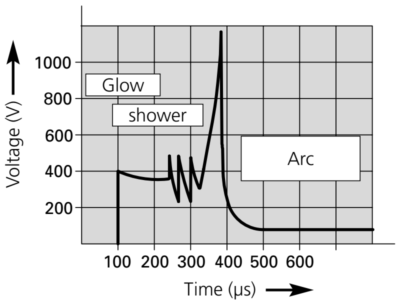
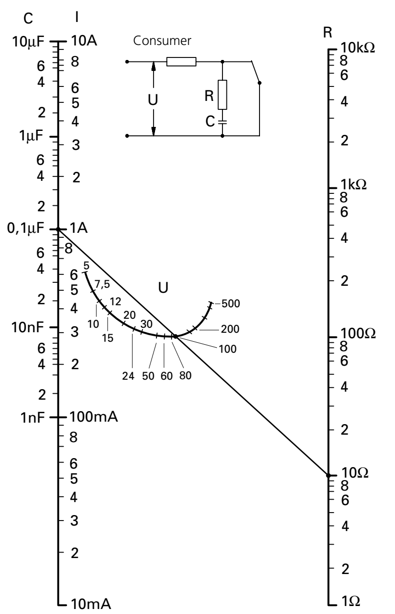
Arc extinguishing, arc suppression

If the upper limit of the arcing voltage – which depends on the switching current and contact material – is exceeded, the relay contact discharges current, leading to material degradation in the contacts. To ensure that contacts perform reliably over a long service life despite this unfavourable phenomenon, circuitry must be designed to include measures to suppress arcing for a given load.

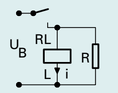
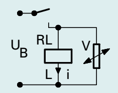
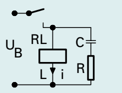
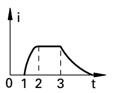
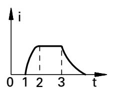
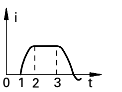
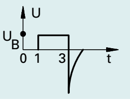
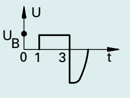
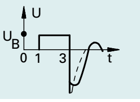
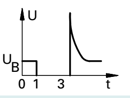
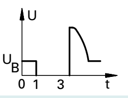
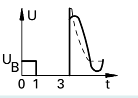
Course of voltage at relay contact with inductive load

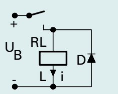
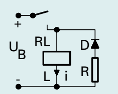
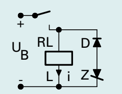
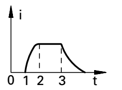
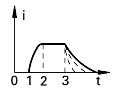
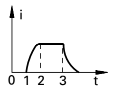
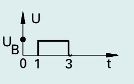
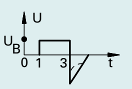
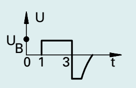
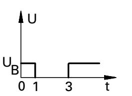
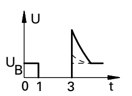
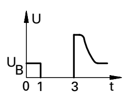


Arc suppression with RC-circuit
Diagram for determining optimum values



Example: U = 100V I = 1 A
The value for C is 0,1 µF
(Point of intersection with R = 10 Ω)

Arc suppression realised with	Resistor	Varistor	RC-circuit
Diagram			
Course of current at load			
Course of voltage at load			
Course of voltage at switch			
Advantages		Relatively short release delay	Small overvoltage short release delay
Disadvantages	Relatively long release delay	Not for all applications	

Arc suppression realised with	Diode	Diode + resistor	Diode + Zener diode
Diagram			
Course of current at load			
Course of voltage at load			
Course of voltage at switch			
Advantages	Small overvoltage	Overvoltage and release delay depends on R	Small overvoltage, short release delay
Disadvantages	Release delay very long	Release delay long	

Approvals

Approvals are copyright protected marks of institutes charged with testing components. Once a product or process has been awarded the approval after testing and evaluation, the manufacturer may affix the corresponding certificate of approval to his product or facility.

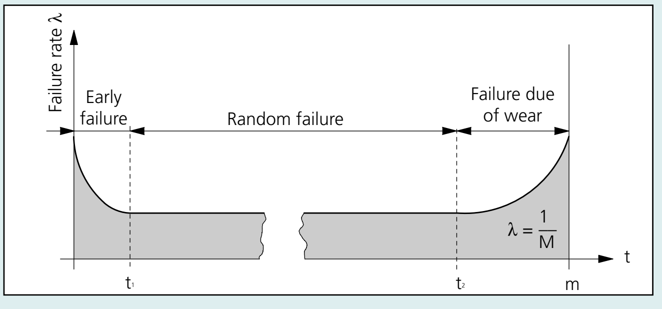
Automated soldering line proof

Automated soldering line proof relays are suitable for both automated and hand soldering. However, in flux and rinsing processes, the relays may not be immersed. Caution is also in order when cleaning agents are used. Here residue may damage the relays. These relays are often called „dust-proof".

Bathtub curve

Common term for the curve that describes the expected failure rate of electronics with time. Initially high, it drops to near 0 for the majority of the system's lifetime and rises again as it wears out.

a) **Early failure:** Here the failure rate has a distinctly declining tendency.
b) **Random failure:** Within this range, the failure rate is constant; this range is generally described as its „service life".
c) **Failure due to wear:** Here the failure rate increases as the component and material age.



Bounce

Bouncing occurs primarily when an electromechanical contact closes and the kinetic energy stored in the moving part of the contact is released, causing the part to bounce back and sever the contact. Usually this process, which is often called chatter, is repeated several times

at briefer intervals as the bouncing distance decreases. The subsequent contact tremor (oscillating contract force) is not considered as part of the bouncing process – it is actually part of the „dynamic contact resistance" or decay phase

Bounce time

According to DIN 41215, bounce time is the time elapsed between the first to the last opening or closure (make or break) of a relay contact when a relay is switching from one status to the other. The pick-up and drop off phases are not included in the bounce time.

Burnoff

Burnoff is material degradation induced by switching contact arcing.

Constant current

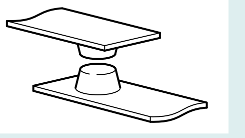
The value of the current which can be continuously applied to the relay contacts within the permissible temperature rise limit.

Contact type

– by type

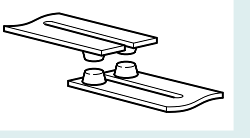
Single-Pole Single Throw

Switch with only one moving and one stationary contact. With this type of relay contact, a single pole contact is responsible for establishing electrical contact.



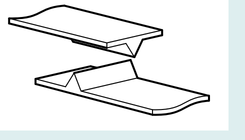
Double Pole Single Throw

A double pole consists of two contacts that operate in parallel. This enhances the contact reliability and is primarily used to switch low current and voltage circuits (dry circuits)



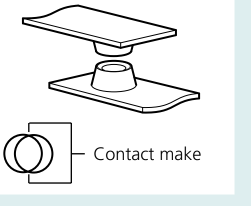
Cross contact

These rail-shaped contacts are perpendicular to each other – i.e. at a 90° angle – to form a cross.



Crown contact

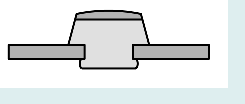
The ring of this type of contact closes at two slightly offset points. Through a relatively high amount of pressure on these points, the contact force is able to penetrate dust and debris. The contact is self-cleaning.



– by type of manufacture

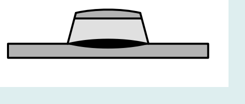
Riveted contact

The contact terminal is riveted to the contact carrier.



Welded contact

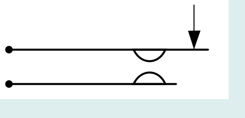
The contact terminal is welded to the contact carrier.



– by function (basic forms)

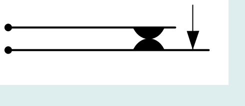
Normally open contact (N.O.)

The condition of this type of contact in its normal (unenergised) state. When the contact is energised, the circuit is opened.



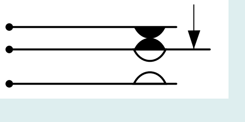
Normally closed contact (N.C.)

The condition of this type of contact in its normal (unenergised) state. When the contact is energised, the circuit is closed.



Change-over contact

A switching contact whereby the normally closed contact breaks before the normally open contact makes.



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Contact force

Contact force is the force that the contact components exert on each other is a closed state.

Contact springs

The majority of relays feature contact springs. These are subjected to mechanical, thermal and electric loads. It is essential that heat generated by flowing current and arcing does not unduly influence the performance of the spring.

Drop out current

Drop current is a peak current that flows through a relay and coil to de-energise it and break the circuit.

Electrical service life

The life of a relay when it is switched at the rated operating conditions (maximum switching frequency, contact resistance, make and break values, insulation resistance etc.) with the rated load applied to its contacts at a performance probability of 95%.

Contact materials

Material	Description	Density [g/cm³]	Melting point [°C]	Boiling point [°C]	Hardness soft [HV]	Hardness hard [HV]	thermal conductance at 20°C [W/(K x m)]	electrical conductance [m/(Ω x mm²)]	specific electrical resistance [(Ω x mm²)/m]
AgNi0,15	Fine silver	10,5	960	2200	55	100	415	58	0,017
AgCuNi	Hard silver (Argodur)	10,4	940	2200	70	115	385	52	0,019
AgCu3	Hard silver	10,4	900-938	2200	80	160	372	47,6 (soft) 43,4	0,021 (soft) 0,023
AgCdO10	Silver cadmium oxide	10,2	961	2200 Ag-share	70	110	307	48	0,021
$AgSnO_2$ 10P	Silver tin oxide	9,9	961	2200 Ag-share	70	110	*	49	0,020
W	Tungsten	19,3	3410	5930	—	—	130	18,18	0,055
Au...	Gold plating	*	*	*	*	*	*	*	*
AgNi10	Silver nickel 10	10,3	961	2200 Ag-share	50	90	350	54	0,018

Creeping and leakage distance

Creeping and leakage distances are safety spaces or margins between all of the current carrying components as well as between current carrying and non-current carrying grounded components. These are generally defined as follows:
Leakage distance is the shortest direct distance between two points – i.e. the air gap.
Creeping distance is the shortest distance between two points along the surface of an insulation material. This distance between two points can be increased by incorporating channels or grooves in the design.

Electric strength

Electric strength or voltage stability describes the voltage which can be routed to two electrodes that are insulated from one another without causing a discharge.
Voltage stability depends on the following factors:
- Thickness and purity of the insulation material
- Loss angle of the insulation material
- Temperature and duration of the effect
- Humidity
- Array of the electrodes

Forcibly guided contacts

Contacts can be guided forcibly when they are connected mechanically so that the make and break contacts cannot be closed at the same time. For this type of setup, that contacts maintain a distance of at least 0.5 mm over the entire service life, even under flawed operating conditions.

Gold flashing

Gold flashing does not fully cover the contact (layer thickness less than 0.5 µm) and serves to protect a contact during storage. The layer is porous and thus the protective benefits of gold flashing is controversial. Gold flashing is irrelevant to the switching performance of a relay.

Hard gold plating

Hard gold plating is a layer that covers the basic material of a contact fully in a thickness of 2µm (4 – 6µm at ELESTA). It prevents corrosion of a contact and is used for switching small loads (dry circuits) where no or minimal arcing occurs.

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Immersion proof / sealed

Immersion proof relays can be subjected to a rinsing process. In compliance with the manufacturer's stipulations, no cleaning agents may penetrate to the interior of the relay. Immersion proof relays also provide good protection against dust, particles and waste gas penetration.

Inrush current

The peak value of a current which a load requires when first being energised. It is essential to take the intensity and duration of inrush current into account for certain types of loads when capacitors or lamps be installed in the circuit. These will draw a substantially larger initial current than carry current.

Insulation resistance

Insulation resistance is the smallest amount of resistance offered by an insulating material. It is measured at 500V between insulated parts via ohm meter or galvanometer. If the contacts feature substantially better insulation from the coil or a grounded non-current-carrying part, then this is annotated in the relay table.

Load ratings

Relay contacts are generally rated for five different loads, which are listed under items a) through e).
The load rating g) is reserved for contactors. For the load rating f), there is no clear-cut dividing line between a relay and a contactor; in other words, the value is not defined exactly.
The following table defines the voltage and current limits for these seven load range ratings. In this case, the current values apply to the contact load on make and break rather than the thermal limiting value.

a) Dry circuits
b) Low level circuits
c) Minimum current circuits (short arcs may occur here)
d) Intermediate level circuits
e) High level circuits (stable arcs are typical here)
f) Low power contacts
g) Power contacts

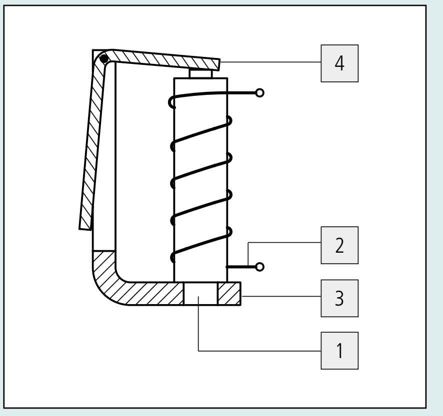
	Area of stable arcs			Area of short arcs	Upper limit is the melting voltage U_S	Upper limit is the softening voltage U_E
	U>300 <1kV	U>10V <300V	U<10V	U<10V	U<300mV	U<100mV
I<10mA					**b**	**a**
I<100mA				**c**		
I<300mA			**d***			
I<10A			**e**			
I<50A		**f**				
I>50A	**g**					

* I = 50 to 400 mA, U = 28 V direct current

Magnet system

A magnet system comprises all parts of a magnetic circuit that have a function in determining its flow.

It consists of a:
1) Coil core
2) Coil
3) Yoke
4) Actuator arm



Mechanical service life

The life of a relay in terms of its mechanical functions when it is operated at room temperature and at the maximum mechanical operating frequency without applying a load to its contacts while all specifications and operating prerequisites are met.

Monostable relays

A monostable relay is a two position relay. If it is equipped with a change over contact, the NC spring is closed in the unenergised state.

Mounting position

This describes the position that a relay must be mounted in to ensure flawless operation. All ELESTA relays can be mounted in any position.

Nominal value (nominal voltage, nominal current, nominal energising (make or break), nominal power)

Other relay-related specifications are assigned to the nominal value. For example, rise time is indicated for the nominal voltage rather than the pick-up voltage (make or break voltage). Generally, the nominal value is equivalent to the operating value. The effective values hold true for alternating voltage.

Operating voltage

The guaranteed range of input voltage in which a relay is designed to operate flawlessly.

The specification for the operating voltage normally refers to a temperature of 20°. Usually, it is depicted in a diagram as a nominal value with a maximum and minimum tolerance between the nominal coil voltage and the actual energising voltage. The value varies depending on the ambient temperature of the relay.

– Example:

Relay SGR 282 24 V DC

Ambient temperature T = 40°C

Nominal coil voltage U_N = 24 V DC

To find out the maximum operating voltage U_{Bmax} and the minimum operating voltage U_{Bmin}.

– Solution:

Based on the SGR 282 diagram, the following minimal and maximum operating voltages can be calculated:

$U_{Bmin} = U_N \times (U_B/U_N)$

$U_{Bmax} = U_N \times (U_B/U_N)$

Locate the abscissa value 40°C and from it, follow a vertical line until it intersects with the lower curve (2). The corresponding ordinate value is $U_B/U_N = 0.8$.

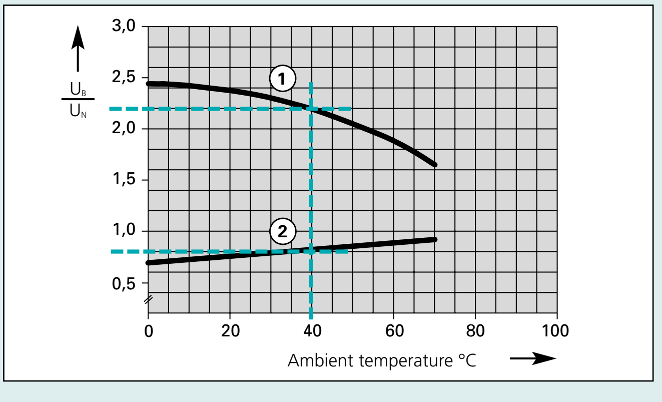
Multiply this value by the nominal voltage:

U_{Bmin} = 24 V x 0.8 = 19.2 V

Locate the abscissa value 40°C and from it, follow a vertical line until it intersects with the upper curve (1). The corresponding ordinate value is $U_B/U_N = 2.2$.

Multiply this value by the nominal voltage:

U_{Bmax} = 24 V x 2.2 = 52.8 V



Pick-up delay

Delay on make or break, wiper impulses, signalling functions and other impulse generators are often implemented via a timing function which delays the ON event upon initial application of power to the electronic timing device. Either the functions are integrated in the relay as a single component (timer relay) or as combination module featuring a relay and socket (time delay module STM).

Pick-up voltage

Lowest possible exciting voltage that will energise a relay. The specification for the pick-up voltage normally refers to a temperature of 20°C.

Protection according to DIN 40050 and IEC 144:

Parts must be encapsulated to protect people from being exposed to electrically charged components and electrical equipment from penetration by solids and water. The crucial degrees of protection are listed in the following table. These specifications do not indicate by what measure a component is gas-tight in terms of mechanical or thermal usage.

Protection classes

Diverse types of options are available to protect against shock-hazard voltages when using electrical devices. These options are grouped in protection classes. Devices rated at Protection Class 0 and 0I are not approved for use in Germany.

Protection Class I: Here shock-hazard protection is not just a matter of basic insulation. It stipulates an additional protective measure in which exposed, touchable components are connected to the ground of the hard-wired circuitry. If the basic insulation should fail, the parts are not subjected to dangerous electrical charges.

Protection Class II: Here shock-hazard protection is not just a matter of basic insulation, but also of an additional protective measure featuring double or reinforced insulation. This class does not stipulate a ground circuit, nor does it presume any other safety preconditions.

Protection Class III: Here protection against electrical shock is facilitated through safe extra-low voltage. Devices rated in this class do not generate voltages that exceed extra-low voltages.

Protective Separation

In industrial applications, the norms for control voltage circuits and circuits with 230 Volt mains power (Surge Voltage Category 3) call for a creeping and leakage distance of ≥ 5.5 mm between these circuits. In the market segments for office machines and household devices, the applicable standards dictate creeping and leakage distances of ≥ 8 mm. For applications in explosion-proof rooms, ≥ 10 mm are mandatory.

A creeping and leakage distance of ≥ 10 mm applies to the latest generation of relays that must comply with these norms. This stipulation inevitably influences the dimensions of the relays.

Pull in power

The pull in power describes the power in the coil to excite or energise a relay. The specification for the pull in power normally refers to a temperature of 20°C.

Remanence relays

These are relays that – due to the remanence of the iron core – remain actuated even when the requisite excitation does not take place or the energising level deviates substantially.

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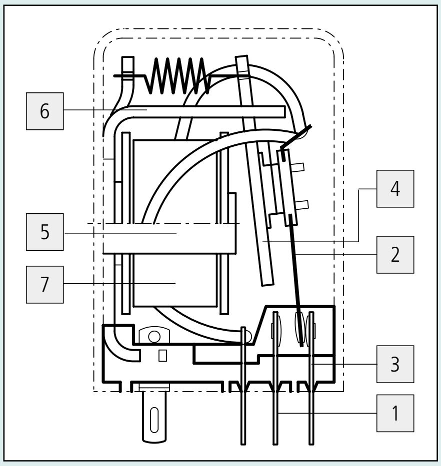
Relay design

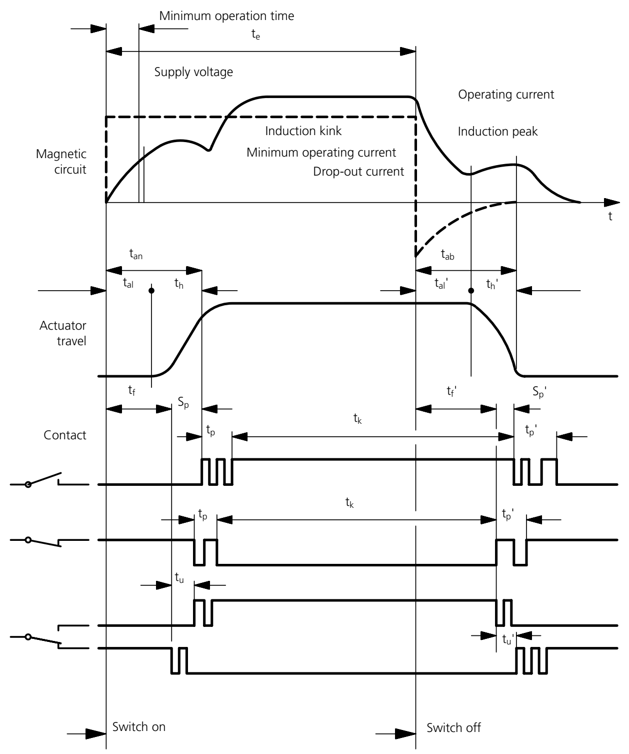
A relay is structured as follows:

1) Make contact (Normally open contact)
2) Break before make contact (Change-over contact)
3) Break contact (Normally closed contact)
4) Actuator arm
5) Coil core
6) Yoke
7) Relay coil



Relay times

Relay times describe the duration of a switching operation and depend on the type of relay. Generally, these values are specified as electrical and mechanical time constants at a given excitation.



t_{ab}	=	Release time	t_f , t_f'	=	Early contact closing
t_{al} , t_{al}'	=	Start up time	t_k	=	Contact time
t_{an}	=	Response time	t_p , t_p'	=	Bounce time
t_h , t_h'	=	Motion time	t_u , t_u'	=	Switch over time
t_e	=	Switch on time	S_p , S_p'	=	Spreading

Safety relays

Safety relays must meet special safety stipulations, for example in controls for power-driven presses (ZH1/457). Here forcibly guided contacts and a minimum distance of 0.5 mm between contacts are mandatory in case of failure or defects.

Sensitive coil

A sensitive coil is a relay coil that – in comparison to a standard coil in a relay component series – consumes less electrical power.

Shock resistance

Shock resistance describes an acceleration in g, the duration of which is stipulated in IEC 68-2-27 or NARM Std. RS401-A. The contact may not be interrupted for longer than 10 µs, nor may any damage occur.

Soldering guidelines

All print relays and sockets are suitable for automated soldering lines. The temperature of soldering baths may not exceed 270 °C. The component may be immersed in a soldering bath for no longer than 5 seconds. To protect the environment, soldering materials that do not require rinsing should be used. Caution is in order when using watery solutions – if the relays are submerged in the solution, liquid can penetrate the relays and damage these.

Switching capacity as determined by current and voltage

The on and off spikes – also called peaks or surges – are primarily of interest in opening and closing electrical contacts. When an inductive electrical circuit is opened, often a substantially higher voltage than the one produced by the source of the current must be switched off. Conversely, often when capacitive circuit are closed, spikes occur that may destroy other components as well as arc weld the contacts.

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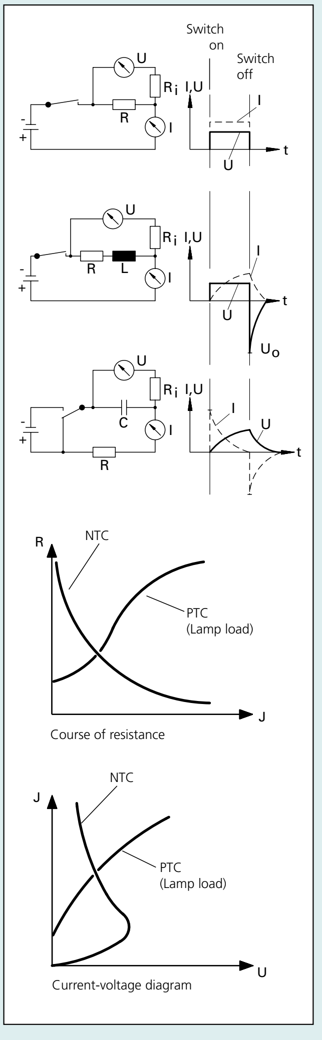
a) For resistive loads (Resistance R): Current I and Voltage U immediately rise to operating level when the circuit is switched on and immediately fall when it is switched off.

b) For inductive loads (Inductivity L): The current 1-exp (-Rt/L) rises proportionally to the operating level and falls exponentially when the circuit is switched off. The voltage immediately rises to operating level and when the circuit is switched off, surges in the opposite direction and falls exponentially.

c) For capacitive loads (Capacitive C): A spike with exponential fall is generated when the circuit is switched on and off. When the circuit is closed, the spike only occurs when the capacitive circuit is unloaded. The voltage responds in a similar manner to the current in an inductive circuit.

d) and e) Thermistor lamp load: In a circuit equipped with thermistors that feature opposite attributes, in many cases the inrush current can be compensated.



Posistor lamp load: High inrush current occurs when posistors (iron-hydrogen resistor, heating coils, e.g. made of tungsten) of electrode tubes and resistance furnaces.

Sticking

Sticking in monostable relays means that the actuator armature does not return to the home position after the coil was excited. The reason for this can be either insufficient restoring force or a too great remanence in the iron core. This problem can be solved by installing a metal partition or dividing pin.

Time modules

Time modules are programmable time components (STM), which in conjunction with an SKR 115 industry relay, execute simple time-based functions (e.g flashing, make delays etc.).

Vibration resistance

Vibration resistance describes the capability of a component to withstand a sine shaped acceleration of a defined extent in predetermined frequency range without changing the switching status (longer than 10 µs) and suffering any damage (IEC 68). For example, the specification 10/2000 indicates that a device or component is resistant to this type of acceleration of 10 g up to a frequency of 2000 Hz.

Washproof

Washproof may only be subjected to rinsing processes provided special conditions are met, for example the SGR print relays equipped with O-rings for this purpose.

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