Output voltage/current and PD Pulse waveform monitoring function

5.3 16502 Milliohm Meter

5.3.1 Objective: Measurement of contact resistance

5.3.2 Basic specification

- Accuracy: 0.05%
- 0.001mΩ~1.9999MΩmeasurement range and 4½-digit resolution
- Provide pulse measurement signals for selection, which can deduct the error caused by the thermoelectric effect when measuring small resistance.

5.4 19056 Hi-Pot Tester

5.4.1 Objective: Detection of the withstand voltage between relay contacts or between contact and coil.

5.4.2 Basic specification

- Programmable AC withstand voltage output:10kVac
- High precision ammeter: 0.01mA~20mA
- Breakdown voltage (BDV) analysis function
- High voltage contact check (HVCC) function

5.5 11210 IR Meter

5.5.1 Objective: Insulation resistance test between relay contacts or between contact and coil.

5.5.2 Basic specification

- Programmable DC voltage output: 1KVdc max.
- Maximum 50mA charge current
- Insulation resistance test range: 0.01kΩ ~ 10TΩ

6. Test Methods

6.1 Test Wiring Method

6.1.1 Partial discharge test between contacts and coils

Short-circuit the relay contacts and coil leads respectively and connect them to the high-voltage side (HV) and low-voltage side (LOW) of the test equipment as Figure 3 shows.

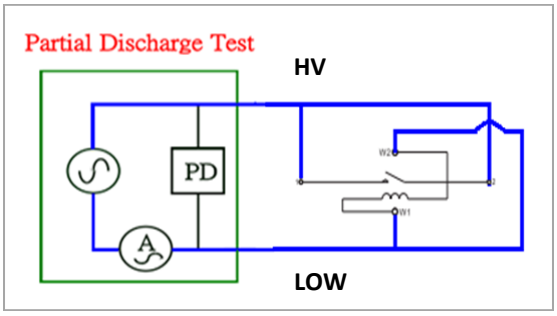


Figure (3) Diagram of Wiring between Contacts and Coils for Partial Discharge Test

6.2 Other Test Recommendations

6.2.1 1pcs is preferable for a single test. The more PINs of the relay or increased amount in a single test, the exposed area of related metal (PIN) will increase. This will enlarge the influence degree of partial discharge test caused by environmental interference.

6.2.2 Connect with the automated test socket.

- It is better to directly contact the HV BOX probe with the test socket on the automatic equipment.
- If an external test lead is required, the wire should be as short as possible (<50cm).

6.2.3 Reduce the interference of test environment.

- Install a metal isolation cover on the LOW side and ground it.
- The metal exposed area on the LOW side of the test fixture should be as small as possible.

6.2.4 When selecting the fixture materials, use high-strength insulating materials to avoid partial discharges generated by the fixture itself.

6.2.5 Automation mechanism and fixture designers

- Designers must have relevant knowledge of high-voltage test applications, and consider the insulation distance requirements at the beginning of the design.
- The test fixture should clearly specify the size and pitch of the DUT to facilitate evaluating its applicability when replaced.
- Any design changes need to consider the insulation withstand voltage requirements of the fixture.
- The use of conductive metal materials should be minimized for the components used in the test socket to avoid increasing environmental noise interference.

7. Reference Document

[1] Partial Discharge Tester 19501-K User's Manual