

Relay General Application Guidelines

Preface

The product reliability is meant its working reliability. It is identified as the probability that a relay can perform a required function under given conditions for a given duration or number of cycles. It is formed by the product's intrinsic reliability and application reliability. The former is determined by the product design and manufacturing process, while the latter is related having the customer's proper selection and the manufacturer's the before-service and after-service. With many years' experience, we provide these application guidelines. Although we are not updated with the ever changing application circuits, we would like to discuss and exchange ideas with the customers so as to raise the working reliability of the relays.

1. SIMPLE PRINCIPLE

Relay is an automatic electrical switch, when given a certain input signal, such as electricity, magnetism, light, heat or pressure etc and maintain a long enough time, it can automatically switch the control circuit to produce a jump change. When the input is reduced to a certain extent and maintain a long enough time, it then restored to its original state, the control circuit is also stepped back to the original status. Regardless of the relay function principle and structure of any form, it is always consists of input circuit, comparative structure and output circuit. Therefore, the relay is a four-terminal component, and its input and output must be isolated.

Of electromagnetic relays, it is the electromagnetic suction and the elastic material mechanical reaction force that makes the jump change in the output circuit (contacts circuit) (regardless of permanent magnet of latching relay). After the relay has passed the verification of design and production, its electromagnetic suction and mechanical reaction force is generally able to meet the relationship shown in Figure 1. The arch is for electromagnetic suction, the curve is for mechanical reaction force. Here:

U_c rated voltage U_b pick-up voltage, specified
 U_e hold voltage, specified U_p actual pick-up voltage

Regarding the magnetic circuit, when the coil is powered, the magnetic components in the magnetic circuit will be magnetized. When coil is applied with U_b , it is a rational magnetic circuit design to have its partly magnetization curve of the magnetic system as A point in Figure 2, the soft magnetic parts close to full capacity when armature is pulled in ; When coil is applied with U_c , the curve is as that point B in Figure 2, the soft magnetic parts have been basically saturated when armature is pulled in.

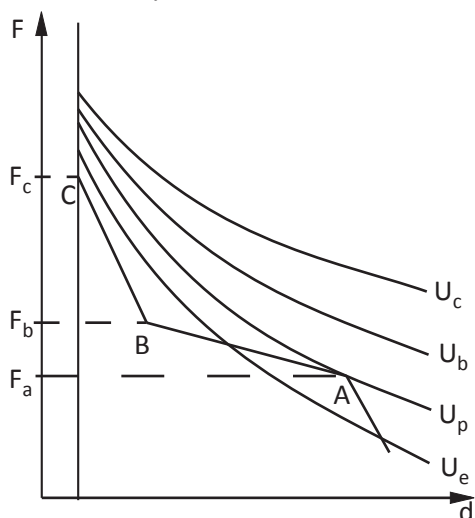


Figure 1: suction force and reaction force curve

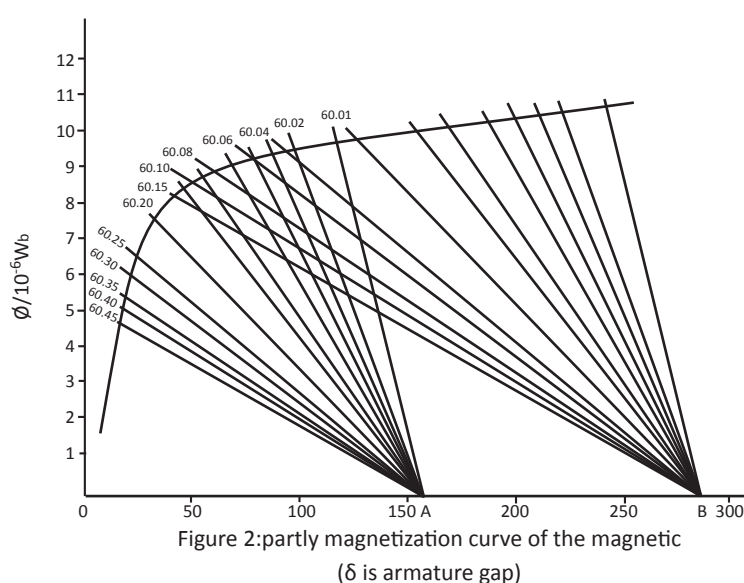


Figure 2: partly magnetization curve of the magnetic
(δ is armature gap)

There are a lot of relay applications, they summed up as follows:

- 1) Separation between the inout and output circuit
- 2) Signal transfer (from make break or whereas)
- 3) Strengthening output circuit (Between transfer several loads or different power loads)
- 4) Repeating signal
- 5) Transfer different voltage or current
- 6) Remain output signal
- 7) Locking circuit
- 8) Providing remote control



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2. DEFINITION OF RELAY TERMINOLOGY

Electrical relay

Device designed to produce sudden and predetermined changes in one or more output circuits when certain conditions are fulfilled in the electric input circuits controlling the device.

All-or-Nothing Relay

Electrical relay ,which is intended to be energized by a quantity, the value of which is either within its operative range or effectively zero .

Note:“All-or-nothing relays ”include both “elementary relays ”and “time relays”.

Electromechanical Relay

Electrical relay in which the intended response results mainly from the movement of mechanical elements.

Electromagnetic Relay

Electromechanical relay in with the designed response is produced by means of electromagnetic forces.

Monostable relay

Electrical relay which ,having responded to an energizing quantity and having changed its condition ,returns to its previous condition when that quantity is removed.

Bistable relay

Electrical relay which, having responded to an energizing quantity and having changed its condition ,remains in that condition after the quantity has been removed; a further appropriate energization is required to make it change its condition..

Polarized Relay

Elementary relay, the change of condition of which depends upon the polarity of its DC energizing quantity.

Latching Relay

A double stabilized relay remaining energizing state after energizing is gone. It is called a mechanic latching relay if the energizing state is latched mechanically. It is called a magnet latching relay if the energizing state is latched by the magnetic force from the hard magnet or half-hard magnet material.

Reed Relay

It is an electrical relay using the sealed contact part as the output circuit. The sealed contact part is also used as magnet armature. The relays are defined as wet and dry reed relays according to whether they use liquid metal mercury as their carrying liquid.

Rated Value

Value of a quantity used for specification purposes, established for a specific set of operating conditions.

Coil Rated Voltage

The coil voltage which make the relay work, meeting all the electrical, mechanical and environmental requirements.

Operate Voltage (also named pick-up value)

Value of the input voltage at which a relay operates .

Non-operate Voltage (also named non-pick-up value)

Value of the input voltage at which a monostable relay does not operate.

Release Voltage

Value of the input voltage at which a monostable relay releases .

Non-release Voltage (sometimes it is called latching value)

Value of the input voltage at which a relay does not release .

Operate range of the input voltage

Range of values of the input voltage for which a relay is able to perform its specified function.

Pickup value (voltage),specified

As the current or voltage on an unoperated relay is increased , the value (voltage) at or below which all contacts must function.

Hold value (voltage), specified

As the current or voltage on an operated relay is decreased , the value which must be reached before any contact change occurs.

Reset voltage

Value of the input voltage at which a bistable relay resets.

Non Reset voltage

Value of the input voltage at which a bistable relay does not reset.

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Operate Time

Time interval between the application of the specified input voltage to a relay in the release condition and the change of state of the last output circuit, bounce time not included.

Release Time

Time interval between the removal of the specified input voltage from a monostable relay in the operate condition and the change of state of the last output circuit, bounce time not included.

Reset time

Time interval between the application of the specified input voltage to a bistable relay in the operate condition and the change of state of the last output circuit, bounce time 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.

Notes: Bounce is defined by GJB as: it is one bounce when voltage drop between Contacts $\geq 90\%$ of open circuit voltage, and the time $\geq 10\mu\text{s}$.*

Stabilization time

Time interval between the instant when a specified input voltage is applied to an electromechanical relay and the instant when the last output circuit is closed /open and fulfils the specified requirements, bounce time included.

Contact Time Difference

For a relay having several contacts of the same type, the difference between the maximum value of the operate (release) time of slowest and the minimum value of the operate (release) time of the fastest.

Contact circuit

Output circuit containing contact members.

Note: A change-over contact involves two connected contact circuits.

Contact set

Combination of contact within a relay, separated by their insulation (see Figure 3).

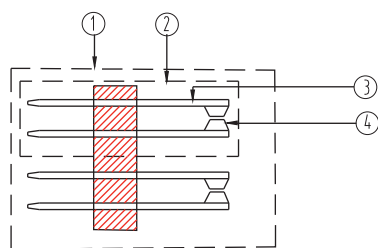


Fig.3 Contact set

- (1) contact set
- (2) contact circuit; output circuit
- (3) contact member
- (4) contact point

Contact point

Part of a contact member at which the contact circuit close or opens (see Figure 3).

Contact Resistance

Resistance or voltage-drop measured from the contact terminals when they are closed.

Notes: GJB specifies that the measuring part shall be within 3.2mm from terminal end.

Contact Gap

Gap between the contact points when the contact circuit is open.

Creepage Distance

The shortest path along the surface of an insulating material between the two reference points.

Clearance

It is the shortest straight-line distance in air between the two reference points.

Shelf Life

The shelf duration interval when the relay cannot put into operation but can store before the relay's unstable change appears and when the relay cannot operate its function according to the concerned specs.

Confidence

Probability of estimated correctness.



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Contact load categories - GB definition(that is IEC terminology)

CC0: A load characterized by a maximum switching voltage of 30mV and maximum switching current of 10mA

CC1: A low load without contact arcing.

NOTE Arcing with a duration of up to 1ms is disregarded.

CC2: A high load where contact arcing can occur.

Low level 10 μ A \times 50mV to 10mA \times 6V

Intermediate 10mA \times 6V to 100mA \times 28V

High level > 100mA \times 28V.

Load Types

Resistive: GB specified: $L \leq R \times 10^{-6}$; or $L \leq 10^{-4}$ H (R- Ω , L-H)

GJB specified: $L/R \leq 0.4$ ms; AC: $\cos\Phi = 1$ 0-001

Inductance: $L/R = 0.005s \pm 15\%$, load range: <250V, <1A, used for communication, dataprocessing

$L/R = 0.040s \pm 15\%$, load range: 0.02-600V, <100A, AC: $\cos\Phi = 0.4 \pm 0.1$.

Note: allow to use other than 0.040s, yet consent is required between the manufacturer and the user.

Categories of protection

GB(IEC)specified:

RT0: Unenclosed contact Relay not provided with a protective case.

RTI: Dust protected relay Relay provided with a case which protects its mechanism from dust.

RTII: Flux proof relay Relay capable of being automatically soldered without allowing the migration of solder fluxes beyond the intended areas.

RTIII: 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.

NOTE In service, this type of relay is sometimes vented to the atmosphere after the soldering or washing process, in this case the requirements with respect to clearances and creepage distances can change.

RTIV: Sealed relay Relay provided with a case which has no venting to the outside atmosphere, and having a time constant better than 2×10^4 s in accordance with IEC 60068-2-17.

RTV: Hermetically sealed relay Sealed relay having an enhanced level of sealing, assuring a time constant better than 2×10^6 s in accordance with IEC 60068-2-17.

GJB specified:

Dust cover;

Plastic seal: Leakage ratio $\leq 1 \text{ Pa} \cdot \text{cm}^3/\text{s}$;

Hermetic seal;

Effective cavity inside the product $\geq 33 \text{ cm}^3$, Leakage ratio $\leq 1 \times 10^{-1} \text{ Pa} \cdot \text{cm}^3/\text{s}$,

Effective cavity inside the product $< 33 \text{ cm}^3$, Leakage ratio $\leq 1 \times 10^{-3} \text{ Pa} \cdot \text{cm}^3/\text{s}$.

Leakage Ratio

The dry air volume passing through one or several leakage channels per sec. under high pressure 101.3kPa and low pressure 0.13 kPa at 25°C. The unit is $\text{Pa} \cdot \text{cm}^3/\text{s}$.

Basic Module

Module is a unit of size used as an increment in module co-ordination(ISO standard 1791) Basic module(M) is a step in a grid system as shown Fig 5.

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Fig.7 Relay connect in parallel II

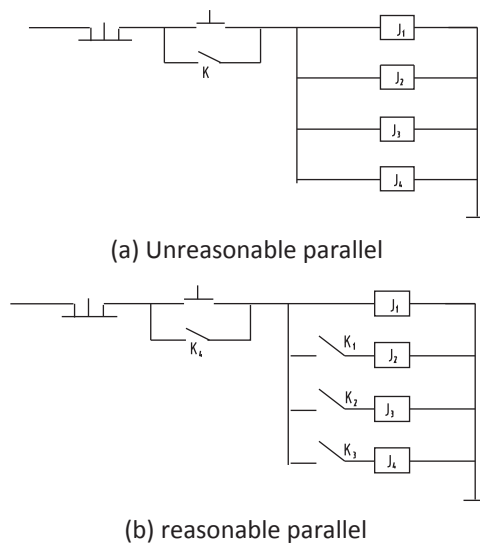


Fig.8 Relay connect in parallel III

D. Contact

1) General requirement

Contact shall be used based on rated load nature of the contact size, its upper limit shall not exceed the upper rating limit, and the lower limit shall not exceed the lower requirements. It is easy to have problems if contact not used within specs scope.

It is one of the methods to improve the reliability by use at lower rating, but be careful when decreased to intermediate current, especially at high temperatures. The relay contacts which can switch 10A reliably, may not be able to perform reliably at low current level; A product which can work reliably at rated load and low-level current, not necessarily reliable under intermediate current.

Should not improve contact rated load by using two contacts in parallel, nor enhance the rated voltage by application of contacts in series, because contacts do not always move simultaneously. When using redundancy technology to improve system reliability, pay attention to contact failure modes and failure mechanism. Two relay contacts connecting in parallel may make contact first off then on visa versa. When paralleling one relay contacts, it is important to the standards in accordance with, transfer time definition in MIL conclude several group of contacts, yet transfer time definition in IEC conclude only one group of contacts, not guaranteeing two pairs of contact group of the same product do not bridge connecting. Furthermore, the existing MIL-PRF-39016E on the contact first break then make testing is wrong. (see section 4.8.8.4.1 in M39016), need to implement the MIL-PRF-39016F: 2002 on testing method. However, its specified transfer time is only more than $1\mu\text{s}$. By the way, the definition of transfer time in IEC 61811-50, -53 and -54 and -55 is similar with that in M39016F, but these standards for minimum transfer time specifies $100\mu\text{s}$ min.

Relay cover is marked with only the rated resistive load value, the ratings of other nature and the smallest rated load should check the product detailed specifications or obtain the related materials from manufacturer.

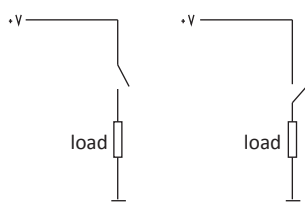
The relay which can switch single-phase AC power supply does not necessarily to be suitable to switch 2 non-synchronous single-phase AC load. Any product being used with more than 10mA/6V (resistive) or being tested is no longer recommended for low-level.

2) Contact Connect

Contact circuit and its symbol, see section 6. C.2).

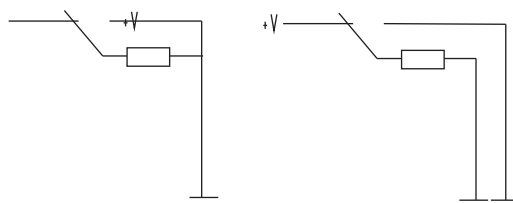
Connection of load circuits impact a lot on the contacts performance reliability. Figure 9 (b) is more reasonable than Figure 9 (a), because the former arcing time is half shorter than the latter. Figure 10 are two unreasonable connection, especially in motor load, inductive load or capacitive load.

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(a) Unreasonable

Fig.9 connection



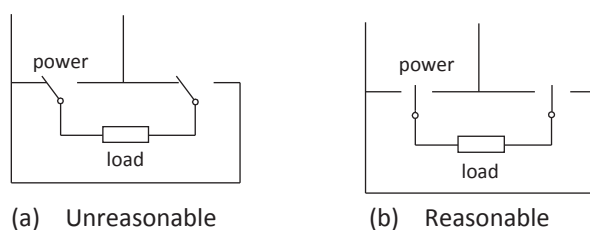
(b) Reasonable

Fig.10 Unreasonable load circuit

For phase conversion, polarity conversion load, three location contacts (E type) should be selected, such as Figure 10 and Figure 9 (b), yet, Figure 9 (a) is not recommended, unless authorized by manufacturer, at this time, product should have specific time for conversion, its life test should be in accordance with IEC 61810-1:2008 and IEC 61810-7:2006 requirements.

Contact between metal:

Contact with different metals can form electrolytic potential, at moisture or corrosive atmosphere, due to the impact of original battery, it will accelerate corrosion. Relevant relay standards require that the coupling between different metal potential difference must not exceed 0.25V. Table 4 gives commonly used metal electromotive force (with silver as the base) and permitted coupling of the metal. If the coupling after electromotive force more than 0.25V, the metal should be plated with another metal on, so as to ensure coupling electromotive force less than 0.25V.



(a) Unreasonable

(b) Reasonable

Fig.11 Polarity conversion

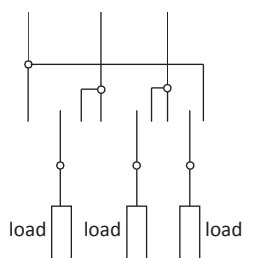


Fig.12 Phase conversion

E. When the contact load > CC1, there will be arcing, along with sparks and metal flying, therefore, RTO products are forbidden on PC board. RTO and RT I products are forbidden under explosive atmosphere or heavier wind sand condition, preferably RT 4 or RT 5 Products are recommended.

Although relay has certain anti-interference ability, but relay should not be installed near big magnetic field, unless being magnetic shielded, because of limited anti-interference ability. The interval between several relays installed side by side should be 1mm at least.

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When install relays, do not hit on relays or bend the leads. For bolt or screw terminal installation, the torque should not be greater than the values listed in Table 5. If the terminal leads are too long, it is better to contact with manufacturers to get shorter leads products. The users should not cut leads short themselves.

Table5 : Bolt Twisting Force Value (Nm)

Bolt specs		M2.5	M3.0	M3.5	M4.0	M5.0	M6.0	M8.0
For wire connection	head-in	0.40	0.50	0.80	1.20	2.00	2.50	
	head-out	0.20	0.25	0.40	0.70	0.80		
For terminals		0.40	0.50	1.00	2.28	4.00	8.00	11.00
For mounting			1.00	2.00	4.20			

F. Relay soldering and Cleaning

1) Mounting

Avoid bending the terminals and hitting the relay. A bent terminal will not assure relay characteristics, especially a sealed relay. If the terminal is too long, please ask the manufacturer to make a short one, not to cut by yourself.

2) Flux coating

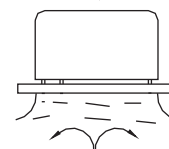
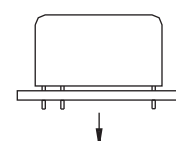
Do not overflow onto the top of PC board. Use rosin-based flux, not to use acid-based flux. Automatic flux coating is just suitable for sealed type relay, hand flux coating shall be used for dust-cover type relay.

3) Preheating

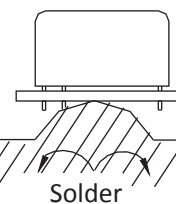
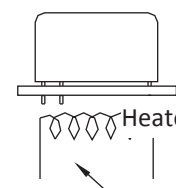
Preheating acts to improve solderability, but the preheating temp. shall not be over the highest temp. designed with the product.

4) Soldering

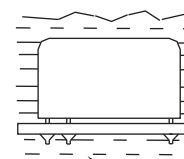
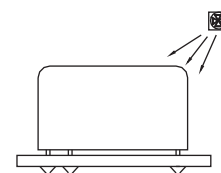
The use of pure tin is not allowed, when using Sn-Pb alloy, Pb≥3%.



Foamed flux



Solder



Washing Solvent

Table 6: Relay Soldering

Automatic soldering	Hand soldering
Wave soldering	Electric iron
No solder overflow PC board	Iron power 30-60W
Solder temp > 250°C (482°F)	Iron power ≥ 300°C (572°F)
Solder time ≤ 5s	Solder time ≤ 3s
Tin: H63, H65 or H1SnPb10	Tin: H63, H65 or H1SnPb10

Note: Soldering temperature with non-lead solder material should increase by 30°C.

5) Cooling

An immediate cooling after soldering, avoid using frozen gas blow. Clean relay when its temp. is back to the room temp. Avoid of terminal cut if terminal cut is carried out, breaking of wire at a coil may be caused by vibration of a catter.

6).Cleaning

Immersion cleaning is just suitable for sealed type relay. Avoid ultrasonic cleaning. Avoid the cleaning solvent penetrate the relay when brushing clean the relay. Use alcohol cleaning solvent. After cleaning, open the vent hole if there is one in the case, but avoid the solid particle dropping into the relay.

G. The contact between metals:

The contact between different metals will produce couples-potential difference, in the atmosphere of moist or corrosion, it will speed the corrosion by the effect of primary battery . The relative standard of relay have stipulated that the coupling potential difference should not be over 0.25V. The table 9 has listed common metals electromotive force (basic standard by silver) and compatible coupling metals. Ought to plate anther metal on the coupled metal to ensure coupled electromotive force being less than 0.25V, if the electromotive force is over 0.25V after coupling.



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Group No.	Metallurgical category	EMF V	Anodic index 0.01V	
1	Gold, solid and plated; gold-platinum alloys; wrought platinum (most cathodic)	0.15	0	○
2	Rhodium plated on silver-plated copper	0.05	10	● ○
3	Silver, solid or plated; high silver alloys	0	15	● ● ○
4	Nickel, solid or plated; monel metal high nickel-copper alloys	-0.15	30	● ● ○
5	Copper, solid or plated; low brasses or bronzes silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion-resistant steels	-0.20	35	● ● ● ○
6	Commercial yellow brasses and bronzes	-0.25	40	● ● ● ○
7	High brasses and bronzes, naval brass; Muntz metal	-0.30	45	● ● ● ○
8	18 percent chromium type corrosion-resistant steels	-0.35	50	● ● ● ● ○
9	Chromium, plated; Tin, plated; 12 percent chromium type corrosion-resistant steels	-0.45	60	● ● ● ● ● ○
10	Tin-plate; tinplate; tin-load colder	-0.50	65	● ● ● ● ● ○
11	Lead, solid or plated; high lead alloys	-0.55	70	● ● ● ● ● ○
12	Aluminum, wrought alloys of the duralumin type	-0.60	75	● ● ● ● ● ○
13	Iron, wrought alloys other than duralumin type; aluminum, case alloys of the silicon type	-0.70	85	● ● ● ● ● ○
14	Aluminum, wrought alloys other than duralumin type; aluminum, case alloys of the silicon type	-0.75	90	● ● ● ● ● ○
15	Aluminum, cast alloys other than silicon type; cadmium, plated and chromated	-0.80	95	● ● ● ● ● ○
16	Hot-dip-zinc plate; galvanized steel	-1.05	120	● ○
17	Zinc, wrought; zinc-base die-casting alloys; Zinc, plated	-1.10	125	●
18	Magnesium and magnesium-base alloys, cast and wrought (most anodic)	-1.60	175	●

Note: Compatible couples-potential difference of 0.25V maximum between groups;

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wires		Material	bareness single wire (A)	Non-bareness Wire or handle conductor (A)	Material	bareness single wire (A)	Non-bareness Wire or handle conductor (A)
Diameters (mm)	area (mm ²)						
0.50	0.20	Cu	11 16 22 32 41 55 73 101 135 181 211 245 283 382	2 5 7.5 10 13 17 23 33 46 60 80 100 125 150 175 200	Al	60 83 108 152 174 202 235 266	36 50 66 82 105 123 145 162
0.60	0.28						
0.80	0.50						
1.00	0.79						
1.25	1.23						
1.60	2.01						
2.00	3.14						
2.80	6.16						
3.15	7.80						
4.00	12.57						
5.60	24.63						
6.50	33.18						
7.20	40.72						
8.00	50.27						
9.00	63.62						
11.00	95.02						

(4) Users should select the appropriate relay based on the conditions of operation.

(5) Manufacturers should provide the necessary data such as the reliability of the rated life expectancy and its failure rate (including the confidence level) and cautions at use.

REFERENCE DOCUMENT

[1] MIL-PRF-39016F:2002;MIL-PRF-32140:2004;MIL-STD-217F:1991;MIL-STD-1346B:1985;

[2] GB/T 2900.63;GB/T 21711.1-2008;

[3] NARM:«Engineers' Relay Handbook»1990;

[4] IEC 60255-23:IEC 61709:1996;IEC 61810-1:2008;IEC 61810-2:2005IEC 61810-7:2006;

[5] GJB 65B-94,GJB 360A-96; GJB 548;GJB 1461-92;

[6] Zhou Jian-xiong:“JRC-490M Design of Ultra-compact Sealed DC Electromagnetic Relay”, Electrical components,1998 NO.2.

[7] Electronics Standardization Institute:“The Base of Reliability” 1980.

[8] Zheng Tian-pei:“Inspection of Electromagnetic Relay” Ningbo Forward Relay Corporation Ltd.2006

[9] Zhang Jiao-suo:“The Research of Relay Arc Phenomenon and Its Parameters Test”, master's thesis of Xi'an Jiaotong University 1987

[10] Ningbo Forward Relay Corporation Ltd “Product Catalogue”2005

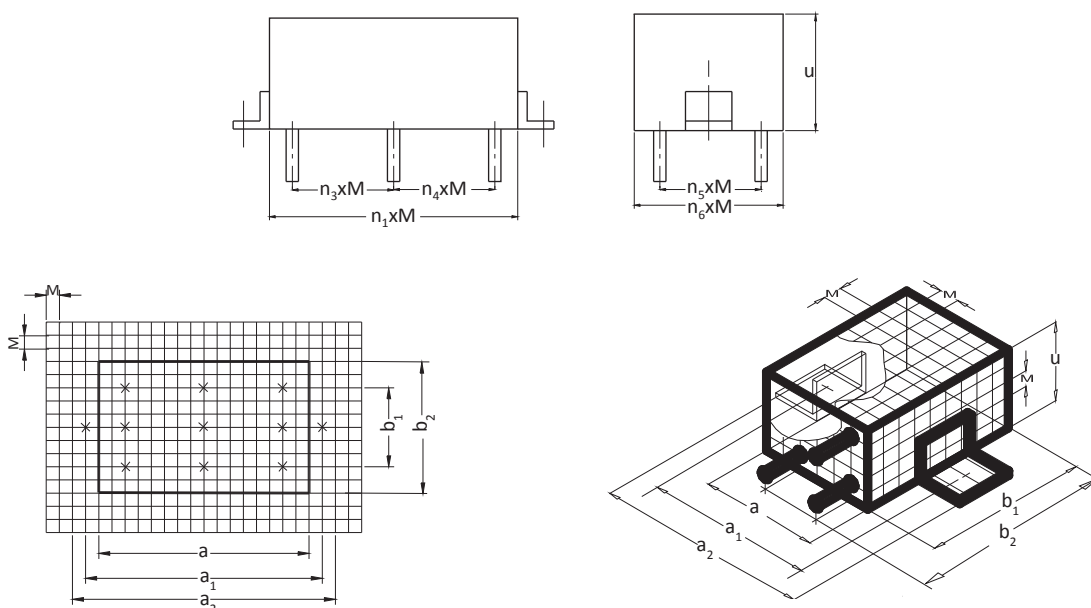


Fig.4 Basic Module

3.CONCERNED STANDARD INTRODUCTION (Just for controlling Relays)

The standard of People's Republic of China(GB) is identical with IEC(International Electromechanical Commission),while the military standard of PRC(GJB) is identical with MIL(America Military) standard. They are specified as follows:

Table of Standard Contents

- IEC 61810-1 "Electromechanical elementary relays Part 1:General and safety requirements"
- IEC 61810-7 "Electromechanical elementary relays Part 7:Test and measurement procedures"
- GB/T10232-94 " Electrical Relays Part 7:Test and Measurement Procedures for electromechanical All-or-Nothing Relay"(equal to IEC 255-7)
- GB/T 14598.1-2002"Electrical Relays Part 23:Contact Performance"(IEC 60255-23:1994 IDT)
- GB/T 14598.2-93"Electrical Relays All-or Nothing Electrical Relays"(IEC 255-1-00 IDT)
- GB/T 14598.3-93"Electrical Relays Part 5:Insulation tests for Electrical Relays"(IEC 255-5 IDT)
- GB/T 14598.4-93"Electrical Relays Part 14:Endurance Test for Electrical Relays Contacts-Preferred Values for Contact Loads"(IEC 255-14 IDT)
- GB/T 14598.5-93"Electrical Relays Part 15:Endurance Tests for Electrical Relays Contacts Specification for the Characteristics of Test Equipment"(IEC 255-15 IDT)
- GB/T 14598.6-93"Electrical Relays Part 18:Dimensions for General Purpose All-or-Nothing Relays"(IEC 255-18 IDT)
- GB/T 14598.7-95"Electrical Relays Part 3:Single Input Energizing Volume Relay with Timing Limit and Self Timing Limit"(IEC 255-3 IDT)
- GB/T 14598.8-95"Electrical Relays part 20: Protective System"(IEC 255-20 IDT)
- GB/T 14598.9-95"Electrical Relays Part 22:Volume Relay and Protective Device Electrical Distribution Test, Part 3 Electromagnetic Field Distribution Test"(IEC 255-22-3 IDT)
- GB/T 14598.10-96"Electrical Relays Part 22:Volume Relay and Protective Device Electrical Distribution Test, Part 4 Fast Instant Distribution Test"(IEC 255-22-4 IDT)
- GB/T 14598.11-1997"Electrical Relays Part 19: Sectional Specification Electromechanical All-or Nothing Relays of Assessed Quality"(IEC 255-19 IDT)
- GB/T 14598.12-1998"Electrical Relays Part 19: Blank Detail Specification Electromechanical All-or Nothing Relays of Assessed Quality Test Schedules 1, 2 and 3"(IEC 255-19-1 IDT)
- GB/T 16608-2002"Electrical Relays Part 10: Application of the IEC Quality Assessment System for Electronic Components to All-or-Nothing Relays"(IEC 255-10 IDT)
- GJB 65B-99"Relays, electromagnetic , established reliability, general specification for"(MIL-R-39016E IDT)
- GJB 1042A-2002"Relays, electromagnetic, general specification for"(MIL-R-5757H IDT)

Relay General Application Guidelines

GJB 1461“Relays electromagnetic including established Reliability Type, general specification for” (MIL-R-6106J IDT)

GJB 1513“Relays ,hybrid and solid state, time delay, general specification for”(MIL-R-83726B IDT)

GJB 1514“Relays ,mercury wetted reed, general specification for”(MIL-R-83407 IDT)

GJB 1515“Relays ,solid state, general specification for”(MIL-R-28750 IDT)

GJB1930“Switches, reed, general specification for”(equal to MIL-S-55433)

GJB2449“Relays , electromechanical ,general purpose ,non-hermetically sealed, plasticenclosure, general specification for” (equal to MIL-R-83520)

GJB2888“Relays ,electromagnetic, power switching , established reliability, general specification for” equal to (MIL-R-83536)

4. GENERAL REQUIREMENTS

A. Safety

1) Life and property safety, and pollution free

Relay should maximize the use of environmental protection materials, recyclable materials and regenerated materials. Materials should be able to self-extinguishing, Not self-ignition, non-combustion, non-release harmful levels of gases (such as to enable cover explosion, toxic or to contaminate contact); at a longer period of time (3 ~ 7 years), no transformation, non-deformation; plastics used must be thermosetting, no cotton or wood filler; reinforced plastics should not release solid particles in the thermal shock; leak test should not use silicone oil; external part shall have zinc plated; forbidden or less use of the following 18 kinds of materials, use only when other materials can not meet the performance requirements, these materials are:

Chromium and its compounds, cadmium and its compounds, lead and its compounds, mercury and its compounds, nickel and its compounds, benzene, toluene, xylene, dichloroethane, chloroform, trichlorethylene, tetrachlorophthalic ethylene, tetrafluoroethylene CFC, MEK, Freon, cyanide and its compounds, methyl isobutyl ketone, magnesium and its compounds.

Others, such as electromagnetic interference, radio frequency interference, noise and electromagnetic compatibility and other restrictions should also be limited.

Some European users claim not to use poly PBDE (PBDE), poly biphenyls (PBB) and perfluorooctane acid (PFOS) (as a flame retardant).

2)Normal performance under predictable environment

That is environmental adaptability, such as insulation (including lightning strikes, electrical clearance, creepage distance, etc.), dangerous fire test, heat and flame resistance, PTI, flame, electromagnetic interference and mechanical stress (vibration shocks, centrifugation, etc.) and some climate parameters (climate cycle, thermal shock, humidity, salt spray, thermal resistance, dust, solvent resistance and fluid contamination, etc.). Furthermore, products and their packages should be able to withstand rough road transportation, such as vibrations and swing tests, as well as storage test.

Material highest temperature specified and its proof should be in line with IEC 60695-2-10 and IEC 61810-1:2008 Article 16. Material should be subject to IEC 60695-2-12 (flammability index) and IEC 60695-2-13 (ignition temperature) test.

B. Quality consistency

Product selection can get away failed product at early stage and improve the reliability of the entire batch of products, but the selection can not improve the reliability of single product. It should not rely on selection to get best individual product from a lot. Therefore, 100% test items (such as hand-over inspection), if the failure number is cumulatively more than 10%, the entire batch should be rejected.



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C. Useful life and failure rate

There are two ways to express product function reliability

1) In determining the percentage of failure (also known as the cumulative failure rate) under the cycle number, that is, the useful life expectancy. On behalf of IEC 61810-2:2005 and MIL-PRF-32140: 2004. The former specifies failure percentage as 10%, confidence level as 90%. The later specifies a cumulative failure rate as 1%, confidence level as 95%. Both get from Weibull distribution.

2) The largest failure rate within useful life expectancy, it represents in M39016E, M6106J, M83536A and IEC 60255-23. MIL indicates product failure rate got from index sub-layout, classification and upgrading test confidence level as 90%, the maintenance of test confidence level as 60%. IEC is got from Weibull distribution.

Note: a) The failure rate and useful life provided by manufacturers are got from testing lab, not the user's actual failure rate at the time of use, the conversion relations is referred in item 5.1.

b) As the test data is obtained from a test laboratory, there is an issue of confidence level $(1-\alpha)$, that is, the probability estimates are right. In other words, users have certain risk, the risk is (α) .

D. Quality assurance

1) Quality assurance systems: Quality assurance systems are ISO9001, ISO14001, ISO/TS 16949, QS 9000 and GJB 546 and GJB/T 9001.

2) Testing instruments and equipment

Modern industrial production approach great importance to SPC (statistical process control), it requires data to do statistics, requires inspection to get the data. In relay manufacturing process, (regardless of semi-automatic automatic manufacturing) have several quality control points, inspecting a certain number of parts and components every day from time to time for quality control and supervision. There are dozens of items in ISO9001 mentioned about inspection and testing. There are two key factors in inspection and testing: First is testing instruments and equipment; second is testing standards. This is also one of the key parts in Quality Assurance, One of five elements in QS9000 is MSA (Measurement Systems Analysis).

Detected by the instrument, equipment must go through the standardization of the review should be subject to a considerable level of identification of sector organizations. Detected used instruments, equipment, testing theory, testing methods, and add stress, data collection and failure criterion must be consistent with existing standards, and even nouns, terminology. Instrumentation, the life should not be based on the length of time should be based on compliance with existing criteria. Their regular school certificates and seized standard should be marked on the name, standard number and year of release. Instrumentation, equipment manufacturers and the supplier should provide a measurement system analysis (including error analysis) and identification of certificate, identification certificate shall be marked with the name of the standard, the standard number, version and release year, rather than marked in line with the general MIL or IEC. Standard of care in general a few years will be revised or updated.

Domestic relay the relevant standards are generally equivalent to the corresponding international standards, GJB equivalent MIL, such as GJB 65B-99 idt MIL-PRF-39016E: 1994; GB / T equivalent to IEC, such as GB / T 10232-93 idt IEC 255-7 : 1991, but often after several years later. Such as MIL-PRF-39016F: 2002, MIL-PRF-32140: 2004 or IEC 61810-1:2008, IEC 61810-2:2005 and IEC 61810-7:2006 (the predecessor of which is IEC 255-7), etc. At present, no equivalent to the corresponding standard.

5. SELECTION OF RELAY

It is an important aspect to have relay reliable performance for users to select proper relay according to their usage conditions and requirements, some cases are listed in Table 1 for user reference.

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Table 1 Relay parameters and their using conditions

Item	Using Conditions	Requirements	Remarks
Energizing condition	DC or AC Rated Value	DC or AC relay Rated voltage U_c Pick-up voltage $U_b \leq 75\%U_c(\text{DC})$ $\leq 85\%U_c(\text{AC})$ Release voltage $U_f \leq 10\% \sim 5\%(\text{DC})$ $\leq 15\%U_c(\text{AC})$	AC relay shall specify 50Hz or 60Hz Tolerance: MIL $\pm 10\%$, IEC $\pm 5\%$. When voltage from $U_b \rightarrow U_c \rightarrow U_e$ or from $U_f \rightarrow 0 \rightarrow U_a$ (non-operate voltage), contact is not allowed to change status (break or re-close),except for normal contact bounce back Measurement should be done at three axles.
	Output power Power supply res R_s (or Z_s) Max environmental temp T_{max} Provide DC supply by using component or filter, Continuous working (energizing) for several days	Coil consumption(W) Coil resistance R_0 (or Z_0)should > 20 times R_s or Z_s Max allowed working temp T_{max} Heat resistance= $\Delta T/W$ Temp rise $\Delta T = \text{material temp} - T_{max}$ When component anti-voltage at $\leq 10U_c$,should have coil Latching relay	Tolerance $\pm 10\%$ Base temp 23°C Any transient suppression will affect relay pu-in and drop-out time as well as life.
Load switching	Switching mode and load numbers, phase transfer. Rated load nature & level. allowed contact circuit consumption	Contact mode and load numbers Best to select(K)type contact Rated load nature, max value and min value Pay attention to inrush current of special load. Contact circuit resistance(or voltage drop)and its stability. That is under U_b, U_c, U_e and $U_f, zero, U_a$ contact circuit resistance and difference of max and min.	Contact types referring to table 2 Tolerance $\pm 10\%$; inrush current of special load referring to table 3. Difference of max and min contact circuit resistance should be $\approx 10\%$ of beginning value. Step function testing, test per each cycle, total 3 times.
	allowed contact circuit resistance abnormal change time. Rated life Failure rate	If $< 10\mu\text{s}$, it should be specified in the contract Rated life(whether with reliability) Failure rate under different rated loads	IEC specify any abnormal changes less than $10\mu\text{s}$ is to be ignored Best value under T_{max} Failure ratio of middle level current under high temperature specify separately. Manufacturer should provide magnet route structure type
Time parameters	Max switching ratio	max switching ratio = $\frac{0.1}{t_0 + t_r}$ (time/s) t_0 operate time, t_r release time	Higher level (or CC2) should reduce
	Allowed max switching time	time for contact to stable closing (or break) t_c	
	Transfer time	Transfer time t_s	$t_s \geq 1\mu\text{s}(\text{MIL})$ or $t_s \geq 100\mu\text{s}(\text{IEC})$

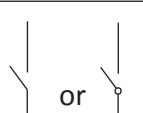










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Table 1 Relay parameters and their using conditions

Item	Using Conditions	Requirements	Remarks
Environmental condition	Environmental temp PC Board use	Allowed operating temp range Not to select RT0, should select RTII ~ RTV solder ability solder heat-resistant	Terminal pin space distance and mounting holes space distance is full times of 0.508mm. Pb free solder material is 30°C higher than that of Pb solder material
	1000m above high air space or high vacuum	Low air pressure Best to select latching relay	
	Used on transport equipmet (tools). damp or corrosive	It is better to add bumps and (or) swing tests besides vibration shock and centrifuge tests. Relative humidity, salt spray, solvent resistant and fluid tests	Discuss with manufacturer for specific requirement
	gases containing explosiv gas place sensitive to electromagnetism	Should select RTIV or RTV Electromagnetic Compatibility	Manufacturer should provide effective internal space for the produc in accordance with GJB 151A and GJB 152A, discuss with manufacturer for specific request.
	Several products side-by-side or near large current line	Electromagnetic interference	
	Insulation property	Insulation resistance, Dielectric strength (including lightning strike) clearance, creeping distance, PTI	
	Mounting method socket	Mounting method Contact resistance between relay terminal pin and socket	May be measured with contact circuit in the socket
	Safety certificates	UL, VDE, TÜV, CCC, CQC etc.	
	For special items, try to find the relevant standards, if there is no standards to be based on, should try to put forward specific quantitative requirements and test methods.		
Notes:	Unless otherwise specified, all electrical and mechanical and environmental parameters tolerance is ± 10% It shall be speculated in the contract if there are other requirements, as when there.		

Table 2: contact arrangements

Name	SPSTNO	SPSTNC	SPDT(B-M)	SPDTNO	SPDT(M-B)	SPSTNODM	SPSTNCDM	
Marks	 or 				 or 			
Alphabet Lettet	China	H	D	Z	E	B	SH	SD
	USA	A	B	C	K	D	U	V

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Table 3: Types of loads and level of inrush current

Types of loads	Level of inrush current	Inrush time(s)	Remarks
Resistive	Steady current		$L \leq 10^{-4}H$ or $\cos\phi = > 0.95$
Solenoid	10-20 times as large as the steady current	0.07-0.1	Shall be regarded as inductive load, but $\tau = L/R < 10^{-4}s$ can be regarded as resistive load
Motor	5-10 times as large as the steady current	0.2-0.5	Can replace the test with 5-6 times current resistive load
Incandescent lamp	10-15 times as large as the steady current	0.34	
Mercury lamp	About 3 times as large as the steady current	180~300	
Flourescent lamp	5-10 times as large as the steady current	≤ 10	
Sodium vapor lamp	1-3 times as large as the steady current		
Condenser	20-40 times as large as the steady current	0.01-0.04	Long transfer wire, fiter, power source shall be regarded as capacitive load
Transformer	5-15 times as large as the steady current		
Contacto	3-10 times as large as the steady current	0.02-0.04	

6. The use of Relays

A. Reliability and an average failure interval

Reliability, as mentioned above, there are two expressions: one for rated life expectancy under certain failure percentage (cumulative failure rate); one for the greatest failure rate within a given life expectancy period. The former is raised after 2004.

1.) Reliability level

Reliability $R(t)$ according to the definition of probability theory, there is $R(t_0) = 1 - F(t_0)$, $F(t)$ for the cumulative failure rate (or failure percentage). If t_0 for useful life expectancy with reliability index, according to IEC 61810-2:2005 provisions, $F(t_0) \leq 10\%$, confidence level is 90% then there is reliability of $R(t_0) = 1 - F(t_0) = 90\%$, the user's risk 10%. In accordance with MIL-PRF-32140: 2004 requirements, $F(t_0) \leq 1\%$, confidence level is 95%, then there is reliability degree of $R(t_0) = 1 - F(t_0) = 99\%$, the user's risk is 5%.

Note: a) IEC and MIL get useful Life expectancy (t_0) and the reliability $R(t_0)$ by using Weibull distribution.

b) Different rated load has a different failure mode and mechanism, so a Weibull straight line can only represent one rated load.

c) The rated life expectancy (t_j) of a product without reliability specs, naturally not have $R(t_j)$ values, it is not subject to restrictions of the failure percentage, only pass or failure.

2.) Mean operating time between failures MTBF

Accrding to the definition of $MTBF = 1 / \lambda$, the failure rate provided by the manufacturers is not the actual failure rate in use, user's failure rate λ should be converted based on actual usage conditions and product magnetic circui.

Military product in accordance with MIL-STD-217F: 1991 has $\lambda = \lambda_T \cdot \pi_L \cdot \pi_Q \cdot \pi_E \cdot \pi_C \cdot \pi_{CY} \cdot \pi_F$ unit Fitow or h^{-1} . Note: π_F for structural parameters, related to the magnetic circuit structure. (See Appendix A)

Commercial products in accordance with IEC 61709:1996, has $\lambda_c = \lambda_r \cdot \pi_{ES} \cdot \pi_s \cdot \pi_T$ unit1 / cycle. λ_R in the formula is failure rate provided by the factory, π for a variety of factors (see Appendix A).

$\lambda = f \cdot \lambda_c$, f for actual motion of each h.



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Note: a) MIL λ_R is got by exponential distribution, and samples under test are equally patterned in accordance with the rated load, therefore, in terms of single rated load, the number of samples are not in conformity with a given failure rate by number of samples required. Furthermore, grading and upgrading qualification test confidence level 90%, user's risk 10%; maintaining qualification test confidence level 60%, user's risk is 40%.

b) M39016F specify high-temperature intermediate-current (100mA/28V) is not included in the failure rate calculation, but required samples number is 4, per action motion 5×10^4 times, one failure is allowed. If the intermediate-current test fails, the failure rate qualification test is still determined as a failure.

I think for the products with reliability specs, it is significant benefit for the users to determine the system reliability and estimate working hours if manufactures can provide useful life expectancy and failure rate under assured failure percentage, because the former can not determine failure rate of each motion within the life expectancy, while the latter can not determine the reliability level within the life expectancy.

B. Incoming inspection

Products must have a factory test certificate, if necessary, a third-party inspection report is required. Condition allowed, incoming inspection should be done, pay attention to the following for incoming inspection

- 1) Documentation procedures: order contract - product detail specs - general specification - quality assurance regulations, documents.
- 2) Inspection and testing instrument and equipment should be in accordance with the requirements of 4.D).2.
- 3) Manufacturer should give priority to the use of general specs or standards for test circuit and (or) equipment to make the testing, it is acceptable to use the same effective other testing methods due to production or other request, but the equivalent method must be approved by the qualification department or user. In case of dispute, arbitration is referred based on general specs or standard,.
- 4) Inspection and testing must be done in accordance with the relevant standards, including the measurement sequence. Product detail specs, general specification and relative standards should be the most latest updated and effective version.
- 5) Other cautions:
 - a) Unless otherwise specified, before the test. the product should not be damage or non-destructive treatment which may make the test results invalid.
 - b) The previous item measurement should not make the next item measurement invalid.
 - c) Testing should not bring any pollution and damage to the products.
 - d) Measurement should be repeatability and reproducibility.
 - e) It is better to have statistical analysis on the batch test results.

The relevant detailed information regarding testing, please see the "Electromagnetic Relay Testing " published by Ningbo Forward Relay Corporation Ltd. in 2006.

C. Coil

1)General requirement

Power: Power adjustment rate should be $\leq 5\%$, the ripple of DC power supply should be $<6\%$ peak - peak cycle and random drift $<1\%$; AC power should be sine wave, waveform coefficient between 0.95 ~ 1.25, waveform distortion $< 1\%$.

Energizing amount: rated value (including polarity). If there are no other requirements, tolerance is $\pm 10\%$. Actual to be zero under release status, voltage caused by the leakage current should be $<2\%$.

Note: a) The use of any coil voltage less than the rated coil voltage will compromise the operation of the relay .

b) pick-up, hold and release voltage for test purposes only, are not to be used as design criteria.

c) NARM states in "Engineer's Relay Handbook" 15.3.7: " relay should not work under pick-up voltage.

d) when energizing is too high, the higher part after pulling-in will be converted mostly to heat and flux leakage, more harm than good.

Energizing time: relay at continuous work should be energized continuously; magnetic latching relays energizing time is three times the operate or release time, whichever is greater; for the dual-coil magnetic latching relay, two coils should not be energized at the same time.

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Suppression circuit: it is not recommended for the users to add their own suppression circuit, any transient suppression circuit will extend the action or (and) the release time, affecting life expectancy. If needed, consult with the manufacturers and state in the contract, it is best to have the factory to provided, where necessary, to carry out life test.

2)Circuit Connection

MIL specify the circuit diagrams should be printed on the relay cover in the following way.

Circuit diagrams side face up, then turn the relay through the circuit diagram axial direction, until the lead end facing the observer. At this time, every lead at the location of the circuit diagram shown up. The coil lead positive polarity indicated by special color glass insulator. IEC standard mark number for other leads, mark "+" for coil lead.

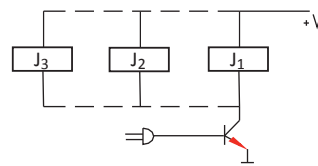


Fig.5 Transistor driven circuit

When energizing with transistors, it is important to pay attention to the relationship of leakage current and conduction voltage drop and working current, circuit as shown in Figure 5, it is OK to inspire one relay, but not functional to inspire two relays, when inspiring 3 relays, the relays will not be able to function. When several product coils in parallel, pay attention to coil counter electromotive force, because drop-out and pull-in of several products are not always at the same time. Figure 6 to Figure 8 is comparison of several commonly used circuits in parallel.

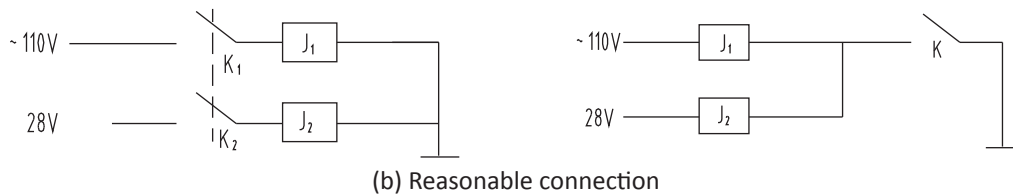
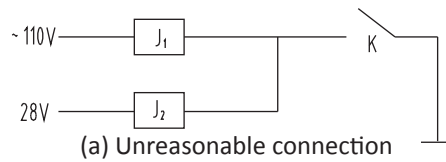


Fig.6 Relay connect in parallel I

