AUTOMOTIVE POWER RELAY USER'S MANUAL

【Safety precautions】

The possibility of defect cannot be eliminated entirely even though EM Devices Corporation has been making continuous effort to enhance the reliability of the relay. To minimize the risks of damage or injury to persons of property arising from a defect in the relay, customer must incorporate sufficient safety measures in its design; such as redundancy, fire-containment and anti-failure features. For proper use of the relay, please check your product with actual load and actual application under actual operating conditions.

【General】

1. Usage and Storage conditions

(1) Ambient temperature
When the relay is used at an ambient temperature exceeding or below the range that is shown in the datasheet and catalog, the performance of the relay may be degraded and the life may be extremely shortened.

(2) Humidity
Under a high humidity (RH85% or higher) environment for a long time, moisture may penetrate inside the relay. This moisture may combine with NOx or SOx generated by glow discharges to produce nitric acid or sulfuric acid. In this case, the acid produced may corrode the metal that forms the relay, and it may cause operation troubles in the relay.

(3) Low temperature and humidity atmosphere
If the relay is exposed to a low-temperature, low-humidity atmosphere for a long time, its plastic parts may become brittle and fragile.

(4) Water condensation
Water condensation occurs when the ambient temperature drops suddenly from a high temperature and humidity, or the relay is suddenly transferred from a low ambient temperature to a high temperature and humidity. Condensation causes the failures like insulation deterioration, wire disconnection and rust etc. Please evaluate in the actual usage.

(5) Freezing
Freezing means, the moisture contained in the surrounding environment and inside the relay freezes when the ambient temperature falls below the freezing point.
The freezing causes the sticking of movable portion, the operation delay and the contact conduction failure etc. Please evaluate in the actual usage.

(6) Atmospheric pressure
The relay supposes to use under normal pressures (810 to 1200hPa). However, if it is used under other pressure conditions, it's performance may be destroyed and the relay may be deformed. This can cause functional troubles with the relays. Be sure to use the relay under normal pressure conditions.

(7) Vibration and Shock
The use of the relay under conditions that are not specified may cause malfunction or damage. Excessive vibration and shock during contact load current carrying may cause considerable damage or wear of the contacts.
Please absolutely avoid the ultrasonic and high frequency vibration to the relay that adversely affects its performance.

(8) Influence of magnetic fields
Under the influence of magnetic flux leaking from a transformer, speaker, or magnet placed near the relay; the operate and release voltage; operate and release time, and other dynamic characteristics may change. In applications where these characteristics changes can cause problems, it is necessary to take measures such as magnetic shielding.

(9) Plastic molding for relay body
Please do not use this product in such atmosphere where any kind of organic solvent (as benzene, thinner and alcohol) and the strong alkali (as ammonia and caustic soda) may be adhered to this product.

(10) Storage
Please do not keep under high temperature and humidity.

2. Contact load

(1) Limitation of load

Never allow the contact load to exceed the maximum ratings; otherwise, the lifetime of the relay will be dramatically shortened. The lifetime specified in this specification is for certain load conditions, and other factors must be taken into consideration in actual circuits. Therefore, an accurate lifetime must be measured in the actual circuit.

(2) Minimum load

Use the relay at a voltage and current higher than the minimum load. Otherwise, the contact resistance will increase and the electrical continuity cannot be detected. This is because stabilization of the contact surface (electrically and mechanically eliminating minute substances generated on the contact surface) by opening/closing the contacts with the minimum load probably will not occur.

In addition to the above mentioned, even if the load is within the maximum ratings, note that the current does not drop below the minimum load while carrying.

The inspection current should also be used above the minimum load.

(3) Inrush current

When using the relay with a high current or high capacitance load, an inrush current may cause contact dislocation or deposition; therefore check the feasibility of use in the actual circuit.

(4) Switching loads

There are two types of load current control by a relay. One is “non-working”. It is the load current that is switched by the transistor, the relay only carries the load current. The other is “working”. It is a relay that switches and carries the load current. EM Devices recommends the working load current, because the effect of cleaning contacts by the arc phenomenon at the opening/closing the contacts will be expected.

(5) Contact protection circuit

To improve the use of the relay, provide a circuit that suppresses transient current and voltage applied to contacts during opening and closing. The applicable protection circuit differs depending on the load type of the contact.

Contact protection effect depends on the location of protection circuit (load side or contact side, the distance between contact and protection circuit). It is important to confirm the effectiveness of the protection circuit in the actual circuit. In some cases, it is also necessary to conduct lifetime tests using an appropriate equivalent circuit.

(a) Inductive load

In inductive load, electromotive force is generated when the contacts are open. This electromotive force generates an electrical discharge such as arcing and glow discharge. This contact phenomenon can cause extreme contact erosion. To avoid contact erosion, a contact protection circuit is applied to absorb the electromotive force.

Table 1 shows examples of contact protection circuits. Please do not use the protection circuits of capacitor only shown in Table 2.

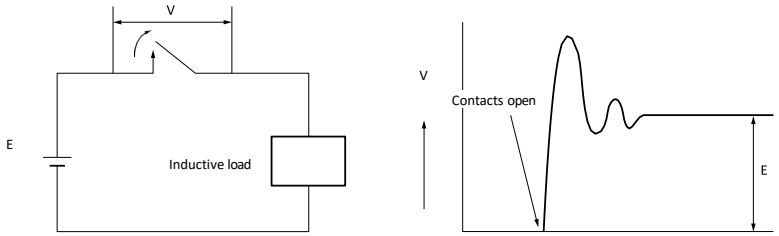


Figure 1 Inductive load circuit

Table 1 Inductive load contact protection circuit

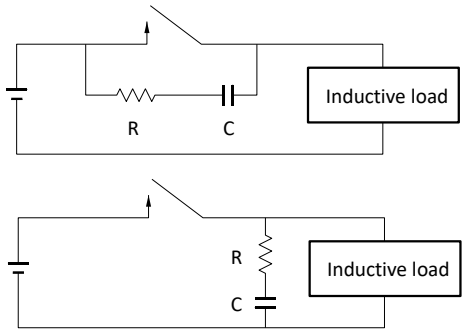
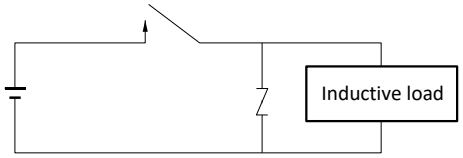
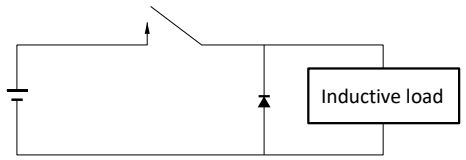
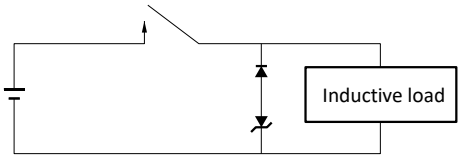
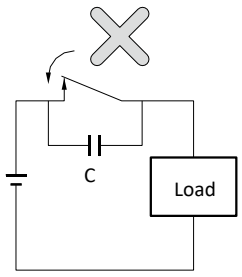
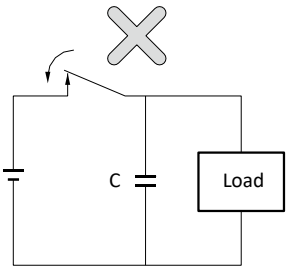
Protection element	Circuit example	Remarks
Capacitor + Resistor (CR Circuit)		$R(\Omega) = \frac{\text{Contact Voltage(V)}}{0.5 \text{ to } 1}$ C(μF) = (0.5 to 1) x Contact Current(A) The withstand voltage of a non-polar capacitor should be 300V or higher.
Varistor		High voltage is suppressed by using the voltage characteristics of the varistor.
Diode		Pay attention to the reverse withstand voltage of the diode. The release time of the relay or solenoid of the load becomes long.
Diode + Zener Diode		The ON time of the diode is controlled by using the Zener voltage characteristics and the release time of the relay or solenoid of the load can be shortened.

Table 2 Example of wrong circuit with a capacitor

	This circuit is effective for arc suppression when the contacts are opened, but when the contacts are closed a capacitor short-circuit current flows, making the contacts more susceptible to metal deposition.		This circuit is effective for arc suppression when the contacts are opened, but when the contacts are closed a capacitor charging current flows, making the contacts more susceptible to metal deposition.

(b) Capacitive load (I)

Capacitors are often used in parallel to the loads like motors to prevent noise and other purpose as shown in figure 2. In that case, inrush current is generated in the circuit. As a result, the contacts can stick together due to projection and pitting that are both formed at contact surface. So, it is necessary to hold down the inrush current by resistor which is connected in series to capacitor. It is desirable that capacitor value is as small as possible and the resistor value is as large as possible.

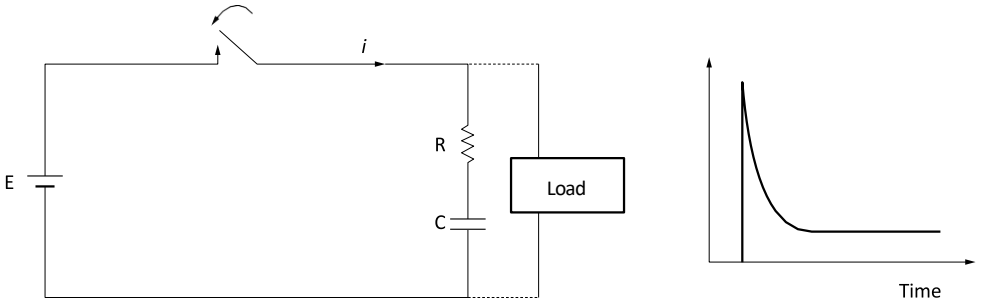


Figure 2 Inrush current of load from capacitor

(c) Capacitive load (II)

It is necessary to be careful when capacitors are connected in the circuit as shown in Figure 3.
When the common contact moves from the make contact to the break contact, the motor generates electromotive force. Capacitor can be charged by over supply voltage. Bigger inrush current from the capacitor flows to the break contact. Because the break contact has the bounce at ON, inrush current damages the break contact. Therefore it is necessary to decrease the inrush current by a resistor which is connected in series to capacitor as shown in Figure 3.
Moreover, a diode connected with the relay coil in parallel can reduce bounces. The diode is more effective than a Zener diode for it.

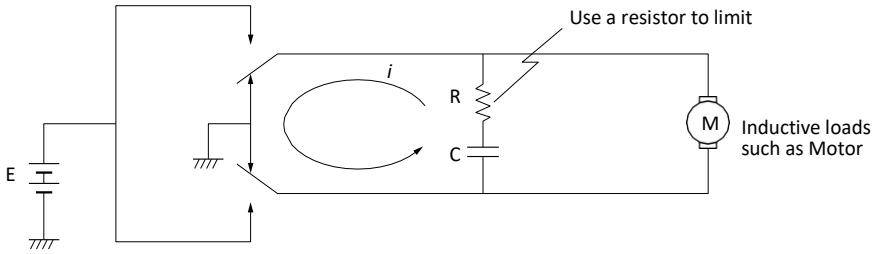


Figure 3 Countermeasure against capacitor in inductive load circuit

(d) Lamp load

Lamp loads like tungsten lamps, have a low initial resistance so that an inrush current of 5 to 10 times as high as the steady state current may flow through the relay contacts. In this case, it is necessary to keep the current within the maximum rated value. A current-limiting resistor is connected to the contacts in series.

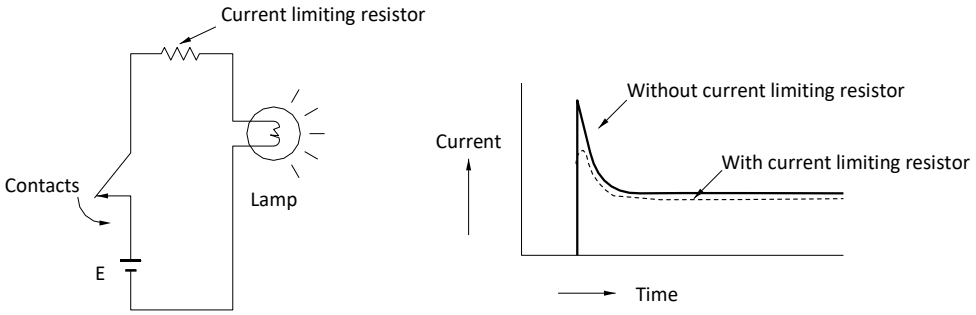


Figure 4 Inrush current under lamp load

(e) Stray line capacitance

When the stray line capacitance is large, the inrush current that is generated due to the stray line capacitance poses a problem. The electric charge on the line capacitance is discharged directly through the contacts when the contacts are closed. The smaller the wiring cable characteristic impedance and the longer the cable, the greater wear on the contacts. It is necessary to connect a current-limiting resistor or surge suppresser in series with the contacts as a protection circuit to suppress the inrush current.

(6) Applied voltage

Note; in case that the voltage that exceeds maximum ratings is applied to contacts, the circuit cannot be broken even if the contacts are opened.

3. Driving relays

(1) Ambient temperature

When the relay is used at an ambient temperature exceeding or below the range that is shown in the catalog, the performance of the relay may be degraded and the life may be extremely shortened.

- Please use the relay at coil rated voltage within the specified temperature range. NOTE: Permissible coil voltage may be restricted and must be confirmed before the relay is used. (Refer to (2) in “Maximum applied coil voltage”).
- The operating characteristics of the relay change with ambient temperature. Confirm the temperature condition in the application and confirm the characteristics changes at the technical documents. Figure 5 shows the example of the temperature characteristics.

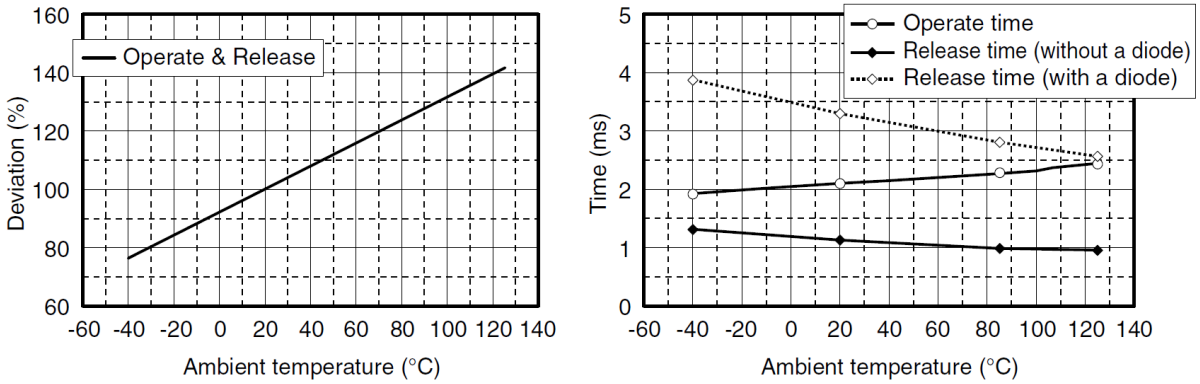


Figure 5 Temperature characteristics of relay (example: EX2 relay)

(2) Maximum applied coil voltage

The maximum applied voltage of the relay coil depends on the ambient temperature and the carrying load current. The upper limit is decided on the heat resistance of the relay. It mainly depends on the permissible temperature of the coil wire and the plastic material. When the voltage applies the coil continuously, the coil generates the heat corresponding to applied voltage. Then the coil temperature rises up. The higher the ambient temperature is, the less the margin of the heat resistance temperature of the coil wire material is. Therefore, it is necessary to restrict the coil voltage at high ambient temperature. Figure 6 shows the example of permissible applied voltage. The coil temperature is also affected by the load current. Consult EM Devices about the permissible maximum applied voltage in use condition like ambient temperature, carrying load current and carrying duration.

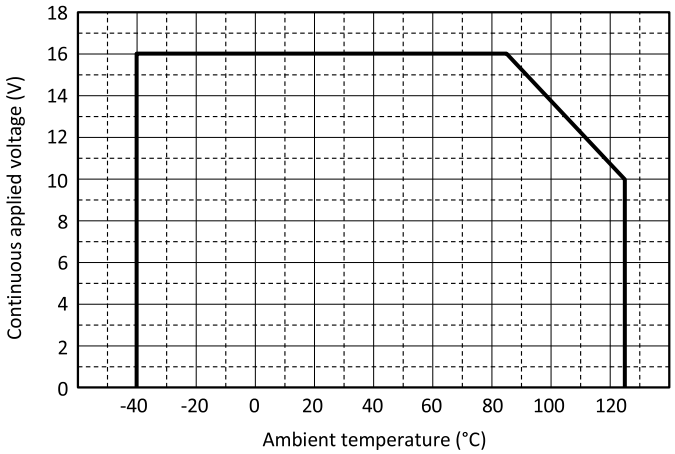


Figure 6 Coil voltage versus temperature derating characteristics (example)

(3) Driving current waveform
The relay referred in this specification document was designed to drive in direct current circuit. Note that when a rippled DC power source is used, abnormalities such as beat in the coil may occur.
If the waveform of the relay coil drive voltage gradually increases and decreases, the speed of the contact's opening/closing gradually decreases too and the relay may not be able to deliver its inherent performance. The voltage must instantaneously rise and fall as a pulse.

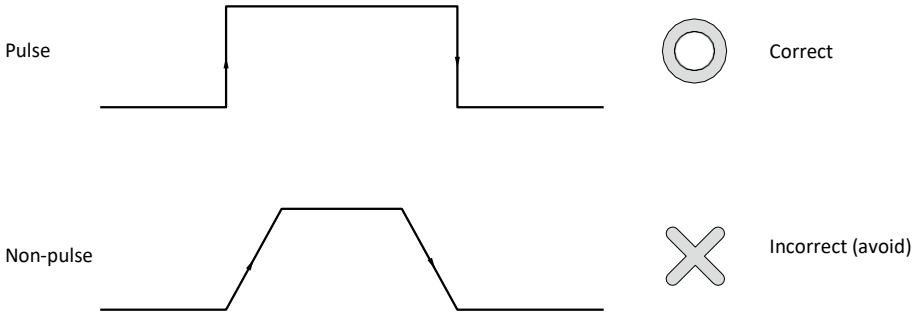


Figure 7 Coil drive waveform

(4) Hot start
There is a case that a relay is energized again immediately after it is energized continuously and after de-energized. This phenomenon is called hot start. The relay might not operate at this case. This is because the increase in the coil resistance due to heat in the relay causes the current to fall even though the applied voltage remains constant. This problem occurs especially when the operating temperature is high and a voltage which is lower than the rated voltage is applied. confirm first the must operate voltage at the time of a hot start.

(5) Long continuous energizing of coil
If the coil is energized continuously for a long time, the sum of relay ambient temperature and temperature increase due to carrying current of contact and coil must be less than the limit of relay operating temperature range.
Use of the relay at a temperature outside this range may adversely affect insulation or contact performance.

(6) Driving circuit

Since the relay coil has an inductive impedance, a counter electromotive force is generated when the coil current is interrupted. If the counter electromotive force may damage the relay driver IC or other components, we recommend implementing a circuit configuration as shown in Figures 8(c) and (d).
The circuit configuration shown in Figure 8(b) is not recommended, as it not only extends the relay release time but may also significantly degrade the relay performance.

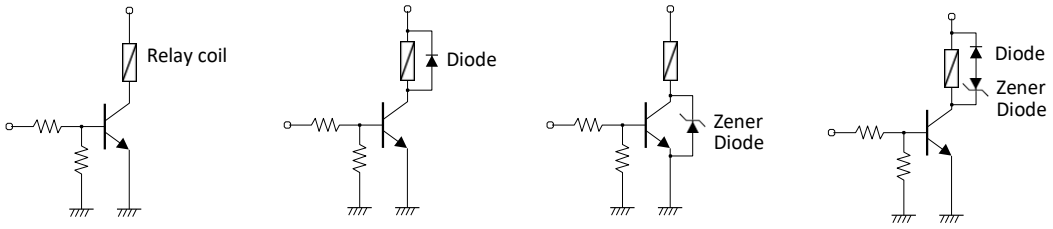


Figure 8 Driving circuit

(7) Opening/Closing frequency

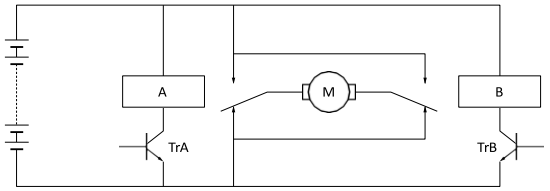
If the contacts open and close frequently with a high current load, repeated electric discharges may cause contact metal welding or damage to the contact spring. Consult EM Devices when using the relay with high current load with frequent opening and closing of contacts.

(8) Power source capacity

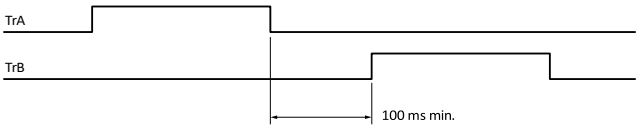
When the same power source is used for the relay drive and the load such as a lamp load. The moment the contacts are closed, the source voltage may drop if the power source capacity is small. In this case, the relay may be released or an oscillation phenomenon where the relay repeatedly releases and operates may occur.
Ensure the power source enough capacity to prevent this phenomenon.

(9) Polarity reversal circuit

Note the operating sequence of 2 relays in case of polarity reversal circuit, is using two single relays or one twin relay which is called H-bridge circuit (Figure 9(a)). If two relays (A and B) are switched at a time, contacts are instantaneously applied power supply voltage and inductive voltage by motor. Contacts are damaged by discharge of excessive voltage. Contact life might decrease by contact welding or contact material transition. It is necessary to take more than 100ms intervals for on/off timing between driving A and B relay (Figure 9(b)).



(a)



(b)

Figure 9 Polarity reversal circuit and coil drive timing

(10) Latching relay

- Apply a voltage to the coil in the polarity specified by the internal connection diagram of the relay. With a double coil latching type relay, do not apply voltage in a manner that both the set and reset coils are energized at the same time.

- A latching relay is driven by a pulsating coil voltage. The pulse width of this drive voltage must be 10ms or wider. If the pulse is too short, the relay may not operate.

- A latching relay is factory-set to the reset state for shipment. However, it may be set while being transported due to vibration or shock. Make sure that the relay is reset when its application system starts operating. When the relay is employed in a portable system, the circuit must be designed so that the relay is reset at the beginning of operation of the system because the relay may be set by unexpected vibration or shock.

- When configuring a self-holding circuit that uses the self-break contacts of the relay, note that the coil drive circuit is disconnected by the self-contacts, causing troubles such as self-oscillation.

(11) Jump Start

Power relay is the product for 12V battery system and does not correspond to 24V “Jump start” testing.

4. Influence of relay operation on surroundings

(1) Electromagnetic noise
Switching the relay coil generates a high electromotive force due to induction. This high voltage might break the relay driver circuits such as microcontrollers. Add an appropriate absorption element such as diode to prevent electronic circuits from malfunctioning.

(2) Arc discharge
Connecting/disconnecting a high current at the relay contacts generates an arc discharge. This discharge may cause electronic circuits such as microcontrollers to malfunction and therefore it is necessary to take appropriate measures such as electrostatic shields or separation of power supply.

(3) Generation of leakage magnetic flux
Leakage magnetic flux exists slightly in the vicinity of the relay when in the magnetized state. Magnetic sensors, etc. that are close to the relay may malfunction.

5. Handling of relays

(1) Use of magazine case stoppers

Generally, relays are packaged in a magazine cases for shipment. When some relays are taken out from the case and space is freed inside the case, be sure to secure the relays in the case with a stopper. If the relays are not enough secured, vibration during transportation may cause contact problems.

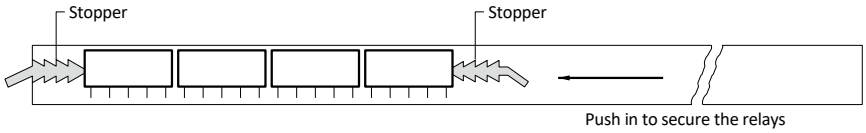


Figure 10 Storage in magazine case

(2) Drop

Do not use relays that have been dropped. If an individual relay product falls from the work table, etc. a shock of 9800m/s2 or more is applied to the relay and its functions may be destroyed. Even if the shock is apparently weak, confirm that there is no abnormality before using the relay.

(3) Long term storage

(a) Contacts

When the relay which has been stored for long term is used, check the electric continuity of it. If the storage condition (temperature, humidity and atmosphere, etc.) is not good, contact surface might decay and can result to contact failure.

(b) Terminals

Check the solderability of terminals. The surface of terminal will become oxidized and the solderability might deteriorate. Moreover; oil, water or solvent, etc. must not splash the terminals.

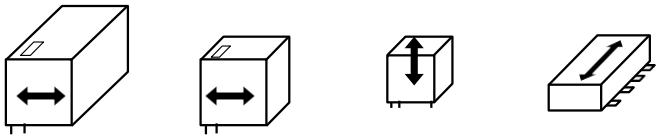
6. Mounting

(1) Print circuit board

For the printed circuit board on which a relay is mounted, use a board of 1 mm or more in thickness. If the printed circuit board is not thick enough, it may be subject to warpage which will add tension to the relay. And if a thermal cycle is applied to the soldered part, cracks may be generated in it. Special care is required for the relay location, base material and through-hole shape.
Consult EM Devices before using the pad layout other than the layout described in catalog.

(2) Relay mounting position

a) The vibration and shock resistance of a relay are greatly affected by its mounting position. It is particularly important to select the mounting position to prevent the break contacts from being momentary open instantaneously due to vibration and shock. The vibration and shock resistance are at a minimum when the direction of vibration and shock applied to the relay matches the operation direction of the armature (movable iron piece) and contacts. Therefore, if it is possible to anticipate the direction of vibration or shocks, mount the relay so that the direction in which vibration or shocks are applied is perpendicular to the direction of the relay armature operation. Figure 11 shows the direction of relay armature operation.



EP2/ET2 | EP1/ET1 | EL1/EM1/EM1K EM1KT/EX1/EX2 HX1/EX1K/AX1/BX1 | EU1/EU2

Figure 11 Direction of armature operation

b) The projection on contact point is generated and fallen by arc discharge. If the fulcrum (=hinge position) of armature is located below the contact point, the projection may fall into the gap of fulcrum and the relay may not operate normally. Therefore, please do NOT mount to the following direction (refer to Figure 12) when you consider the PCB layout and relay direction. If you cannot avoid the mounting direction shown in Figure 12 on the actual usage, please contact EM Devices.

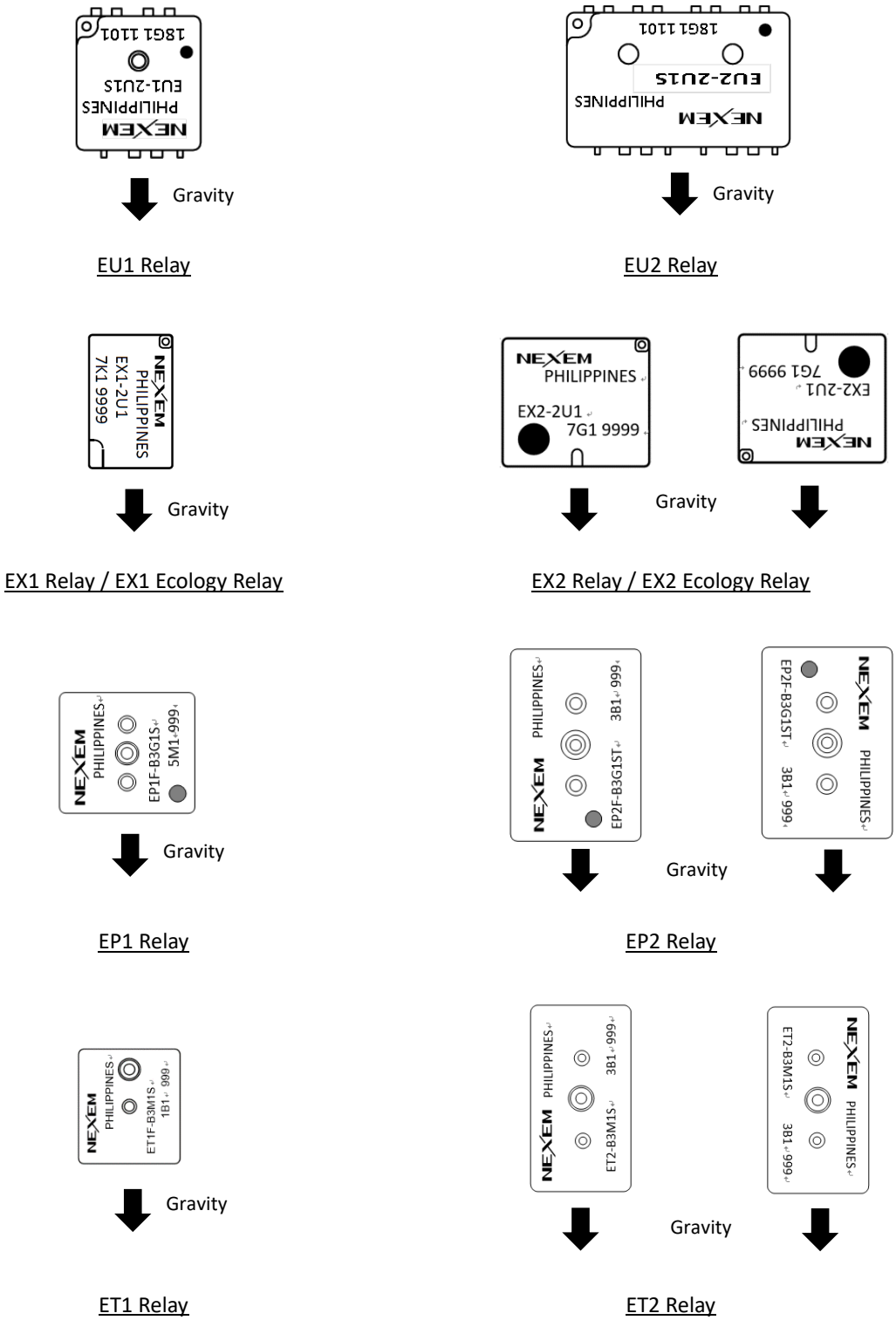


Figure 12-1 Mounting direction to avoid

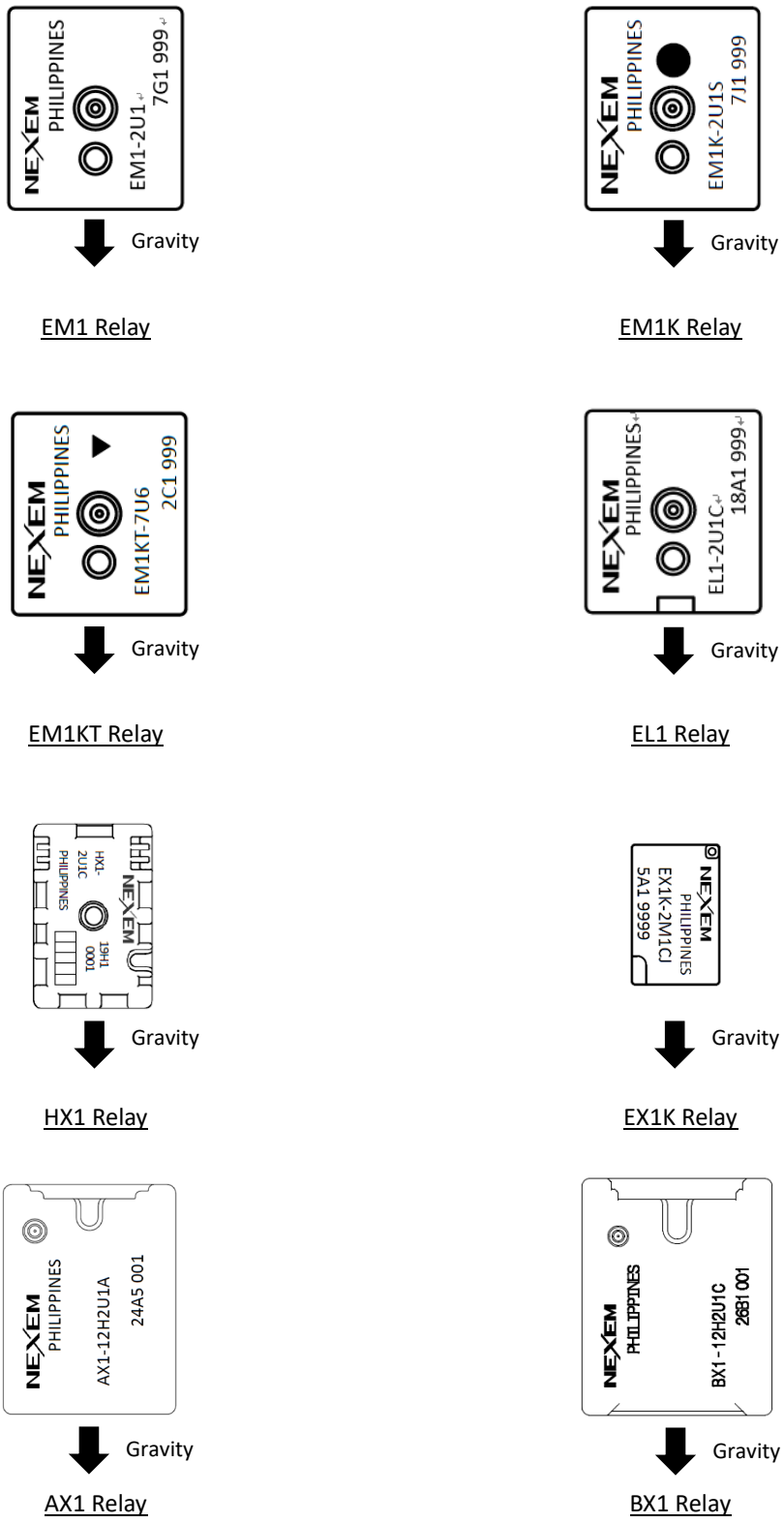


Figure 12-2 Mounting direction to avoid

(3) Chucking
When a relay is mounted using an automatic machine, note that the application of an excessive external force to the cover at the time of chucking or insertion of the relay may damage or change the characteristics of the cover. The chucking force is approximately 4.9N (500 g) or less.

(4) Temporary securing to printed circuit board
Avoid bending the pins to temporarily secure the relay to the printed circuit board. Bending the pins may degrade sealability or adversely influence the internal mechanism.

(5) Relay mounting area
When two or more relays are installed close together, there is a possibility of abnormal heat generation due to mutual interference of heat and failure due to insufficient insulation distance between terminals outside the relay, so please evaluate under actual operating conditions.

(6) Soldering work
In all power relays, terminals are all pre-soldered with Pb free solder.

(a) Automatic soldering (Flow solder)
[Recommended conditions]
*Preheating: 100°C max. , 60 seconds max.
*Solder temperature: 260°C max.
*Solder time: 5 to 10 seconds

(b) Automatic soldering (Reflow solder)
Surface mounting type relay EU1/EU2 and pin in paste reflow type relay are for reflow soldering.
Confirm first the recommended temperature profile to EM Devices.

(c) Manual soldering (by soldering iron)
[Recommended conditions]
*Solder temperature: 350°C max.
*Solder time: 2 to 3 seconds

After soldering is completed, it is recommended to cool down immediately by airflow.
Avoid immersion in cleaning solution immediately after soldering, as this may cause thermal shock and damage to the airtightness. Work with the relay and the printed circuit board when they are back to room temperature.

(7) Cutting terminals
Do not cut the terminals of the relay with a revolving blade or an ultrasonic cutter, because vibration that is applied to the relay during the cutting may cause the characteristics to change, breaking of the coil wire or sticking of the contacts.

(8) Cleaning

Avoid immersing the board in cleaning solvent after soldering, otherwise breaking sealability might be caused by thermal shock. After the relay and board returned to room temperature, clean them.

(a) Cleaning solvent

Use of alcohol or water-based cleaning solvents is recommended. Never use thinner or benzene because these solvents may damage the relay housing.

(b) Ultrasonic cleaning

Avoid ultrasonic cleaning because it may damage driving system, movable contact and spring of relay due to sympathetic vibration.

(9) Coating

In case that coating agent is applied to printed circuit board to secure anticorrosion and insulation, avoid adhesion of it to relay due to dipping, etc. Selective coating by covering relay with something to insulate relay from coating agent is recommended. If application of coating agent to relay is unavoidable, let relay cool to room temperature after soldering and washing before applying coating agent. When thermosetting material is used as a coating agent, heat it until being cured completely. Note; Avoid the use of silicone series coating agent otherwise contact failure may occur.

7. Using SMT Relays

(1) Printed circuit board

Determine the dimensions of the mounting pads on printed circuit board consider the factor of solderability and insulation in order to fit in the mounting accuracy of automatic mounting machine. Refer to the dimensions of the mounting pads in the datasheet and catalog.

(2) Reflow solder

The SMT relay is highly resistant to heat. However, solder the relay under the correct temperature conditions so that the full performance of the relay can function properly. Referring to recommended temperature profile with EM Devices' experiment equipment, be sure to confirm the soldering conditions and the influence of the relay in advance before setting work standards.

(3) Storage

The sealability of a surface mounting relay may be lost if the relay absorbs moisture and when heated during soldering. Note this in cleaning and coating process.

8. Others

(1) Please do not make additional manufacturing upon the relay housing.

The information in this document is based on documents issued in October 2026. The information is subject to change without notice. For actual design-in refer to the latest publications of data sheets, etc., for the most up-dated specifications of the device.

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The possibility of defects cannot be eliminated entirely even though EM Devices Corporation has been making continuous effort to enhance the reliability of miniature power relay. To minimize the risks of damage or injury to persons of property arising from a defect in an EM Devices' products, customer must incorporate sufficient safety measures in its design; such as redundancy fire-containment and anti-failure features.

EM Devices products are classified into three quality grades: Standard, Special, and Specific.
The Specific quality grade applies only to devices that are developed based on a customer designated Quality Assurance program for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade for each device before using it in a particular application.

Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control system, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life sup- port)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

The quality grade of EM Devices products is considered as Standard, unless otherwise it is specified in EM De- vices Datasheets or Data Books. If customers intend to use EM Devices' products for applications other than those specified for Standard quality grade, they should contact an EM Devices sales representative in advance.

The quality grade of the products described in this document is considered as Special.