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Electro-mechanical Relay Terminology for the Energy Industry

by Pan Yijun

Executive summary

As technologies continue to evolve in today's power networks, clarity regarding the impact of electro-mechanical relay performance on electric circuit reliability is becoming a greater concern for energy industry professionals. The complexity of power networks makes it difficult and frustrating for professionals to specify requirements. This paper offers basic guidance through the explanation and definition of core electro-mechanical relay terminology.

Introduction

There is an influx of terms related to electro-mechanical relays that affect the way power networks are configured and rendered reliable. This unnecessarily complex terminology makes it difficult for energy industry professionals to effectively communicate requirements to colleagues and stakeholders and this could lead to suboptimal power network solutions.

Clearly they are the innovation drivers and must-haves for every vendor of the complex jargon used to describe electro-mechanical relays can be easily explained in simple terms surrounding the basic functions of the relay sub-systems: the electromagnetic contact and auxiliary systems. This paper provides explanations of electro-mechanical relay terms common to power networks.

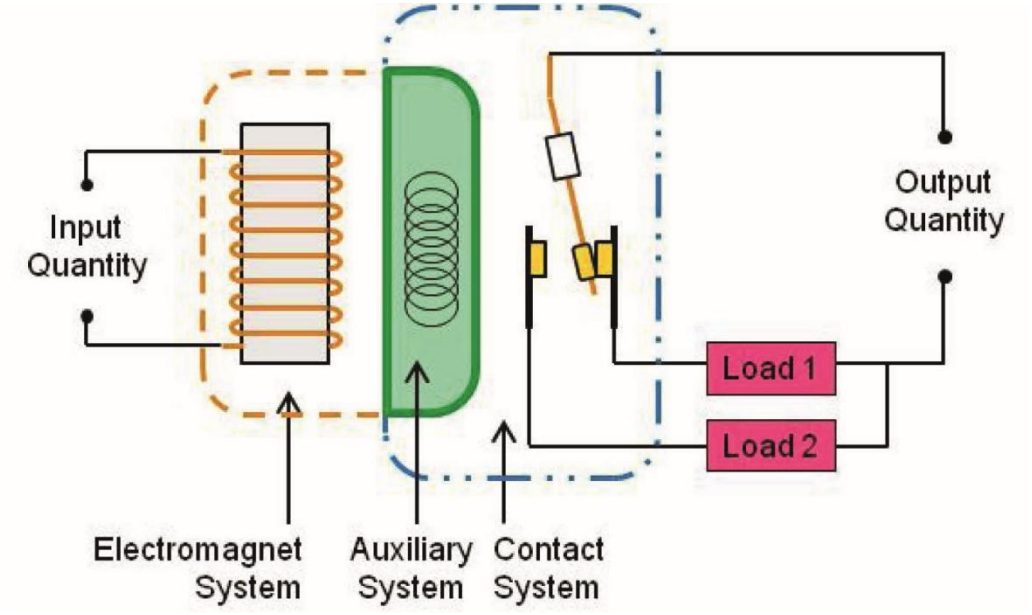
Electro-mechanical relay is the earliest forms of relay product, in which there are three main subsystems:

a. Electromagnetic system, which converts electrical energy into mechanical power.
b. Contact system, which switches electrical contact mechanically.
c. Auxiliary system, which works as a bridge between electromagnetic and contact systems.

When relay product is supplied by an input quantity of small current with rated voltage, the contact system will be driven to switch contact mechanically. The electrical circuit connected to relay contact system will be switched ON or OFF in response to the input stimulus.

Figure 1

Electro-mechanical relay working principle



The technical terms are required to describe relay architecture, performance, safety, and related compliance of environment and standard. This paper will provide the detailed explanation of technical terms and definitions:

1. Standard and Compliance
2. Environment
3. Coil
4. Contact
5. Insulation

Standard and approval

Standard

Unless other indication in technical files of catalogue, datasheet or working instruction, Schneider electro-mechanical relays are designed, manufactured and validated according to the requirements of the following European and International Standards.

- **IEC 61810-1**

Electro-mechanical elementary relays – Part 1: General and safety requirements.

It defines the basic functional and safety requirements and safety-related aspects for applications in all areas of electrical engineering or electronics. The related requirement compliance is verified by the type tests indicated.

- **IEC 61984**

Connectors – Safety requirements and tests.

It applies to the socket products of electro-mechanical relays with rated voltages of 50~1000 V AC/DC and rated currents up to 125 A per contact.

Approvals

Schneider electro-mechanical relays are designed to meet a wide range of stringent requirement of international/regional directives and regulations.

The independent approval agency and test laboratory confirms the compliance with the regulations of the countries that relay products are sold and operated in.

- **CE Marking**

The letters “CE” in marking are the abbreviation of French phrase “Conformité Européene” which literally means “European Conformity”.

It signifies that products have been assessed to meet the essential requirements of relevant European health, safety, and environmental protection legislation and can be sold in European Economic Area (EEA).

Figure 2

CE marking

- **UL Recognized Component Mark**

There are three variations of UL Recognized Component Mark:

Figure 3

UL Recognized Component Mark

The UL Recognized Component Mark means that the product has been tested by UL (Underwriters Laboratories) as a component and meets UL’s requirements as a component. Those components are parts of a larger product or system.

- **UL Listed Mark**

There are three variations of UL listed Mark:

Figure 4

UL Listed Mark

The UL Listed mark means that the product has been tested by UL (Underwriters Laboratories) and meets UL's requirements. These requirements are based primarily on UL's published and nationally recognized Standards for Safety.

- **CSA International Certification Mark**

There are three variations of CSA International Certification Mark:

Figure 5

UL Recognized Component Mark

CSA International (Canadian Standards Association) certification marks indicate that a product, process or service has been tested to a Canadian or U.S. standard and it meets the requirements of an applicable CSA standard or another recognized document used as a basis for certification.

- **EAC Marking**

The EAC marking means Eurasian Conformity.

The product with this marking has been tested through all procedures of the conformity assessment and meets all requirements, which is established by the Customs union technical regulations.

Figure 6

EAC Marking

- **Green Premium eco-label**

Schneider Electric has developed its Green Premium eco-label with defined and clear criteria that include the appropriate information about its environmental projects. In particular, it covers environmental impacts throughout the product life cycle, the identification or elimination of substances of concern and the elements necessary for recycling.

Figure 7

Green Premium eco-label

A Green Premium product meets the four following criteria:

1. RoHS compliance

   Absence of dangerous substances according to the requirements of the EU RoHS directive (Directive 2011/65/EC).

2. REACH information Declaration

   The information of up to date REACH Candidate List for Authorization Substances of Very High Concern (SVHC) content per product. The REACH Candidate list for Authorization is regularly updated usually twice a year by the European Chemical Agency (ECHA). The latest update of the list is accessible here: http://echa.europa.eu/candidate-list-table.

3. PEP publication

   A Product Environmental Profile (PEP) is a quantitative Type III Environmental Declaration in compliance with ISO 14025, which ensures appropriate reliability and transparency. Based on a Life Cycle Assessment (LCA) of the product

along its whole life cycle, the document presents the different impacts such as energy consumption, carbon footprint, consumption of raw materials, and pollution of air, water, and soil.

4. EoLI publication

   In order to complement the Bill of Material and recyclability rate contained in the PEP, the End-of-Life Instruction (EoLI) optimizes recycling and recovery when specific treatment is needed.

- **China RoHS Marking**

There are two types of logos: one is generally green, demonstrating the attribute of environmental protection, namely that the products do not contain any toxic or hazardous substances or elements. Another is normally orange, making prominent the attribute of caution, that the products contain certain toxic or hazardous substances or elements. The replaceable number in the middle of the logo indicates the environmental protection use period (maximum number of years for the product life) for the electronic information product.

Figure 8

China RoHS Marking

China RoHS (Restriction of Hazardous Substances) is the marking for control of pollution caused by electronic information products. They indicate – whether the electronic information products contain any toxic or hazardous substances or elements, the environmental protection use period of the electronic information products, and the recyclability of the electronic information products.

This standard applies to the electronic information products sold in the People's Republic of China.

Reference Values of Influence Quantities

Unless otherwise explicitly stated by the catalogue, datasheet and working instruction, the reference values and tolerance ranges listed in **Table 1** will be applied in validation testing.

Table 1

Reference values of influence quantities

Influence quantity	Reference value	Tolerance range and conditions for testing
Ambient temperature	23°C	±5 K
Atmospheric pressure	96 kPa	86 kPa to 106 kPa
Relative humidity	50%	25% to 75%
External magnetic induction	0	0 ± 5 × 10–4 T in any direction
Position	Horizontal	
Coil Voltage	As indicated by reference	±5% for steady-state conditions
Contact Voltage/Current	As indicated by reference	±5% for steady-state conditions
Frequency	50 Hz or 60 Hz	±2%
Waveform	Sinusoidal	Maximum distortion factor 5%
Shock and vibration	0 Maximum	1 m/s2
Atmospheres	Clean air	Clean air (pollution not exceeding class 3C2 of IEC 60721-3-3)

General data

Ambient Temperature Range

The range of temperature is prescribed for the air surrounding electro-mechanical relay, when it is mounted as indicated by technical specification.

Unless otherwise stated, the preferred ambient temperature range is –40°C to +55°C for the operation of relays.

Relative Humidity

The ratio of the vapor pressure of water vapor in moist air to the saturation vapor pressure with respect to water or ice at the same temperature, is expressed as a percentage.

Relay Technology Category

The categories of relay type describing the sealing degree of product case or contact unit against climatic or other adverse conditions during its installation, transportation or storage, is based on environmental protection.

Table 2

Relay Technology Category

Relay Technology Category	Protection
RT 0: Unenclosed relay	Relay not provided with a protective case
RT I: Dust protected relay	Relay provided with a case which protects its mechanism from dust
RT II: Flux proof relay	Relay capable of being automatically soldered without allowing the migration of solder fluxes beyond the intended areas
RT III: Wash tight relay	Relay capable of being automatically soldered and subsequently undergoing a washing process to remove flux residues without allowing the ingress of flux or washing solvents
RT IV: Sealed relay	Relay provided with a case which has no venting to the outside atmosphere, and having a time constant better than 2 × 104 s in accordance with IEC 60068-2-17
RT V: Hermetically sealed relay	Sealed relay having an enhanced level of sealing, assuring a time constant better than 2 × 106 s in accordance with IEC 60068-2-17

Overvoltage Category

Table 3

Overvoltage Category

The categories of a transient overvoltage condition where an electro-mechanical relay is used in application is provided below:

Overvoltage category	Description
Overvoltage category I	Applies to equipment intended for connection to fixed installations of buildings, but where measures have been taken (either in the fixed installation or in the equipment) to limit transient overvoltage to the level indicated
Overvoltage category II	Applies to equipment intended for connection to fixed installations of buildings
Overvoltage category III	Applies to equipment in fixed installations, and for cases where a higher degree of availability of the equipment is expected
Overvoltage category IV	Applies to equipment intended for use at or near the origin of the installation, from the main distributor towards the mains supply

Degree of Protection

The extent of protection provided by a relay enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water and verified by standardized test methods. A coding system is used to indicate the degrees of protection.

Table 4

Degree of Protection

Element	Numerals or letters	Meaning for the protection of equipment	Meaning for the protection of persons
Code letters	IP	–	–
First characteristic numeral		Against ingress of solid foreign objects	Against access to hazardous parts with:
	0	(non-protected)	(non-protected)
	1	≥50 mm diameter	back of hand
	2	≥12.5 mm diameter	finger
	3	≥2.5 mm diameter	tool
	4	≥1.0 mm diameter	wire
	5	dust-protected	wire
	6	dust-tight	wire
Second characteristic numeral		Against ingress of Water with harmful effects	
	0	(non-protected)	
	1	vertically dripping	
	2	dripping (15° tilted)	
	3	spraying	–
	4	splashing	
	5	jetting	
	6	powerful jetting	
	7	temporary immersion	
	8	continuous immersion	
Additional let- (optional)			Against access to hazardous parts with:
	A	–	back of hand
	B		finger
	C		tool
	D		wire
Supplemen- letter (optional)		Supplementary information specific to:	
	H	High voltage apparatus	–
	M	Motion during water test	
	S	Stationary during water test	
	W	Weather conditions	

Shock

The capability of the relay to function during and/or after non-repetitive shocks encountered in service or during transportation.

Vibration

The capability of the relay to withstand conditions of vibration encountered in service or during transportation.

Coil

Rated Coil Voltage

The recommended voltage value to operate relay as an energizing quantity.

The table below shows Schneider's rated coil voltage for electro-mechanical relays:

Table 5

Rated Coil Voltage (AC)

Rated Coil Voltage

AC				DC		
No.	Ref.	Voltage	Frequency	No.	Ref.	Voltage
1.	*B7	24 VAC	50/60 HZ	1.	*JD	12 VDC
2.	*E7	48 VAC	50/60 HZ	2.	*BD	24 VDC
3.	*N7	60 VAC	50/60 HZ	3.	*HD	30 VDC
4.	*G7	110 VAC	50/60 HZ	4.	*CD	36 VDC
5.	*F7	120 VAC	50/60 HZ	5.	*ED	48 VDC
6.	*K7	127 VAC	50/60 HZ	6.	*ND	60 VDC
7.	*P7	230 VAC	50/60 HZ	7.	*FD	110 VDC
8.	*U7	240 VAC	50/60 HZ	8.	*GD	125 VDC
				9.	*MD	220 VDC
				10.	*UD	250 VDC

Coil Power Consumption

Electrical energy over time supplied to operate relays. The supplied voltage is the rated coil voltage and the LED and resistor are excluded.

Coil Resistance

DC electrical resistance of relays coil is measured between the terminals of the relay.

A negligible temperature rise is involved. The reference temperature shall be 23°C unless otherwise specified.

Pick Up voltage

Value of the coil voltage at which a relay, having previously been energized at that same voltage, can operate. Thermal equilibrium has to be achieved at the maximum ambient temperature.

Maximum coil voltage

Value of the coil voltage, taking into account the effect of heating due to the power dissipated by the coil(s), which when exceeded may result in a relay failure caused by thermal overload. Thermal equilibrium has to be achieved at the maximum ambient temperature.

Operative Range

The range of values of coil voltage for which a relay is able to perform its specified function.

Release Voltage

Value of the coil voltage at which a monostable relay releases at the minimum ambient temperature.

Operating Time

Time interval between the application of the specified coil voltage to a relay in the release condition and the change of state of the last contact circuit, bounce time is not included. The operating time covers the closing time of a make contact and the opening time of a break contact.

Release Time

Time interval between the removal of the specified coil voltage from a monostable relay in the operating condition and the change of state of the last contact circuit, bounce time is not included.

Bounce Time

For a contact which is closing/opening its circuit, time interval between the instant when the contact circuit first closes/opens and the instant when the circuit is finally closed/opened.

Thermal Class

Designation of an electrical insulation system(EIS)/electrical insulating material(EIM) equal to the numerical value of the maximum used temperature in degrees Celsius for which the EIS/EIM is appropriate (IEC 60085).

Table 6

Thermal Class

Thermal Classification (coil insulation system)	Maximum Temperature	Maximum temperature for existing designs
Y	90°C	-
A	105°C	120°C
E	*120°C*	*135°C*
B	130°C	145°C
F	155°C	155°C
H	180°C	175°C
200 (N)	200°C	195°C
220 (R)	220°C	215°C
250 (C)	250°C	-

Contact

Number of Poles

A single pole (SP) means that all contacts in the arrangement open or close contact in one position or a common contact open or close contact with other contacts.

A double pole (DP) means the arrangement consists of two single poles, which are actuated by the common electromagnetic systems and operated concurrently. Likewise, a triple pole (3P) means the arrangement consists of three single poles. Number of poles is generally indicated by the number of single pole followed by a “P” (i.e., a four pole relay is 4P).

Number of Throws

Single throw (ST) contact is designated for the combination of a pair of contacts, where the contact opens in one relay position and the contact closes in another position. Double throw (DT) contact is designated for the combination of three contacts, in which the common one opens contact with the second one but closes contact with the third one in one relay position, in reverse, the common one closes contact with the second one but opens contact with the third one in another relay position.

Normal Position of Contacts

Normally open (NO) is designated for the combination in which contact closes in relay operating condition but opens in relay release condition.

Normally closed (NC) is designated for the combination in which contact closes in relay release condition but opens in relay operating condition.

Change over (CO) is designated for the combination Normally Open and Normally Closed.

Contact Action

Make contact means the contact connection state changes from open to closed. Break contact means the contact connection state changes from closed to open.

Some contact combinations have two independent contacts both connected to a third contact in one relay position, which are designated as double make (DM) when normally open and double break (DB) when normally closed.

Contact Arrangement

Contact arrangement is defined in terms of number of poles, number of throws and normal position, which close or open the electrical circuits connected to the contacts by the relative contact action.

The overall identification of various contact arrangement can be described by the contact form and symbols (as shown in **Table 7**).

Table 7

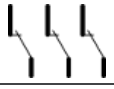
Contact form and Symbols

Form	Description	Word Symbol	Circuit Symbol
A	Make contact	No	
B	Break contact	NC	
C	Changeover contact	CO	
U	Double make on armature		
V	Double break on armature		
X	Double make contact		
Y	Double break contact		
Z	Double make double break contact		

The more complicated contact arrangement can be simplified by the contact form and symbols (as shown in **Table 8**).

Table 8

Contact form and Symbols (complicated)

Form	Description	Word Symbol	Circuit Symbol
2A	2 Make contact	DPST-NO	
3B	3 Break contact	3PST-NC	
4C	4 Changeover contact	4PDT	

Contact Material

Contact material included base material and plating material, which is suitable for contact load, switching operation, application environment, and other performance requirements.

1. Plating materials:

   Gold plating is a method of depositing a thin layer of gold onto the surface of contact rivet by chemical or electrochemical plating. Electro-mechanical relay product normally will choose gold as contact plating material.

   Gold material is very good at corrosion resistance, but has low and stable contact resistance of low contact load. When gold plating thickness is ≤ 1 μm (gold flash), it is only used for storage protection, there is no protection against aggressive atmosphere.

2. Contact materials:

   Contact material is most often a sliver base material or copper base material based on different product applications. There are several typical silver materials used in electro-mechanical relays (as shown in **Table 9**).

Table 9

Contact Material, Technical Advantage and Application

Material	Technical Advantage	Application
Fine-grain silver AgNi0.15	Relatively low contact resistance, low resistance against aggressive atmosphere.	DC loads with low to medium range
Silver-Nickel AgNi90/10	High resistance against electrical wear, low welding tendency, higher contact resistance than AgNi0.15.	AC/DC loads with medium to high range
Silver-Tin-Oxide AgSnO2	Low welding tendency, high wear resistivity with heavy loads, low material transfer	AC/DC load with requirements of high current switching.
Silver-Cadmium-Oxide AgCdO	Low welding tendency, high wear resistance	AC/DC inductive loads with requirement of high current switching

Silver-Cadmium-Oxide, AgCdO, is not compliant with RoHS directive, therefore it is not recommended for new designs.

Contact Resistance

Contact resistance is the electrical resistance value measured between the terminals of a closed contact. It can only be measured reliably when the measuring load is above a particular level, which is normally 24/6VDC, 1A/100mA for Schneider electro-mechanical relays.

A steady state period of operate/release position or a certain number of cycles of storage are recommended before the contact resistance measurement.

Contact Current

Contact current is the performance relay contact that can carry the electrical current during application; it can be specified according to the different contact state.

1. Rated contact current:

   Electric current which a relay contact carries before opening or after closing.

2. Switching Current:

   Electric current which a relay contact makes and/or breaks, it including maximum switching current and minimum switching current.

3. Limiting continuous current:

   Greatest value of electric current which a closed contact is capable of carrying continuously under specified conditions.

4. Limiting short-time current:

Greatest value of electric current which a closed contact is capable of carrying for a specified short period under specified conditions.

Switching Capacity

Switching capacity is the product value of electric current and voltage. A contact is capable of making and/or breaking electrical current under specified conditions such as switching voltage, number of makes, power factor, and time constant. Normally it includes limiting making capacity, limiting breaking capacity, and limiting cycling capacity.

Electrical Endurance

Number of cycles a relay product can achieve without contact failure. Normally relay product will be energized with rated coil voltage and contacts are connected with rated contact load at the upper limit of ambient temperature range.

Table 10

Thermal Class

Classification	Current	Making			Breaking		
Resistive load	AC-1	I	U	Cos ϕ	I	U	Cos ϕ
		Ie	Ue	>0.95	Ie	Ue	>0.95
	DC-1	I	U	L/R (ms)	I	U	L/R
		Ie	Ue	<1	Ie	Ue	1
Inductive load	AC-13	I	U	Cos ϕ	I	U	Cos ϕ
		10 Ie	Ue	0.7	10 Ie	Ue	0.4
	DC-15	I	U	T0.95	I	U	T0.95
		Ie	Ue	6 x P	Ie	Ue	6 x P

I: Switching current

U: Switching voltage

Cos ϕ: Power factor in electrical circuit

T0.95: Time to reach 95% of the steady-state current (Max: 300 ms)

Ie: Rated operating current

Ue: Rated operating voltage

P = Ue × Ie: Steady-state power in W

Mechanical Endurance

Number of cycles a relay product can function properly at ambient room temperature.

Relay product will be energized with rated coil voltage without contact load, the difference between the number of detected cycles and the number of energization cycles cannot exceed the defined criteria.

Duty Factor

Ratio of relay product energization duration to total period in which intermittent or continuous or temporary duty takes place, the duty factor can be expressed as a percentage of the total period.

Contact Reliability

Reliability performance of electro-mechanical relays representative of standard production quality. Usually it is expressed in number of cycles as relay lifetime.

Insulation

Table 11

Thermal Class

Pollution Degree

A classification according to the amount of dry pollution and condensation present in the environment.

Pollution Degree	Description
Pollution degree 1	No pollution or only dry, non-conductive pollution occurs. The pollution has no influence
Pollution degree 2	Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected
Pollution degree 3	Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected

Impulse Withstand Voltage

The maximum abnormal voltage with prescribed form and polarity that relay product can withstand when the voltage surges momentarily due to lightning, switching, etc.

The standard waveform for the simulation of lightning overvoltage is characterized by a front time of 1.2 μs and a time to half value of 50 μs.

Dielectric Strength

The withstand capability of the insulation between specific circuits of the relay or across open contact(s).

Rated Insulation Voltage

DC or AC r.m.s voltage value assigned to electro-mechanical relay. The voltage supply of relay installations cannot exceed the rated insulation voltage.

Insulation Resistance

Electrical resistance under specified conditions between two conductive elements separated by insulating materials.

Conclusion

Electro-mechanical relays are simple, cost economic, but with a very reliable performance. They are widely applied in various industrial control applications. It is very important the right and specific products are selected for related applications.

Normally product catalogue, datasheet, and newsletter will be the reference file for customers to select relay products. The standard terminology of Schneider electro-mechanical relays can help to describe electro-mechanical relays accurately and consistently on architecture, basic function, and performance. Both Schneider and the customer can discuss electro-mechanical relays in the same “Language”, and ensure the right relay products were used in the right application.

About the author

PAN Yijun is a Senior R&D Electro-mechanical Engineer and Schneider Electric EDISON Group Expert Level 1 at electro-technology domain. He holds bachelor’s degrees of Mechatronics Engineering from XIDIAN University, China. He has focused on R&D of electro-mechanical products including relays, socket, and accessories for more than 10 years.

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